THE 1961

AEROSPACE YEAR BOOK

AIA

THE 1961 AEROSPACE YEAR BOOK

FORTY-SECOND ANNUAL EDITION

Official Publication of the Aerospace Industries Association of America, Inc.

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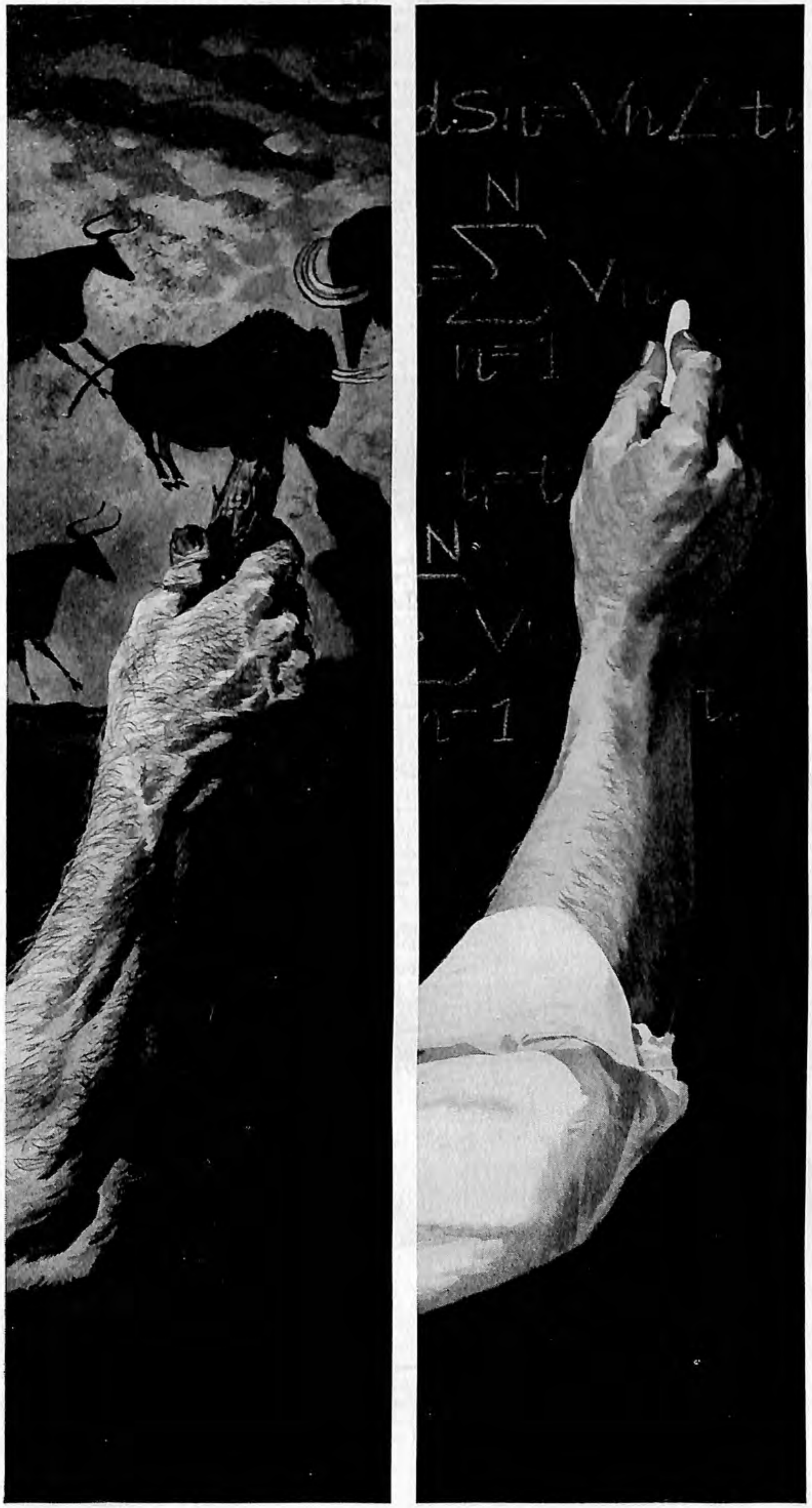
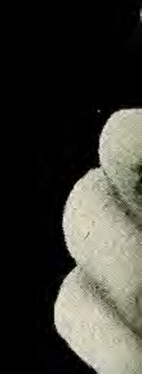
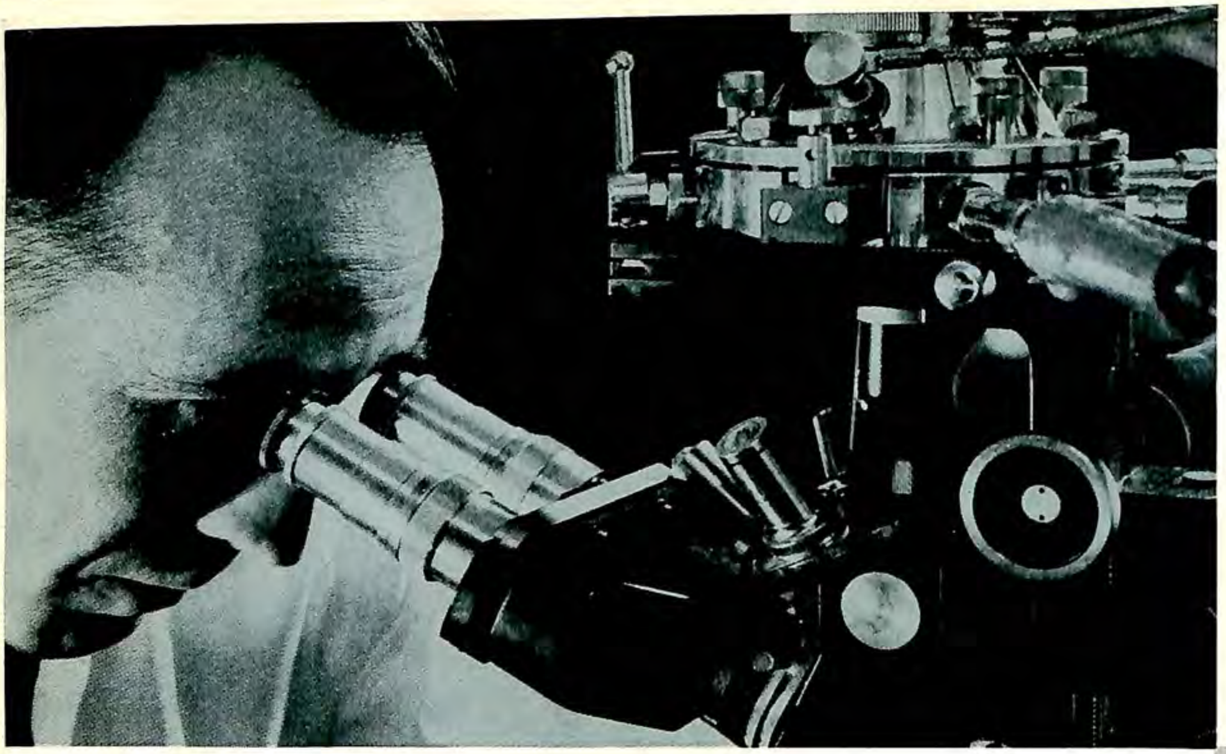
1001 Vermont Avenue, Washington 5, D.C.






electricity?
ISON
DIVISION OF GENERAL MOTORS, INDIANAPOLIS, INDIANA



Extremely high temperature material problems encountered on re-entry into earth's atmosphere are studied with the aid of a plasma jet capable of 30,000°F.

Basic effects of elevated temperatures on various materials are viewed and photographed with the hot stage microscope.

CAPABILITY is spelled r-e-s-e-a-r-c-h

In technology and facility, Vickers continually matches your needs

New fluid power and hot gas systems for aerospace vehicles still in the idea stages are being developed at Vickers. Techniques for converting basic energy into precisely controlled power are continuously being sought by experienced teams of research specialists utilizing the finest scientific equipment.

Creative application of the sciences of hydrodynamics, aerothermodynamics, heat transfer, metallurgy and chemistry have been productively blended with Vickers vast experience in the instrumentation and control fields.

The principal effort of Vickers applied research is now concentrated in three areas: 1. advanced systems and components for attitude controls, 2. secondary rocket nozzle injection and 3. hot gas servo actuation. In addition, continuous refinements are being made to the high performance Vickers hydraulic pumps and motors.

The experienced Vickers Application Engineer in your area will welcome the opportunity to fill you in on additional details. In the meantime, write or call for Bulletin A-6002.

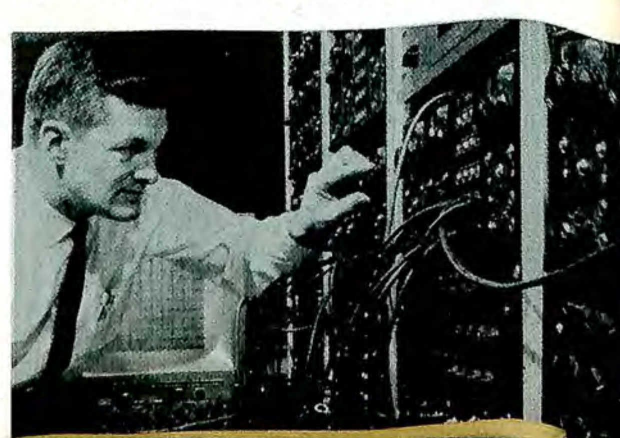
Advanced type of primary and emergency fluid power supply system developed and built by Vickers being readied for feasibility test in an environmental chamber.

AERO HYDRAULICS DIVISION
VICKERS INCORPORATED
DETROIT 32, MICHIGAN
TORRANCE, CALIFORNIA

division of
SPERRY RAND CORPORATION

PROGRAMMED POWER IN: FLUID TRANSFER • POWER TRANSMISSION • ENERGY CONVERSION

Analyses of fluids, propellants and special coolants for electronic equipment is carried out in completely equipped chemistry laboratory.



Analog computer (shown) and solid state Univac digital computer give Vickers the important edge in solving complex engineering problems.

9267

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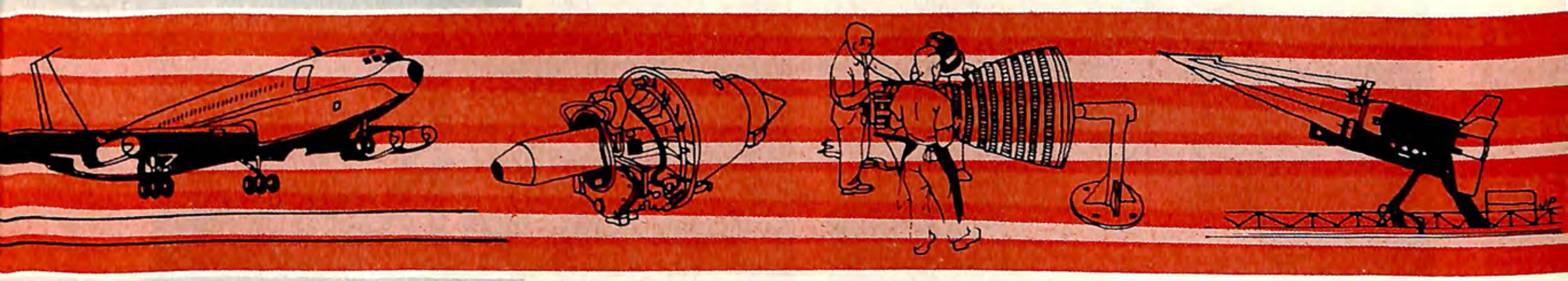
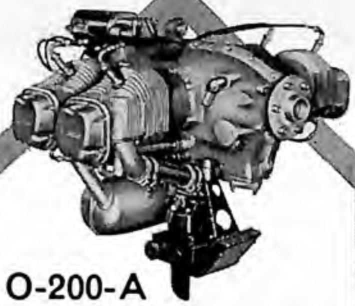


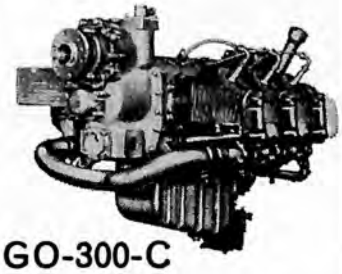
Jacket Design: ***JOE PHILLIPS***

CONTINENTAL AIRCRAFT ENGINES

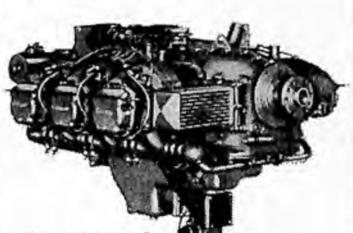
FIRST CHOICE IN UTILITY PLANE POWER



O-200-A



GO-300-C



IO-470-J

26 MODELS—65 TO 310 HORSEPOWER

MODEL	HP	RPM	CYL	WT*	OCTANE
A65	65	2300	4	172	73
C90	95	2575	4	188	80/87
O-200-A	100	2750	4	190	80/87
O-300-D	145	2700	6	267	80/87
GO-300-C, D	175	3200	6	309	80/87
E185	205	2600	6	326	80/87
E225	225	2650	6	363	80/87
O-470-G	240	2600	6	432	91/96
O-470-J	225	2550	6	380	80/87
O-470-K, L	230	2600	6	404	80/87
O-470-M	240	2600	6	410	91/96
IO-470-C, G	250	2600	6	430	91/96
IO-470-D, E, F, L, M	260	2625	6	428	100/130
IO-470-H	260	2625	6	431	100/130
IO-470-J, K	225	2600	6	402	80/87
IO-470-N	260	2625	6	423	100/130
TSIO-470-B	260	2600	6	465	100/130
GIO-470-A	310	3400	6	455	100/130

*All weights approximate

Behind the growing use of airplanes as tools of business and industry is the fact that in company after company they are more than paying their way. As the pioneer in utility aircraft power, Continental Motors takes understandable pride in its role as engine source for the leading planes of this type. It is Continental's sincere belief that the performance of these engines—their power, economy and dependability as proven in thousands of hours of flying every year — has been a major factor in businessmen's acceptance of those aircraft—a factor destined to assure their ever-widening use.

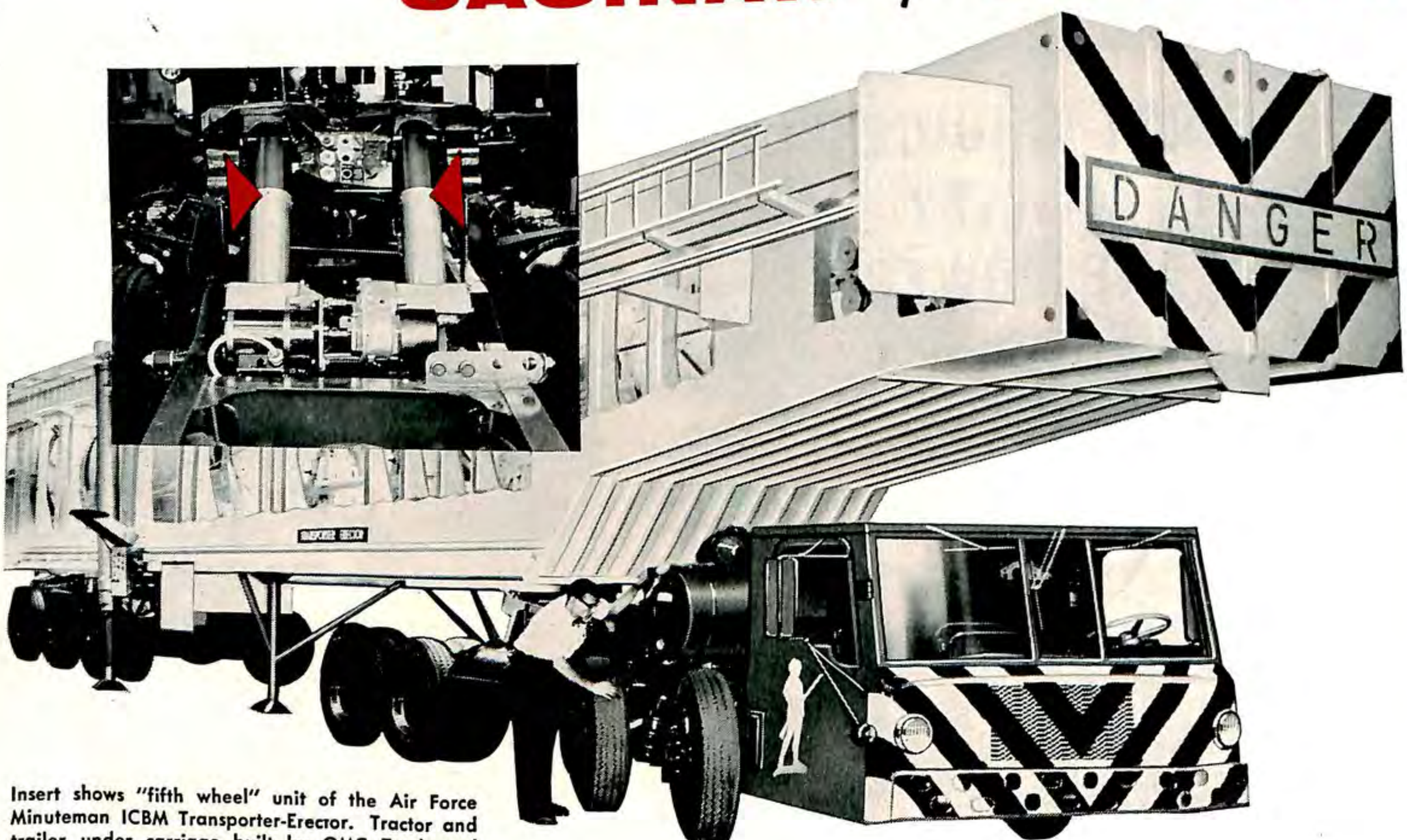
CONTINENTAL MOTORS · Powerful as the Nation · AMERICA'S STANDARD ®

Continental Motors Corporation

AIRCRAFT ENGINE DIVISION
MUSKEGON, MICHIGAN

Hefting a Heavyweight

...A SNAP with SAGINAW b/b SCREWS



Insert shows "fifth wheel" unit of the Air Force Minuteman ICBM Transporter-Erector. Tractor and trailer under carriage built by GMC Truck and Coach Division.

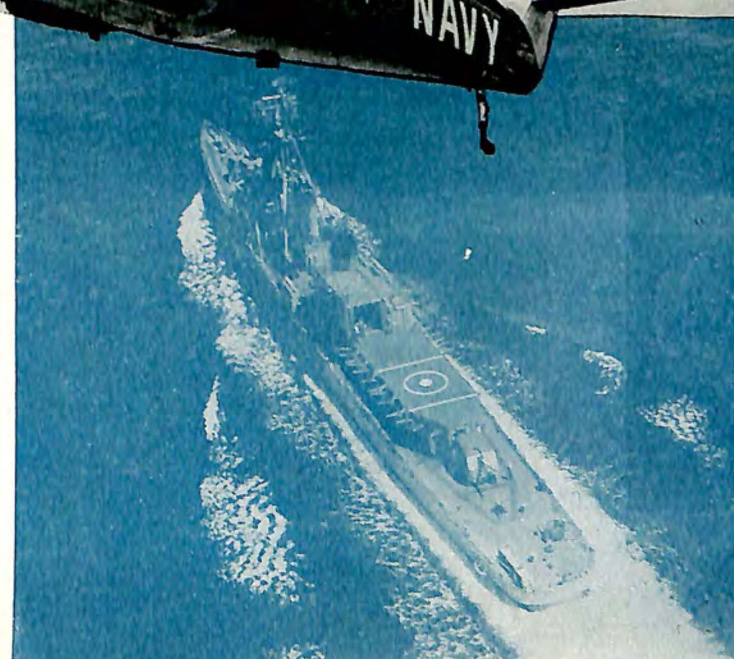
Low-friction Saginaw Ball Bearing Screws allow a small electric motor in the "fifth wheel" unit to rapidly raise and lower the forward end of this transporter of a 65,000 pound missile . . . allows the transporter to pass under highway overpasses and other low clearance obstacles en-route to underground launching sites.

Also, Saginaw b/b Screws are used for leveling jacks on the rear sides of the carriage unit. The effort required to level the undercarriage is so small the jacks are hand-operated. Each of the jacks has a capacity of 65,000 pounds.

The efficiency of Saginaw Ball Bearing Screws and Splines is being used by designers of today's space, air and ground handling systems. They can lower operating costs, reduce maintenance and simplify designs. And they often reduce installation costs. Whatever your application problem, call on Saginaw to help solve it with Saginaw b/b Screws! Saginaw Steering Gear Division, General Motors Corp., Saginaw, Michigan—world's largest producers of b/b screws and splines.

WRITE TODAY FOR NEW 1961 ENGINEERING DATA BOOK OR REFER TO SWEET'S DESIGN FILE

Saginaw ball/bearing Screw



BIG
PERFORMANCE
COMPACT
SIZE

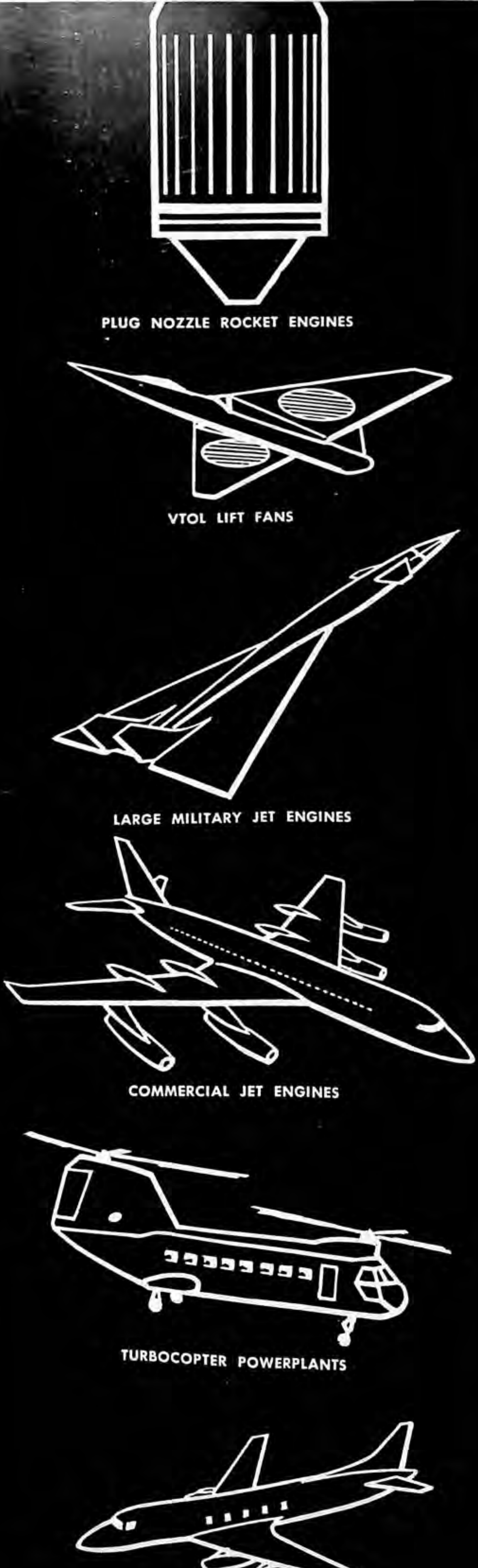
When even the gulls are swimming, the Navy's new Seasprite helicopter can be relied upon to complete its mission.

Equipped with the latest electronic gear, including automatic stabilization and automatic navigation, the Seasprite can shrug off any kind of weather.

Designed to the Navy's needs, the high powered turbine engine is up out of the way, clearing the complete body interior for usable cargo space. The compact HU2K-1 Seasprite is trim on the outside, spacious in the inside with plenty of room for cargo, personnel and black boxes. Remember, the Seasprite is an all-weather helicopter which can operate off ships of the fleet as small as a destroyer.

in national defense KAMAN is part of the plan

THE KAMAN AIRCRAFT CORPORATION • BLOOMFIELD, CONN.



Propulsion Leadership for the Aerospace Age

New advances in propulsion research and development from General Electric are providing aerospace power leadership. These developments include:

- **Rocket engines** for missiles and deep space probes, including advanced plug nozzle designs rated at 1–20 million pounds thrust.

- **Advanced propulsion systems:** ion engines, electrothermal arc-jets and plasma accelerators; nuclear rockets, nuclear turbogenerator systems and lift-fan engines for VTOL aircraft.

- **Military turbopower** spanning the spectrum of propulsion needs . . .

Large military jet engines like the J93, first Mach 3 turbojet, powerplant for the North American B-70 Valkyrie; the Mach 2 J79, powering the McDonnell F4H, North American A3J, Convair B-58, and the Lockheed F-104; plus a growing line of aft-turbofans for subsonic and supersonic transports.

At the other end of the power spectrum, G.E. has developed the J85, which powers the McDonnell GAM-72 decoy missile, Northrop T-38 trainer, Q-4B supersonic target drone; and T58 turboshaft engines powering the Kaman HU2K and HSS-2 helicopters; also T64 turboshaft/turboprop engines for heavy duty helicopters, VTOL, and fixed-wing aircraft.

- **Commercial jet engines** for a broad range of applications . . .

The CJ-805-3 turbojet for the Convair 880, and the advanced CJ-805-23 turbofan for the Convair 990 Coronado and Sud Aviation's Caravelle VII and XIV.

For turbocopters—the Vertol 107 and Sikorsky S-61 and S-62—the experienced, high-performance CT58.

CJ610 turbojet and CF700 turbofan power for executive jet aircraft.

For additional information on any of these aerospace propulsion projects, write to America's oldest and most experienced builder of jet engines:

General Electric Company
Section 206-20
1 River Road
Schenectady 5, N. Y.

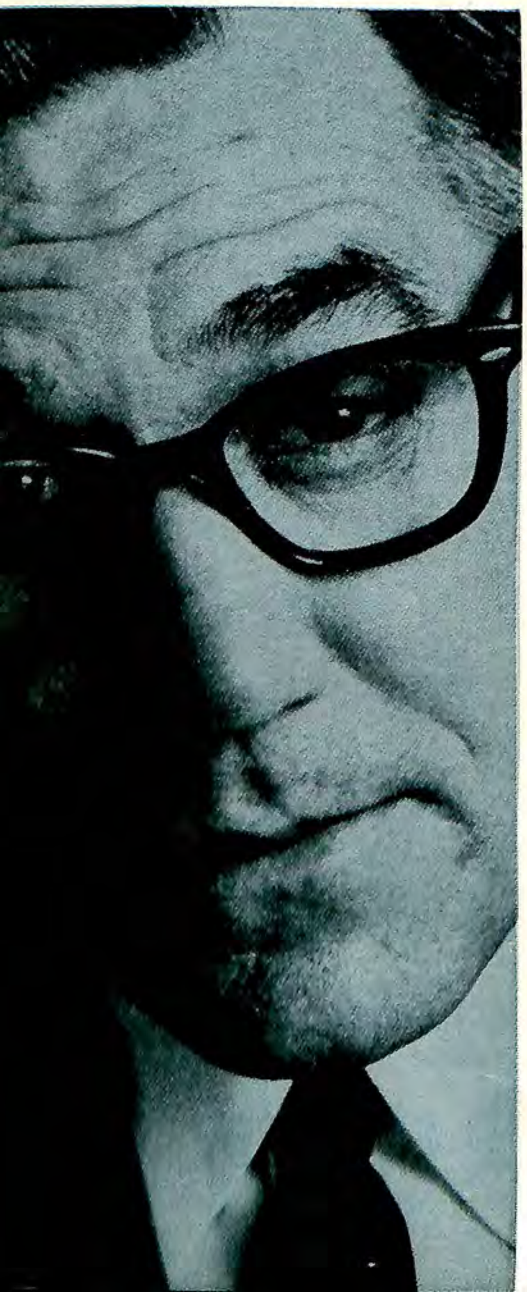
Progress Is Our Most Important Product

GENERAL ELECTRIC

THREE REASONS WHY BENDIX BRAKES ARE BETTER

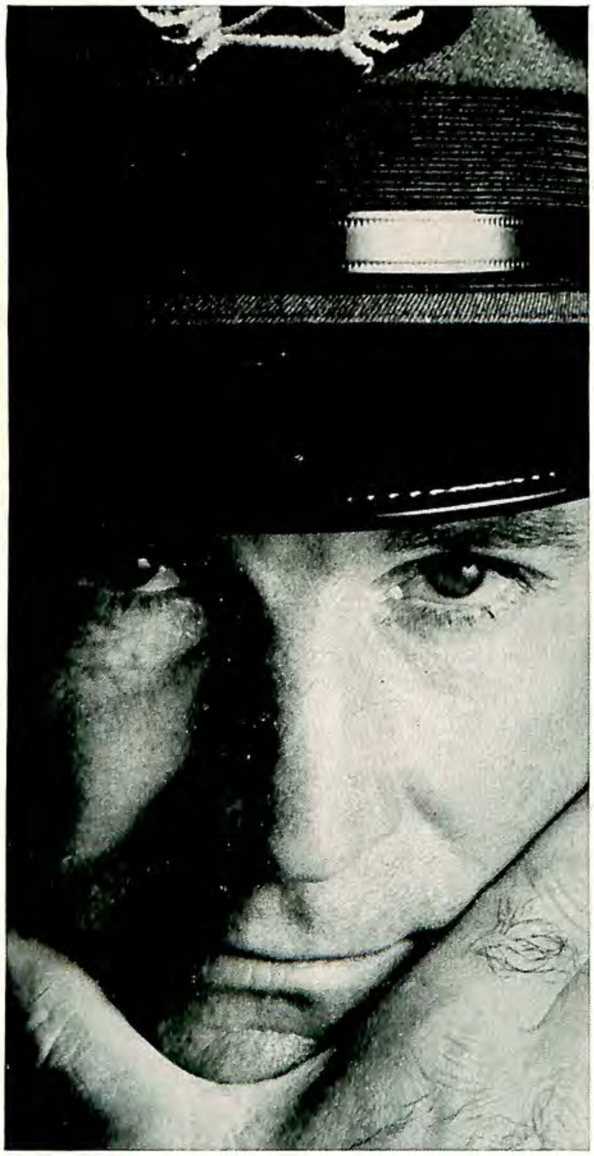
SAVE MONEY
SAYS THE CONTROLLER.

By their own careful accounting, airlines have found that Bendix® brakes combine economy with performance. Cost records kept by those airlines which are using the new jet transport aircraft equipped with Bendix brakes prove that they offer sure savings along with sure stops.



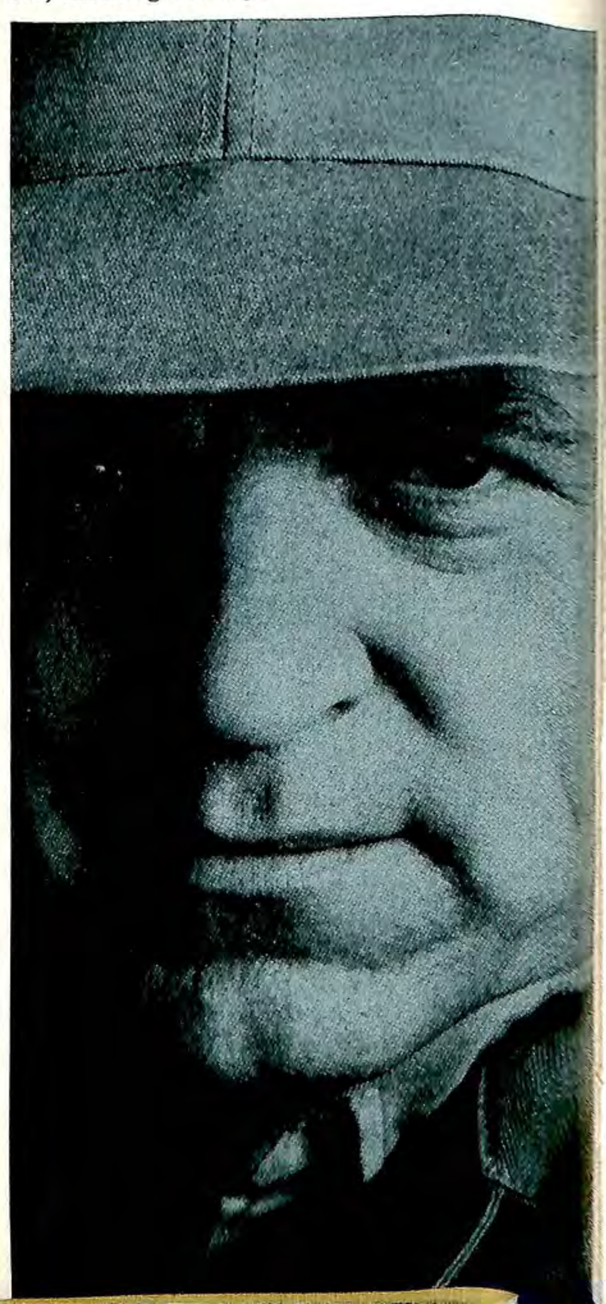
IMPROVE CONTROL
SAYS THE PILOT.

When 150 tons of aircraft touches down at jet-landing speed, Bendix experience pays off for the pilot in safe, sure braking control. This better performance is possible because of the superior materials and designs developed by Bendix—world's most experienced brake manufacturer.



REDUCE TURN-AROUND TIME
SAYS THE MAINTENANCE CHIEF.

Airlines cannot show profits on planes in the shop. That's why maintenance men prefer Bendix brakes for long, dependable service life. Every day Bendix brakes are proving more than a match for the demands of jet transport service. Dependable Bendix brakes help keep airliners in service, making money!



Bendix PRODUCTS DIVISION South Bend, IND.

THE Bendix CORPORATION

Orval R. Cook President
Aerospace Industries Association

FOREWORD

The 12-month period chronicled in this volume was one of intense activity on practically all aerospace fronts and the activity generated notable progress.

In the field of space exploration, the gains were most impressive. Although the most spectacular space accomplishment of 1960, the recovery of live animals after orbit, fell to the Soviet Union, the breadth and scope of the United States program began to pay important dividends. As opposed to this single Soviet "first", American research teams recorded the first recovery of any object from space, the first communications satellite, the first navigation satellites, the first meteorological satellites and the most distant radio transmission from space.

The U.S. space programs, military and civilian, brought forth 14 successful orbiting satellites during 1960, practically all of them of a more sophisticated nature than their predecessors. The Soviet Union orbited but two vehicles. At year-end, there were 17 satellites in earth or solar orbits; 15 of them were American. American prestige in the space exploration field reached its highest point since the start of the Space Age in 1957.

In the area of national defense, the nation's armed forces were considerably strengthened by gains in both numbers and reliability of several types of missiles, particularly in the long range category. The U.S. deterrent force was provided additional depth and mobility by the achievement of operational status of the first water-based intermediate range ballistic missile. At the same time, extraordinary successes noted in the test programs of new, second-generation missiles offered promise of an even more effective missile force in the immediate future.

Similarly, the manned aircraft portion of the integrated defense force was strengthened by the addition of new, high-performance aircraft, by the decision to expand and accelerate the program for a new multisonic strategic bomber, and by authorization for modernization of military airlift.

In commercial aviation, the airlines increased their economic potential and bolstered their international competitive

position through further transition to turbine-powered aircraft, while American transport manufacturers solidified their dominant position in production of airliners with delivery of 230 more turbine transports. The helicopter airlines saw substantial increases in traffic and looked to even greater expansion as they prepared to introduce turbine equipment in 1961.

General aviation, all flying that is neither military nor airline, passed another milestone on its continually ascending growth curve when the number of aircraft in this segment of aviation topped the 70,000 mark.

Of benefit to all segments of aviation was the work accomplished by the Federal Aviation Agency during the year, its second full year of operation. FAA made great gains in air traffic management, introduction of new navigation aids, aviation medicine, and research and development of new systems designed to make tomorrow's airways safer. The critical airspace problem was at least partially solved by reallocation of restricted airspace; the airway structure was reorganized; the first air traffic control computer went into service; and additional navigational facilities were commissioned at the rate of more than one a day.

Progress is never without problems, however, and 1960 brought little alleviation of the problems which beset both the airlines and the aerospace manufacturers. For the manufacturing industry, 1960 was a year of further adjustment to rapidly changing technology and requirements, with attendant effect on techniques, the labor force, facilities and earnings. The airlines were confronted with the myriad problems of placing new types of equipment in service and with the major task of paying for this new equipment in face of declining revenues.

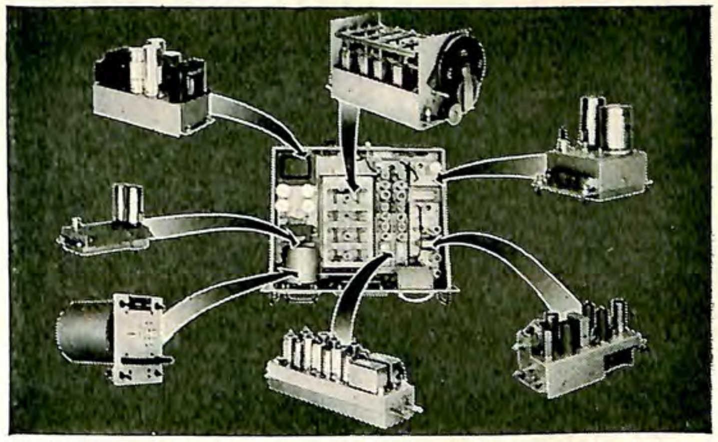
It is paradoxical that, in a year of such solid progress, these two segments of aviation should suffer from economic ill health. Public understanding of the value of these industries to the national economy and security is essential to correction of that situation. The summary of the year's aerospace activities in this 42nd annual edition of the Aerospace Year Book will help foster such understanding.

Orval R. Cook

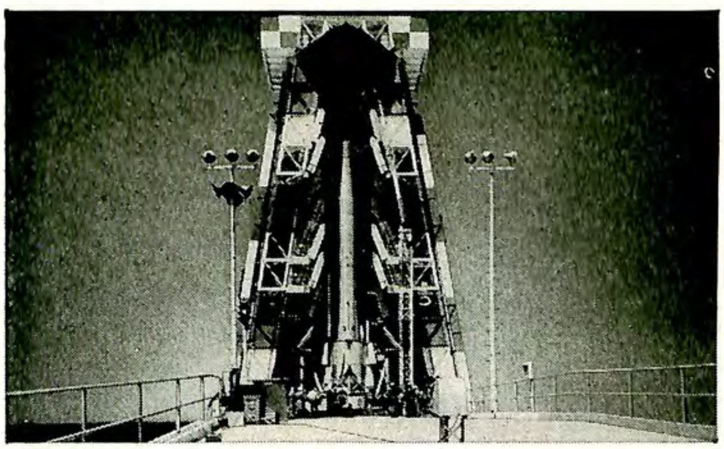
For more than a qua_ter century, Hallicrafters has worked in close partnership with our armed forces on fast solutions to critical military electronics problems. Out of this priceless experience are emerging startling new ideas and hard-hitting, fast-moving techniques to keep our country one jump ahead in electronic warfare . . .

B-52 and other military aircraft will be protected by the most potent Electronic Countermeasures equipments yet devised. These equipments were developed in close teamwork with the Air Force under Hallicrafters' QRC (Quick Reaction Capability) program. Now qualified to meet full environmental specifications, they are in quantity production.

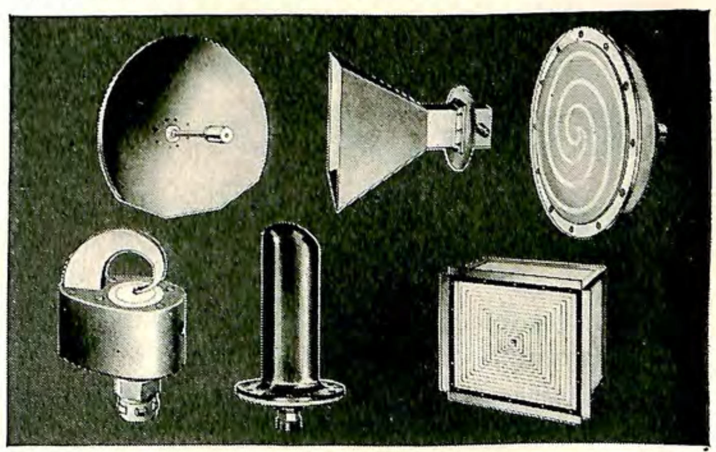
New levels of speed and efficiency are being reached in equipment modernization, retrofit and technical support programs with Hallicrafters' radical new "Blue Streak" project. Specially-trained Maintenance and Technical Support Teams, close-knit and flexible, can be tactically deployed to accomplish maintenance, installation and testing of electronics weapons systems anywhere in the world.



Hallicrafters communications leadership is exemplified by new high frequency Single Sideband receiver, (model no. SX-116). 100% modular design permits simple modification for compatability with existing and future communications systems. Stability, with proper available plug-ins, is better than one part in 10,000,000 per month. Hallicrafters also offers an existing capability in receiving and transmitting techniques up to frequencies of 50,000 megacycles.



Hallicrafters participation in the Atlas missile project helped to develop capability for many areas of the complex missile field, including code translator data systems; ground support equipment; ECM testing and antenna systems. Current explorations involve latest Infra Red techniques.



Airborne antennas and micro-wave components with power capability in excess of 1,000 watts, can be made available to solve tomorrow's very high power handling requirements. Testing of microwave components is possible with special high power generators, designed and built by Hallicrafters.

Looking for a challenging new opportunity? We are interested in qualified engineers at all levels. For full details in confidence, contact William F. Frankart, Director of Engineering.

For further information on Hallicrafters facilities and experience in military electronics research, development and production, please write to:

hallicrafters h company

Military Electronics Division,
Chicago 24, Illinois

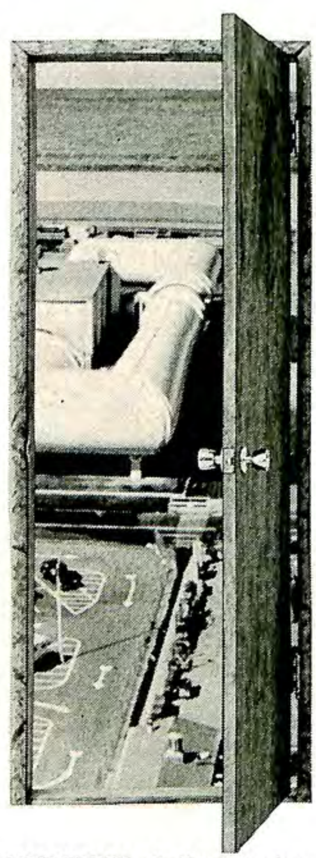
POLARIS: Northrop's Datico checks out Polaris at all levels of maintenance and operation.

SKYBOLT: Guidance and navigation systems are being developed by Northrop for this new and highly secret air-launched ballistic missile.

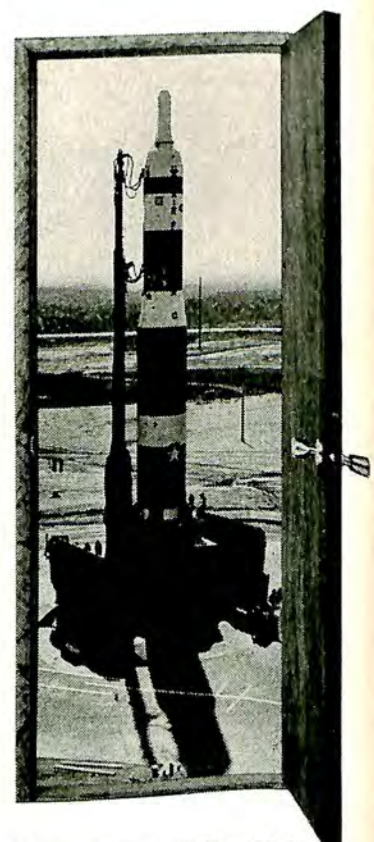
MERCURY: The Northrop landing system is designed to bring the Mercury astronaut down safely.

Northrop is now active in more

X-15: Northrop produces Q-Ball, the flight angle sensor for safe re-entry of X-15 and other aerospace vehicles.



AERODYNAMICS: Northrop's Laminar Flow Control technique is designed to greatly increase aircraft range, flexibility, cargo and passenger capacity.



TITAN: Northrop supplies complete technical and industrial management to activate the T-2 Titan missile base.

Northrop Corporation, Beverly Hills, California • Divisions: Norair, Nortronics, Radioplane, Northrop International

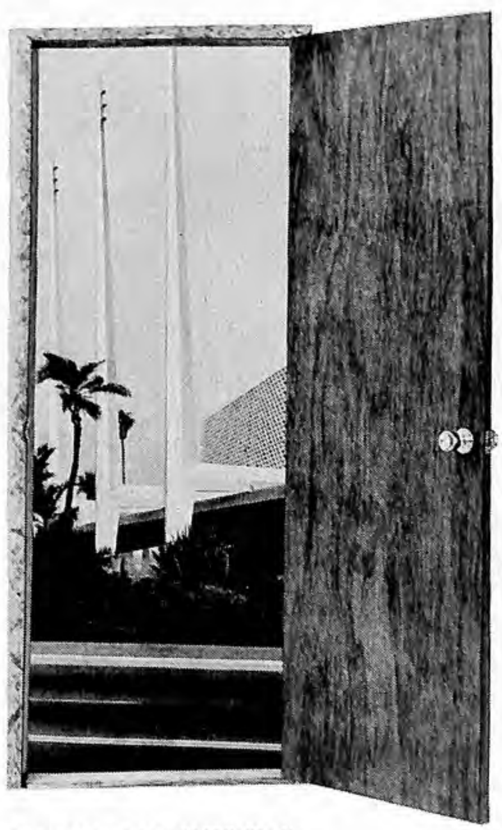
HAWK: Northrop produces airframe components, ground handling and launching equipment for this air defense missile.

COMMUNICATIONS: Northrop designs the trans-Pacific Scatter Communications Network and other world-wide communication systems for U.S. and free world governments.

T-38: World's first supersonic twin-jet trainer is built by Northrop for the United States Air Force.

than 70 important programs

TARGET MISSILES: Northrop has produced more than 50,000 electronically-controlled aerial targets, and surveillance drones.



COMMERCIAL METAL PRODUCTS: Northrop produces aluminum architectural shapes for many important industrial and commercial buildings.

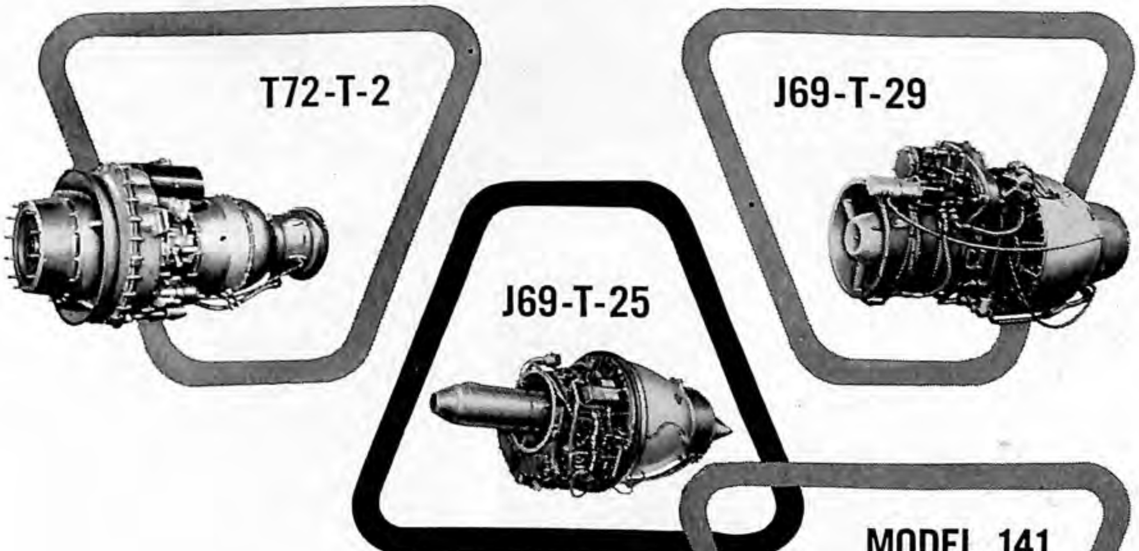
SPACE RESEARCH: Northrop's accelerated space research programs reach into such advanced areas as maneuverability, rendezvous, space vehicle maintenance, space probes, and the survival of men in space.

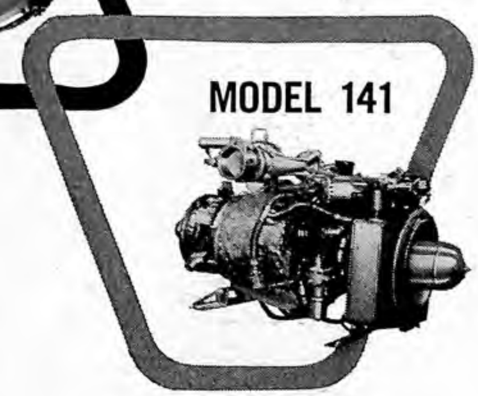
Subsidiaries: Page Communications Engineers, Inc., Acme Metal Molding Company.


FF-075 U.S. AIR FORCE
The three fastest—all from Convair
For the first time in aviation history, *one* firm is building at *one* time, the world's fastest planes of all *three* types—transport, bomber and interceptor:
THE WORLD'S FASTEST TRANSPORT The 615 mph (level cruise) 880
THE WORLD'S FASTEST BOMBER The Mach 2-plus USAF B-58
THE WORLD'S FASTEST INTERCEPTOR The 1525 mph USAF F-106
CONVAIR
DIVISION OF GENERAL DYNAMICS

BEHIND THIS LOW-COST TURBINE POWER

—A Million-Hour Record of Service





Simplicity, operating economy, and low cost have teamed up with a brilliant performance record to make Continental turbine engines an important item in the inventory of American powerplants. The J69 alone has logged more than a million operating hours to date. Advanced models growing out of the J69 program now await industry application. They include aircraft turbojets of 1,400 and 2,400 lbs. thrust, "aft-fan" turbofan engines of 2,600 and 4,000 lbs. thrust, a target-missile turbojet of 2,550 lbs. thrust, altitude thrust augmentation devices for existing turbojets, and the J69-T-35 air pump for boundary layer control. Rounding out Continental's capability in the field of aircraft propulsion is a completely new series of turboshaft and turboprop engines, including the 500-hp, 6,000-rpm 217-5A (U. S. Navy designation T72-T-2) turboshaft, which promises to find use in a wide variety of applications.

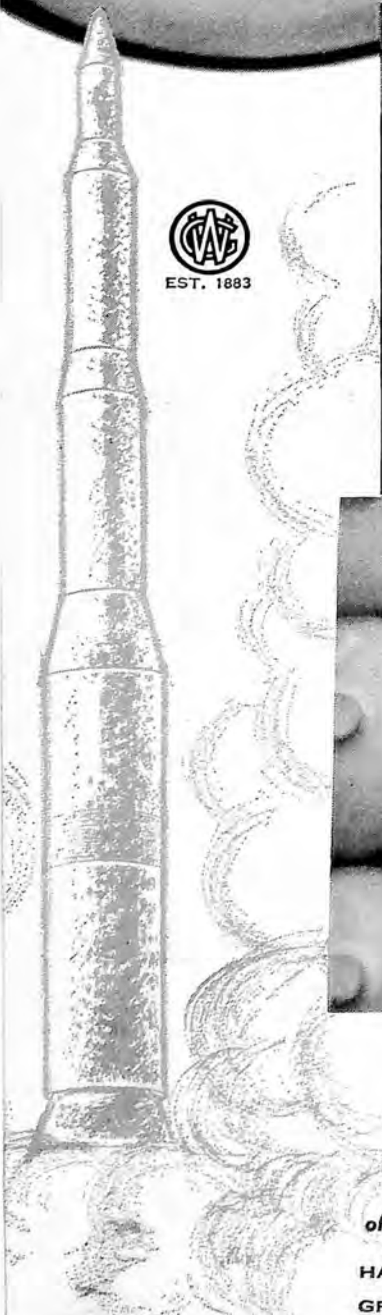
NAVAL 50th ANNIVERSARY 1911 1961 AVIATION

® CONTINENTAL AVIATION

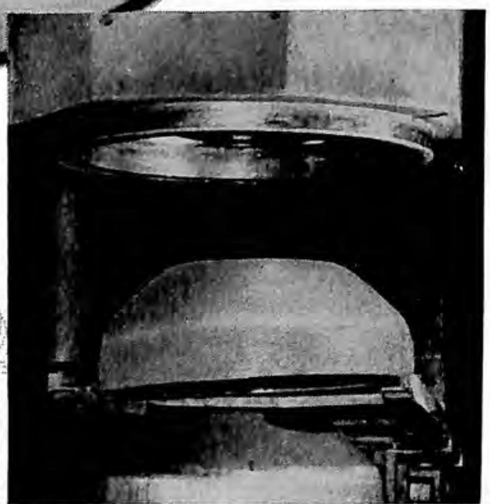
CONTINENTAL AVIATION AND ENGINEERING CORPORATION
12700 KERCHEVAL AVENUE, DETROIT 15, MICHIGAN
SUBSIDIARY OF CONTINENTAL MOTORS CORPORATION
WESTERN SALES OFFICE: 18747 SHERMAN WAY, RESEDA, CALIFORNIA

DOME and CLOSURE FORGINGS

speed solid-propellant missile capabilities



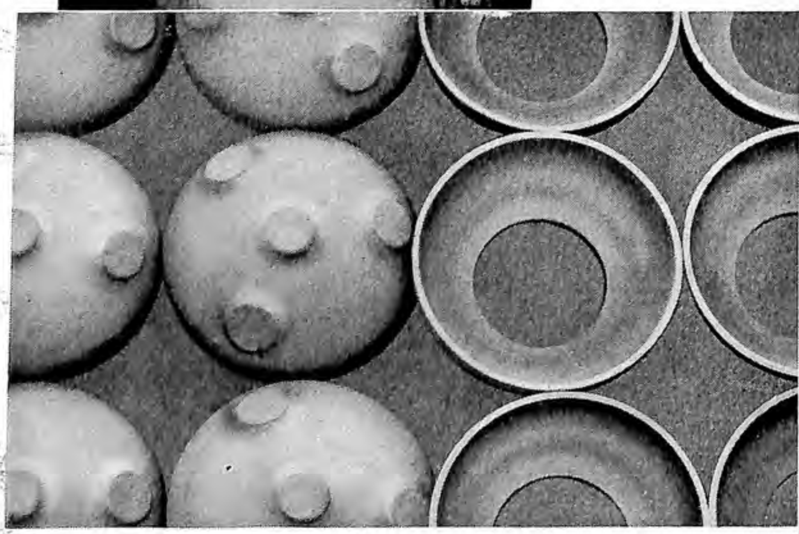
EST. 1883

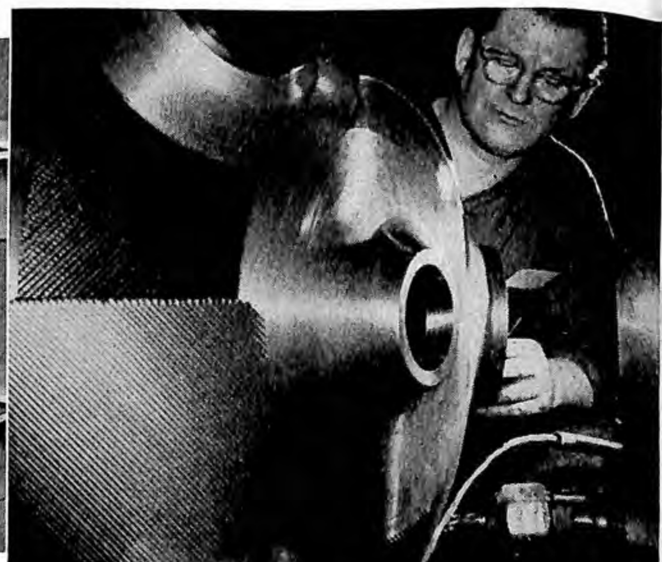


FORGED

OUT OF HIGH-STRENGTH STEELS AND TITANIUM ALLOYS

Dome and closure components, forged and machined by Wyman-Gordon in both low-alloy, high-strength steels and all-beta Titanium—have contributed measurably to our present status in solid-fuel missile development. Research is continuing for the purpose of adapting new materials to these applications. Wyman-Gordon engineer-metallurgists are available to counsel on all phases of forging such critical-service parts. Their assistance can help extend ultimate-strength limits of your space designs.





WYMAN - GORDON

FORGINGS

of Aluminum Magnesium Steel Titanium . . . and Beryllium Molybdenum Columbium and other uncommon materials

HARVEY ILLINOIS — WORCESTER MASSACHUSETTS — DETROIT MICHIGAN

GRAFTON MASSACHUSETTS — LOS ANGELES CALIFORNIA — PALO ALTO CALIFORNIA — FORT WORTH TEXAS


"PEACE MEAL"
This is a Republic F-105 Thunderchief being fed a small part of its daily ration by men of the United States Air Force. "World's most powerful one-man aircraft," the all-weather F-105 Thunderchief is the Tactical Air Command's ready answer to those who would threaten us or our allies.
Responsibility for this country's power to retaliate against aggression rests squarely on the Air Force's combat commands and their allied forces at home and abroad. Their vital job is to discourage enemy aggression in any part of the globe, or in case of attack, to destroy his forces and capability to wage war.
"Home" to the Air Force is aerospace, the operational field for which it is ideally suited by instinct, training and purpose. "On the deck" or limitless miles above the earth, aerospace must be kept as free as the soil man tills.
Air Force pilots flying the all-weather Republic F-105 Thunderchief, are a prime force for keeping the free man's world forever free.
REPUBLIC AVIATION
FARMINGDALE, LONG ISLAND, N. Y.
Designers and Builders of the Incomparable THUNDER-CRAFT

AEROSPACE EVENTS

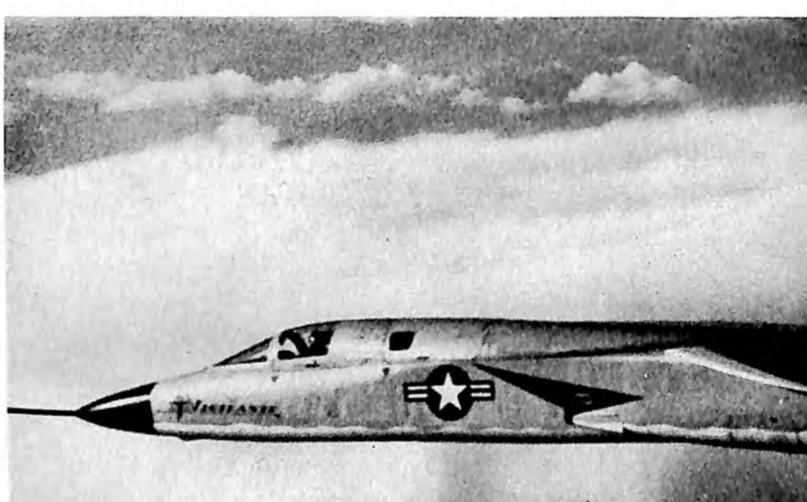
RECORDS

X-15 MARKS

The North American X-15 research plane set two unofficial marks during the year. On August 4, NASA pilot Joe Walker (right) made the fastest flight in history, 2,196 miles per hour. On August 12, Air Force Major Robert M. White (left) flew to a new altitude mark of 136,500 feet. The records bettered rocket-plane marks set in 1956 by Capts. Mel Apt and Iven Kincheloe in the Bell X-2.

F4H WORLD SPEED RECORD

Flying a McDonnell F4H-1 Phantom II, powered by two General Electric J79 engines, Commander John F. Davis, USN, set a new world record of 1,390.24 miles per hour over a 100-kilometer closed circuit course on September 25. Earlier in the month, another F4H-1, piloted by Lt. Col. T. H. Miller, USMC flew at 1,216.76 miles per hour over a 500-kilometer closed course for another record.

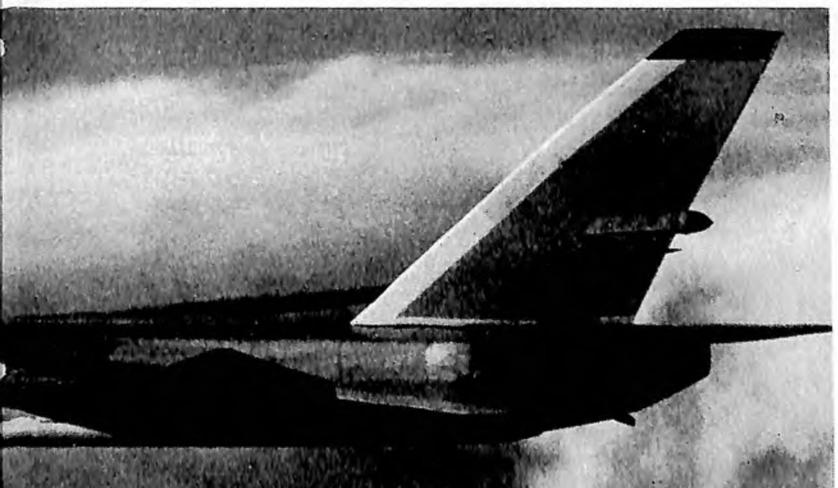


A3J-1 ALTITUDE

On December 13, Navy Commander Leroy A. Heath set a record for altitude with a payload of 1,000 kilo-

B-52G CLOSED CIRCUIT DISTANCE RECORD

Lt. Col. T. R. Grissom, USAF, and a crew of seven, flew a Boeing B-52G to a non-refueled closed circuit distance record of 10,060 miles on December 13. The B-52G, powered by eight Pratt & Whitney J57 engines, was aloft for 19 hours and 44 **minutes.**



PAYLOAD RECORD

grams. He flew to 91,450.8 feet in a North American A3J-1 powered by two General Electric J79 engines.

HELICOPTER RECORDS

An Army Bell HU-1 Iroquois turbine-powered helicopter recaptured three Soviet-held world records and four other international marks. The records, made during the period July 19-26, included: Time to climb to 3,000 meters, 3 minutes, 22.4 seconds; time to climb to 6,000 meters, eight minutes, 10.2 seconds; non-stop distance over closed course, 441.74 miles; three-kilometer speed run, 158.05 miles per hour; 500-kilometer speed, 148.45 miles per hour; 100-kilometer speed, 142.2 miles per hour. The 500-kilometer speed run broke two records, one for all helicopters and a second for helicopters grossing between 3,860 and 6,615 pounds. Power plant in the HU-1 was the Lycoming T53 engine.

COMANCHE CLASS RECORD

Max Conrad, champion lightplane pilot, chalked up another record on July 4. He flew a Piper Comanche PA-24-180, powered by a single Lycoming 0-360 piston engine, to a light aircraft class record for distance in a closed circuit of 6,921.28 miles. Conrad was aloft 60 hours.

LIGHT AIRCRAFT ALTITUDE

Miss Jerrie Cobb, noted aviatrix, scored a lightplane class record of 36,932 feet for altitude without payload. The record was set on September 20 in an Aero Commander powered by two Lycoming engines. It broke the record set earlier in the year by James D. Webber (34,862 feet) in a Lycoming-powered Beech Queen Air.

AWARDS

Although space does not permit inclusion of all who were honored for the achievements in 1960, some of the major award winners are pictured on these pages.

COLLIER TROPHY

The Collier Trophy was presented by President Eisenhower to the team responsible for development, testing, production and operational introduction of the Atlas ICBM: the Air Force, Convair, a Division of General Dynamics Corporation, and Space Technology Laboratories. Shown after the White House presentation are, l. to r., Dr. Louis G. Dunn, president of STL; Frank Pace, Jr., board chairman of General Dynamics; the President; Gen. Curtis E. LeMay, who accepted for the Air Force; and Adm. Arleigh Burke, Chief of Naval Operations.

AMERICAN HELICOPTER SOCIETY AWARDS

Above Left: The Alexander Klemin Award, highest honor bestowed by the AHS, was presented to V. Keith Putnam, Army Transportation Corps, for "achievements in advancing flight test procedures and techniques used in helicopters and other VTOL aircraft." Charles H. Kaman, president of The Kaman Aircraft Corporation and AHS Awards Chairman, makes the presentation.

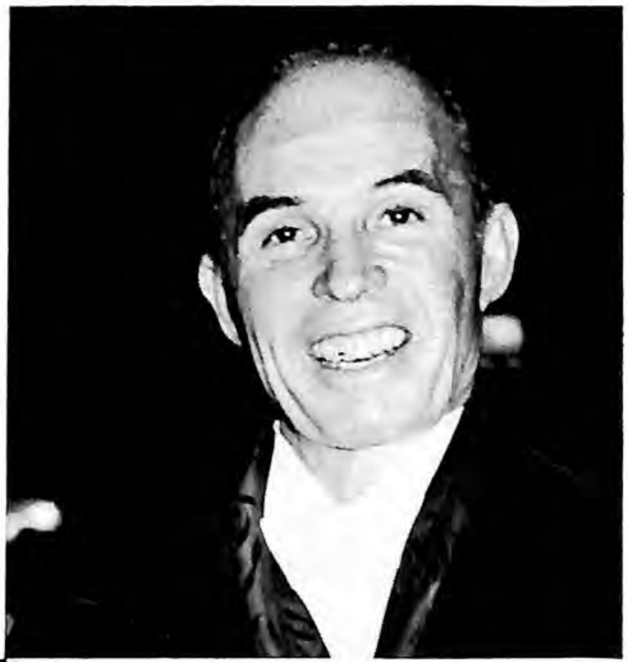
Above Right: The AHS Kossler Award was presented to President Eisenhower's helicopter pilots, Lt. Col. William A. Howell, USA, (center) and Lt. Col. Victor A. Armstrong, USMC, (right), while the Chief Executive beamed approval. Award was given for "consistent demonstration of helicopter convenience and safety."

Below Left: Harvey Gaylord, president of Bell Aerospace Corporation, presents the Grover E. Bell Award to Igor Sikorsky of Sikorsky Aircraft for "outstanding pioneering in the development of the crane helicopter."

Below Right: The Frederick L. Feinberg Award went to Air Force pilots Maj. William C. Davis and Capt. Walter J. Hodgson in recognition of their class E1D helicopter world altitude record.

DANIEL GUGGENHEIM AWARD

For his pioneering work in aeronautical engineering Grover Loening was presented the Daniel Guggenheim Award for 1960.



WRIGHT BROTHERS MEMORIAL TROPHY

Frederick C. Crawford, aviation industrialist, was named recipient of the Wright Brothers Memorial Trophy for "significant public service of enduring value to aviation in the United States."

OCTAVE CHANUTE AWARD

At the summer meeting of the Institute of the Aerospace Sciences, the 1960 Octave Chanute Award was presented to Joseph J. Tymczyszyn, senior engineering test pilot and flight test engineer for the Federal Aviation Agency. Award was made for "a notable contribution made by a pilot to the aeronautical sciences."

FRANK M. HAWKS AWARD

The 20th annual Frank M. Hawks Award for outstanding contributions to the advancement of aviation went to Wayne W. Parrish, president and publisher of American Aviation Publications. The award was made by Air Service Post #501 of the American Legion. Above, Parrish receives the award from Vice Adm. Charles E. Rosendahl (USN, Ret.), executive director of the National Air Transport Coordinating Committee while Harry Bruno, H. A. Bruno & Associates, looks on.

JORDAN

BOSSART

HARMON AWARDS

Two Air Force officers received the 1960 Harmon International Aviation Awards. The Aviator Trophy went to Capt. Joe B. Jordon, who flew a Lockheed F-104 to a new altitude record of 103,395 feet. Capt. Joseph W. Kittinger, who parachuted from 76,400 feet, was presented the Aeronaut Trophy.

GODDARD TROPHY

Karel J. Bossart of Convair was the recipient of the Robert H. Goddard Memorial Trophy, presented at the annual Goddard Memorial Dinner in Washington. Bossart received the award for his contributions to the development of Atlas, the nation's first operational intercontinental ballistic missile.

HUGHES ARMY AVIATION TROPHY

A new trophy for outstanding unit achievement, the Hughes Army Aviation Trophy went to the 1st Reconnaisance Squadron, 16th Cavalry. In photo, Lt. Col. Robert F. Tugman (right), commander of the unit, accepts trophy from Lt. Gen. John C. Oakes, Deputy Chief of Staff for Operations, USA, and Hughes representative Al Bayer.

SCHRIEVER

H. H. ARNOLD TROPHY

The H. H. Arnold Trophy, presented by the Air Research and Development Command, went to Lt. Gen. Bernard A. Schriever, commander of the USAF's Air Research and Development Command. Gen. Schriever was cited for "countless contributions to world peace as a leading architect of the nation's missile power."

HOYT S. VANDENBERG AWARD

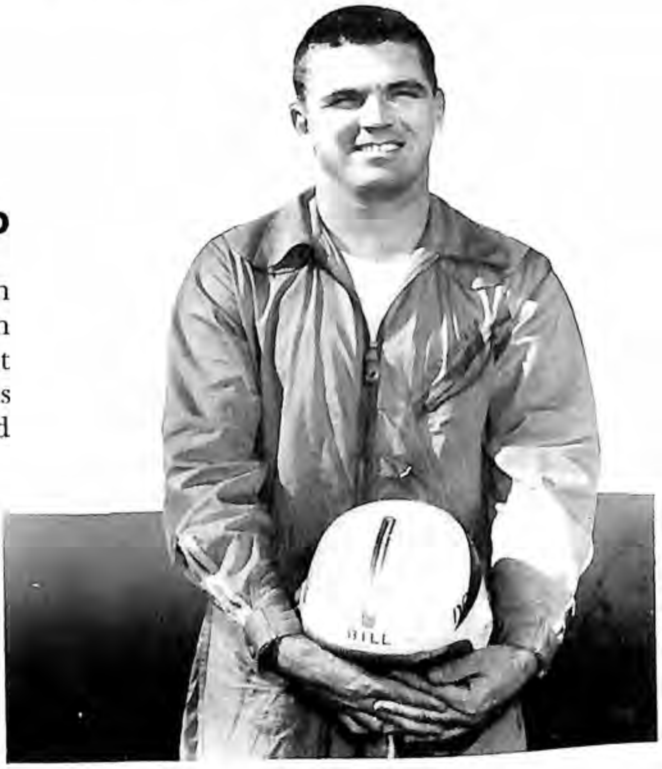
North American Aviation received the Arnold Air Society's Hoyt S. Vandenberg Award for "significant contributions to air research." Here Alex T. Burton, NAA vice president, acccepts the trophy from Gen. Samuel E. Anderson, USAF, commander of Air Materiel Command.

IAS AWARDS

At the annual Honors Night Dinner of the Institute of the Aerospace Sciences in January, the institute presented its awards for achievement in the preceding year. They included: the Hill Space Award, to Dr. James A. Van Allen of NASA for discovery of radiation belts in space; the John Jeffries Award for medical research, to Brig. Gen. Don D. Flickinger, USAF; the Robert M. Losey Award for meteorological research, to Dr. Herbert Riehl, University of Chicago; The Sylvanus Albert Reed Award, to Karel J. Bossart of Convair for his part in developing the Atlas ICBM; the Laurence Sperry Award, to Dr. James E. McCune, Aeronautical Research Associates of Princeton.

IVEN C. KINCHELOE AWARD

The Society of Experimental Test Pilots annual Iven C. Kincheloe Award was presented jointly to William Magruder of Douglas Aircraft Company and Scott Crossfield of North American Aviation. Crossfield was first pilot of the X-15 research plane; Magruder headed the test crew on the first flight of the Douglas DC-8.



GENERAL ELECTRIC TROPHY

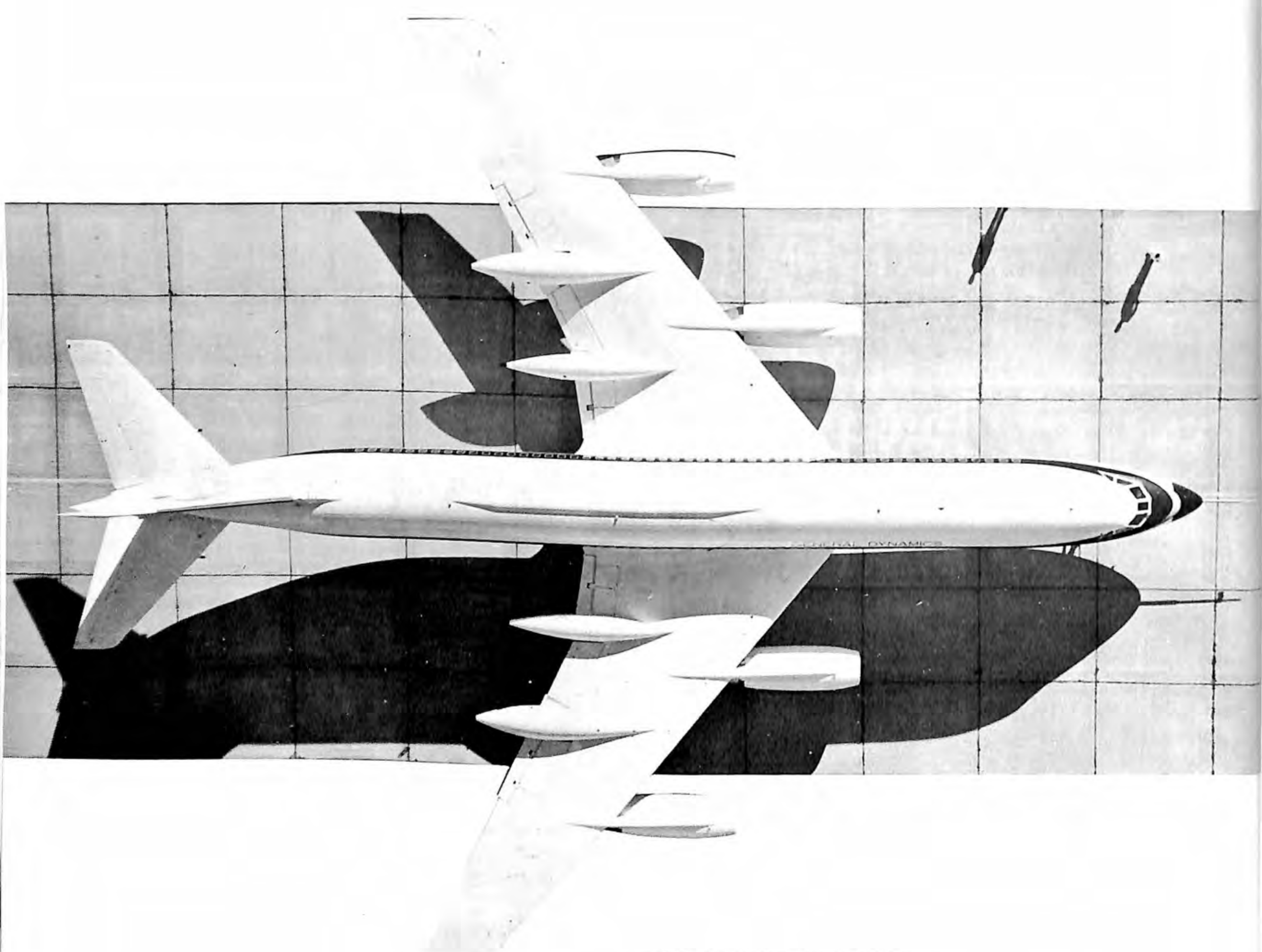
The two pilots who set new closed course records during 1960 (see Records) brought the General Electric Trophy to the Navy. The trophy was presented to Vice Admiral W. F. Raborn, representing the Navy, by GE's manager of marketing, J. D. Wethe. Both records were set in McDonnell F4H-2 aircraft, powered by GE J79 engines. Pictured above are, l. to r., Lt. Col. Thomas H. Miller, USMC, who set the 500-kilometer closed course record; Adm. Raborn; Wethe; Cdr. Frank Davis, USN, 100-kilometer record holder; and D. D. Clark of McDonnell Aircraft Corporation.

DOUGLAS DC-8 INTERCONTINENTAL

Douglas Aircraft Company introduced the Intercontinental version of its DC-8 turbojet transport, which cruises at 585 miles per hour and has a range of 5,000 miles. Identical in size to the basic DC-8, it weighs 310,000 pounds and has greater fuel capacity and heavier construction. Douglas also introduced the Series 40 DC-8, powered by Rolls Royce Conway engines, which cruises at 593 miles per hour.

CONVAIR 880

The Convair 880 went into commercial service on Delta Air Lines routes. The 880, powered by General Electric J79 engines, has a top speed of 615 miles per hour.



CONVAIR 990

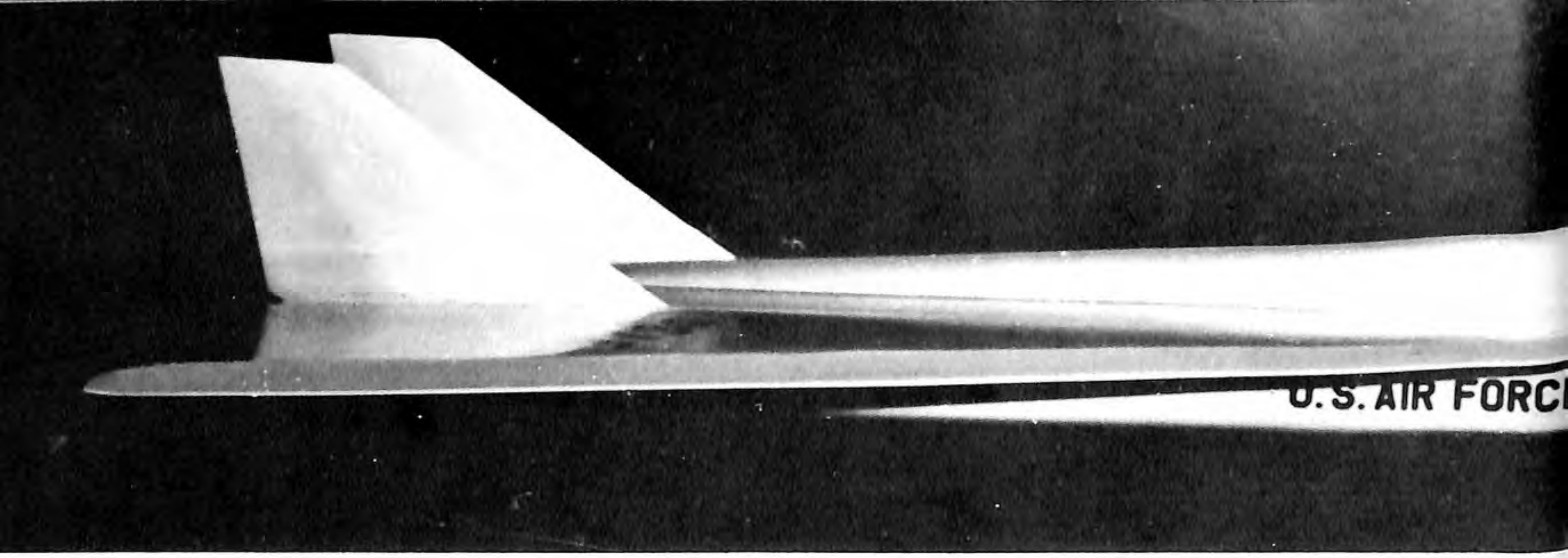
Convair Division of General Dynamics Corporation rolled out its new 990 in November. The 990, powered by advanced GE CJ-805 engines, will fly at 640 miles per hour. Swissair, Scandinavian Airlines System, Real Aerovias of Brazil and American Airlines placed orders for the new jet, scheduled to fly early in 1961.

BOEING 720B

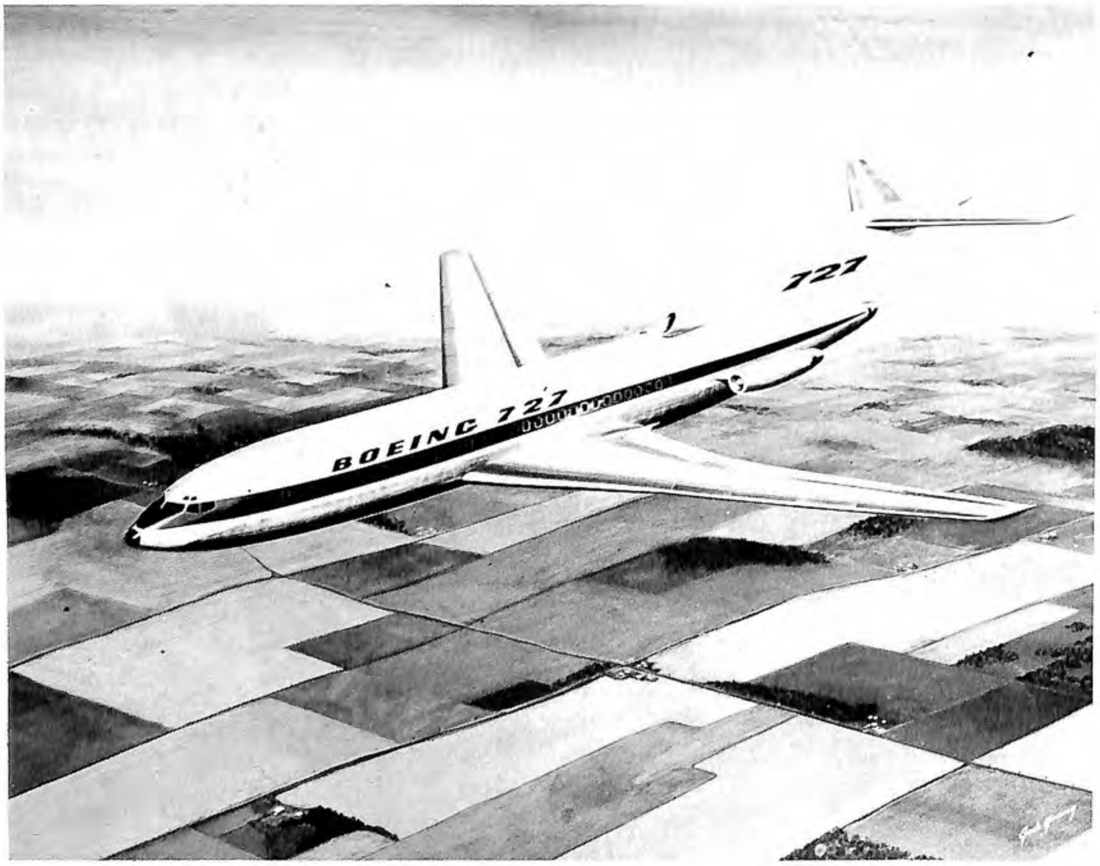
On October 6, Boeing Airplane Company made the first test flight of the new 720B, a turbofan version of the 707 powered by 17,000 pound thrust Pratt & Whitney J3D engines. Also tested during the year was the 707-120B, a conversion from the basic 707 to the turbofan configuration. Five airlines—American, Deutsche Lufthansa, Avianca of Columbia, Western and Ethiopian Airlines—had 720B's on order. In addition, American was converting its entire fleet to the 707-120B model, as was Qantas Empire Airways.

LOCKHEED JETSTAR

First production model of the four-engine Lockheed Jetstar executive transport took to the air in July. Power plants are Pratt & Whitney JT-12 turbojets. The 550-600 mile per hour Jetstar will also see military service in the U.S. and Canada (USAF designation, C-140).

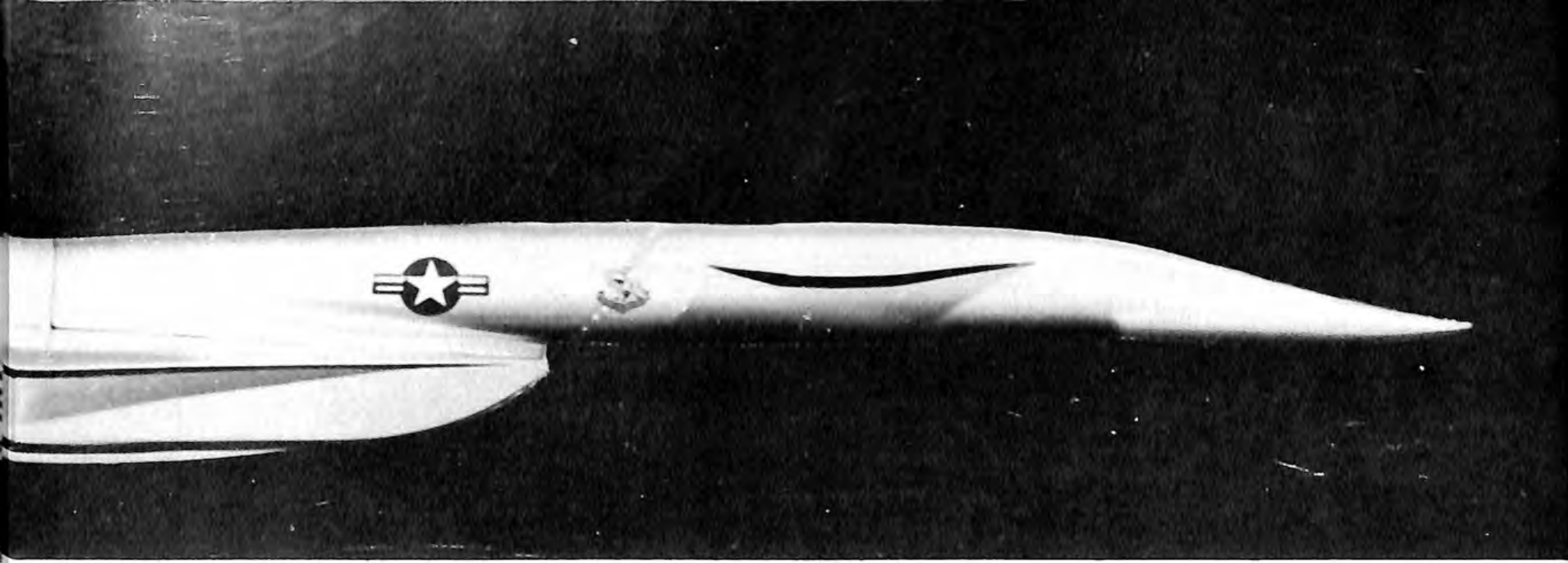


NORTH AMERICAN B-70



BOEING 727

Boeing Airplane Company was developing the smallest of the American jetliner family, the short-range 727, ordered by Eastern and United Air Lines. The 727 carries from 70 to 114 passengers over distances up to 1,700 miles.



The Air Force's program for the North American B-70 Valkyrie strategic bomber was expanded and accelerated during 1960. Powered by six General Electric J93 engines, the B-70 will be trisonic and it will operate at altitudes up to 70,000 feet.

BOEING B-52H

First of the Boeing B-52H's rolled off the assembly line late in 1960. The "H" is a missile platform bomber, equipped to carry the Douglas Sky Bolt air launched ballistic missile. A mobile missile base with an unrefueled range of more than 9,000 miles, the B-52H is powered by Pratt & Whitney turbofan engines.

BELL D-188A

Developed under joint USAF/Navy contract, the Bell D-188A is a Mach 2-plus V/STOL fighter bomber with a subsonic radius of 1,000 miles and a combat ceiling of 67,500 feet. It is powered by eight General Electric J85 engines.

SIKORSKY SKYCRANE

The Sikorsky S-60 Skycrane air lifts a Sikorsky S-58 helicopter. The four-ton S-58's were hauled five miles from Stratford to Bridgeport, Connecticut, during a 1960 shift of overhaul facilities.

SIKORSKY S-61L

Unveiled in December, the Sikorsky S-61L is a twin-turbine rotary wing airliner with a 25-28 passenger capacity. At year-end, it was undergoing certification tests prior to its 1961 entry into scheduled commercial service. Los Angeles Airways and Chicago Helicopter Airways have ordered S-61L's.

BEECH BARON

First flight of a production model Beechcraft Model 55 Baron was made in September. Powered by two Continental 10-470 engines of 260 horsepower each, it is a five-place member of the Beech 1961 line.

CESSNA SKYWAGON

Typical of the 1961 Cessna line is the Model 185 Skywagon.

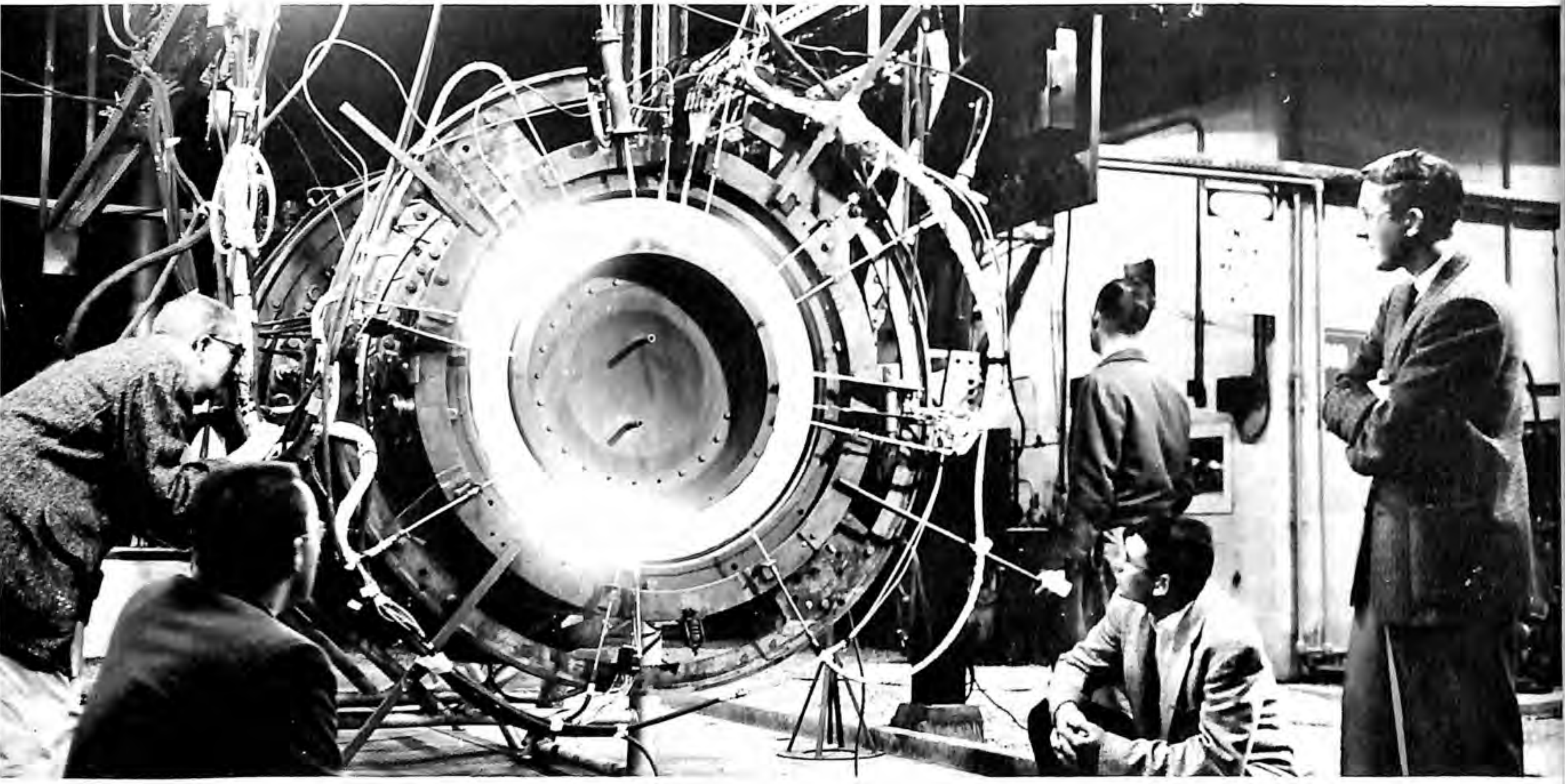
VERTOL 107

The tandem-rotor Vertol 107 transport helicopter was undergoing certification tests prior to service introduction in scheduled helicopter airline use in 1961.

BELL 204B

A 10-place turbine-powered helicopter, the Bell 204B is a commercial version of the Army's record-setting HU-1 Iroquois. Power plant is Lycoming's T53 engine.

NEW ENGINES

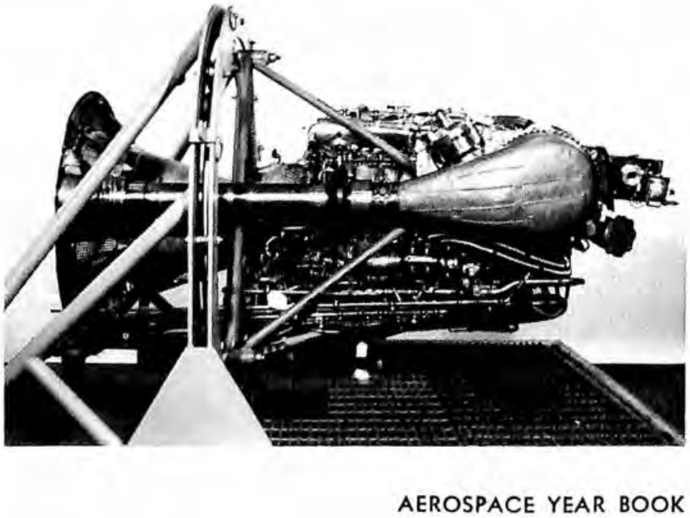


GE J93

Technicians of General Electric Company's Large Jet Engine Department test the combustor of GE's powerful J93 turbojet. Six of the big J93's will power the Air Force's B-70 Mach 3 bomber.

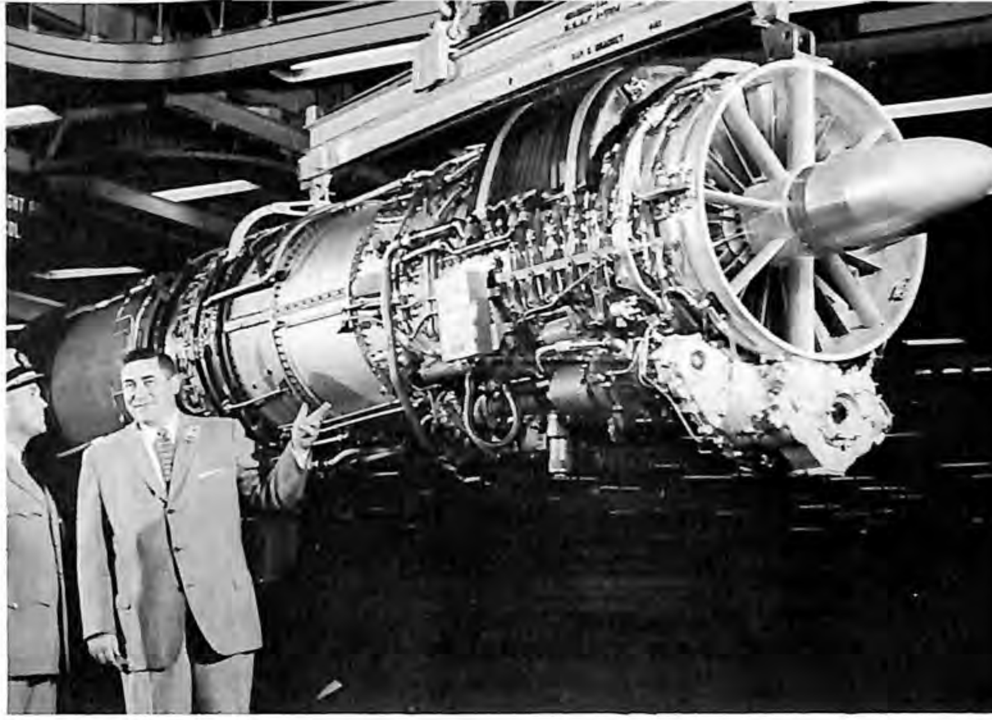
REACTION MOTORS XLR-99

During the year, the North American X-15 made its first flights with the XLR-99 rocket engine, developed by Reaction Motors Division of Thiokol Chemical Corporation. The XLR-99, capable of powering the X-15 to speeds of Mach 6-plus and altitudes of about 50 miles, develops more than 50,000 pounds thrust. Propellants include liquid oxygen (oxidizer) and liquid ammonia (fuel).



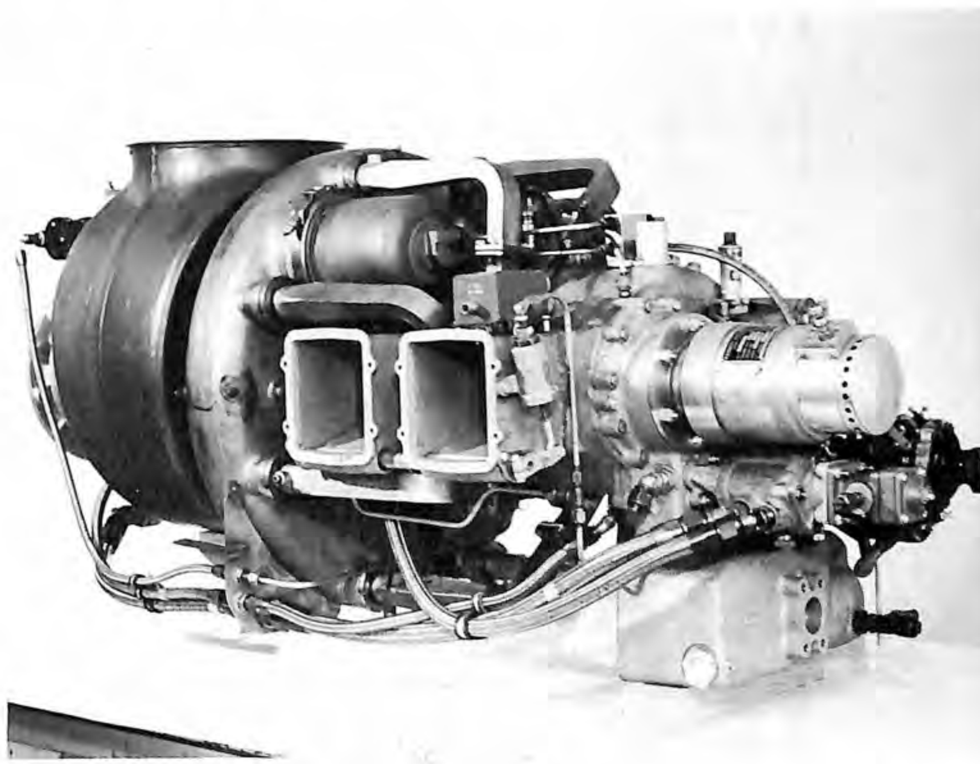
GE J79-8

The Navy accepted the first production model of General Electric's J79-8 turbojet. The "Dash 8" is the power plant for such planes as the Navy record holders F4H Phantom II and North American A3J attack bomber.



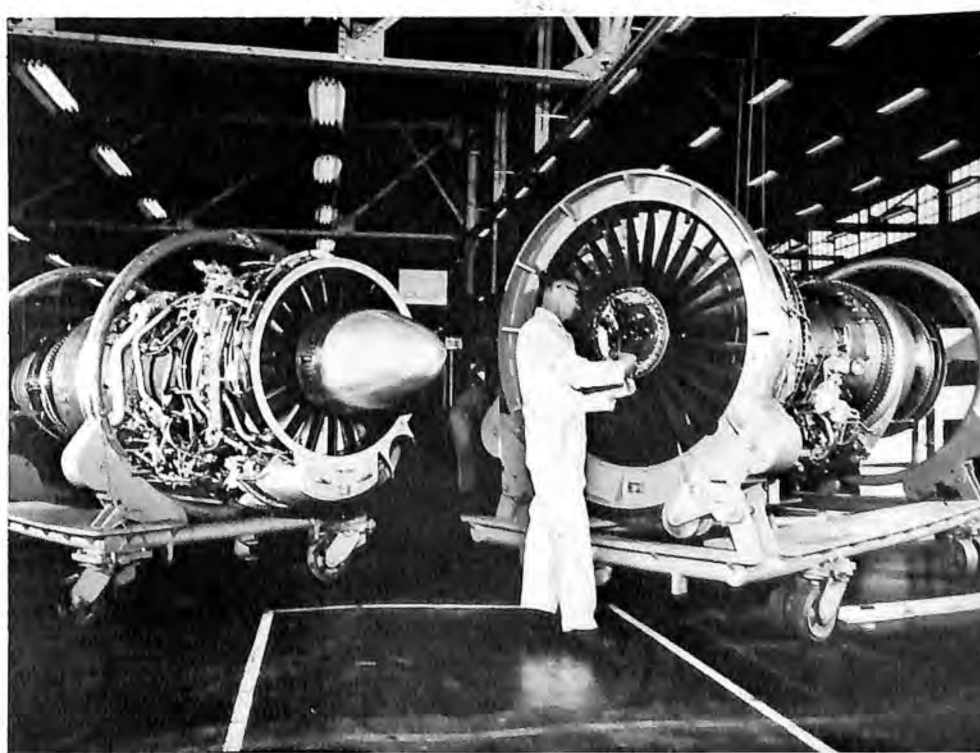
BOEING 520

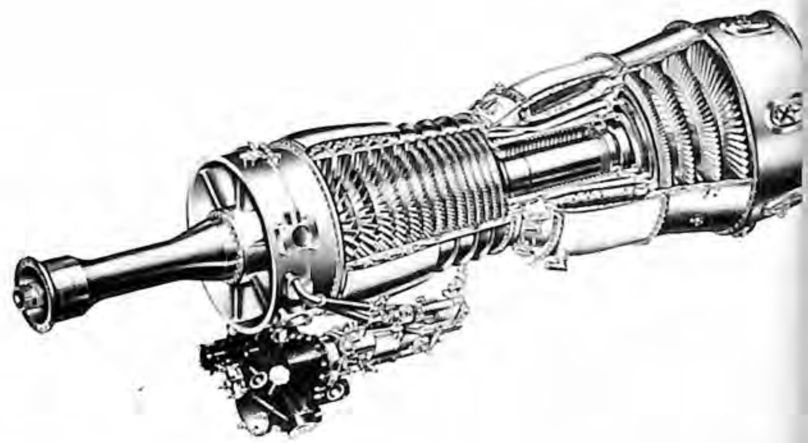
In test status was Boeing Airplane Company's Model 520, a simple cycle two-shaft engine. Power ratings range from 375 to 475 shaft horsepower, with advanced versions in development capable of 550 shaft horsepower. The engine was expected to be commercially available for helicopters and light aircraft in 1961.



PRATT & WHITNEY TURBOFAN

This comparison photo shows external and size differences between Pratt & Whitney's J57-P-43W turbojet and the TF-33-3 turbofan engine (right). The turbofan, power plant for the Boeing B-52H missile platform bomber, provides approximately 50 per cent more take-off thrust, 25 per cent more climb power and 20 per cent greater cruise power. The turbofan is also the powerplant for Boeing's 707 and 720B jetliners.



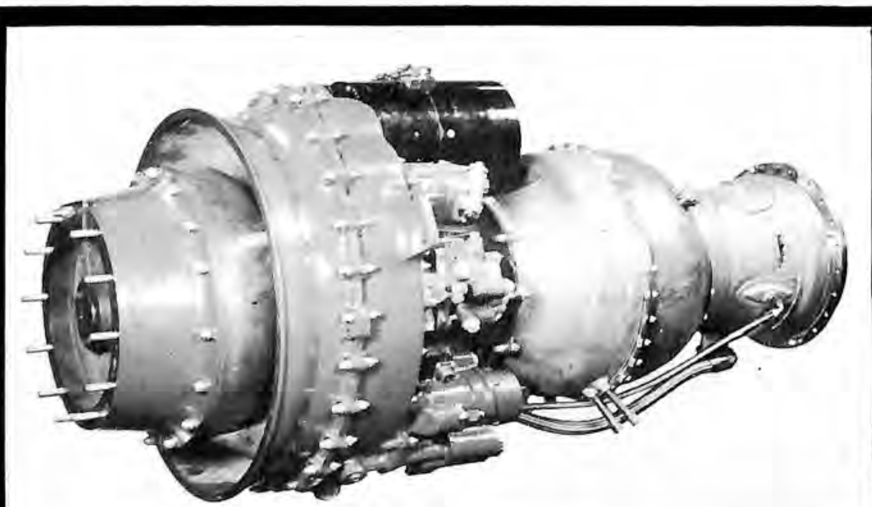


CONTINENTAL J69

Continental Aviation and Engineering Corporation was developing several advanced versions of the basic J69 turbojet. The family included aircraft turbojets of 1,400 and 2,400 pounds thrust, turbofans of 2,600 and 4,000 pounds thrust and a target missile turbojet of 2,550 pounds thrust. Pictured here is the 1,400 pound thrust J69, designated CJ69-1400.

GE YT64-2

General Electric's YT64-2 gas turbine passed its preliminary flight rating test. The turboshaft engine has a 14-stage axial flow compressor, a 12.6 to one pressure ratio, and an airflow rate of 24.5 pounds per second.



CONTINENTAL T72, 217-6A

A company-sponsored development program by Continental Aviation and Engineering Corporation produced a completely new series of turboshaft and turboprop engines in the 500-600 horsepower class. At left is the Model 217-5A (Navy designation T72-T-2), a 500-horsepower turboshaft weighing 210 pounds. At right is the 217-6A turboprop, weighing 230 pounds with power rating similar to the T72.

PEOPLE

The year saw new leaders in many areas of aviation. Among them:

E. Clinton Towl

President
Grumman Aircraft Engineering Corporation

Najeeb E. Halaby

Administrator
Federal Aviation Agency

J. V. Naish

Chairman of the Board
Aerospace Industries Association

T. Roland Berner

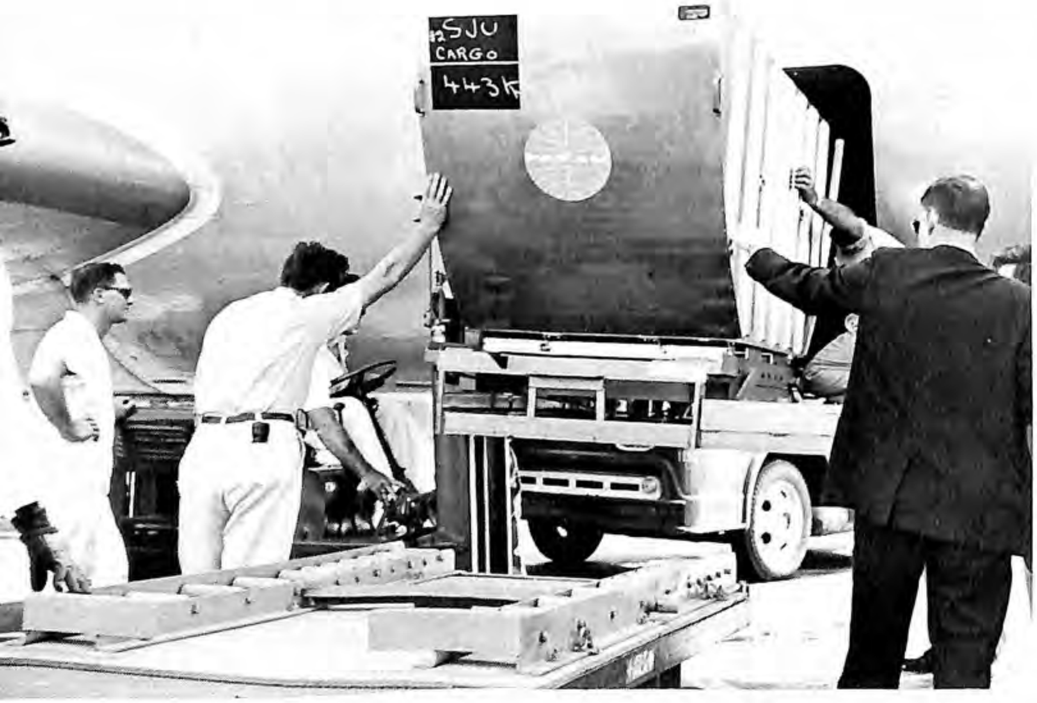
Chairman and President
Curtiss-Wright Corporation

Donald L. Putt (Lt. Gen., USAF, Ret.)

President
Institute of the Aerospace Sciences

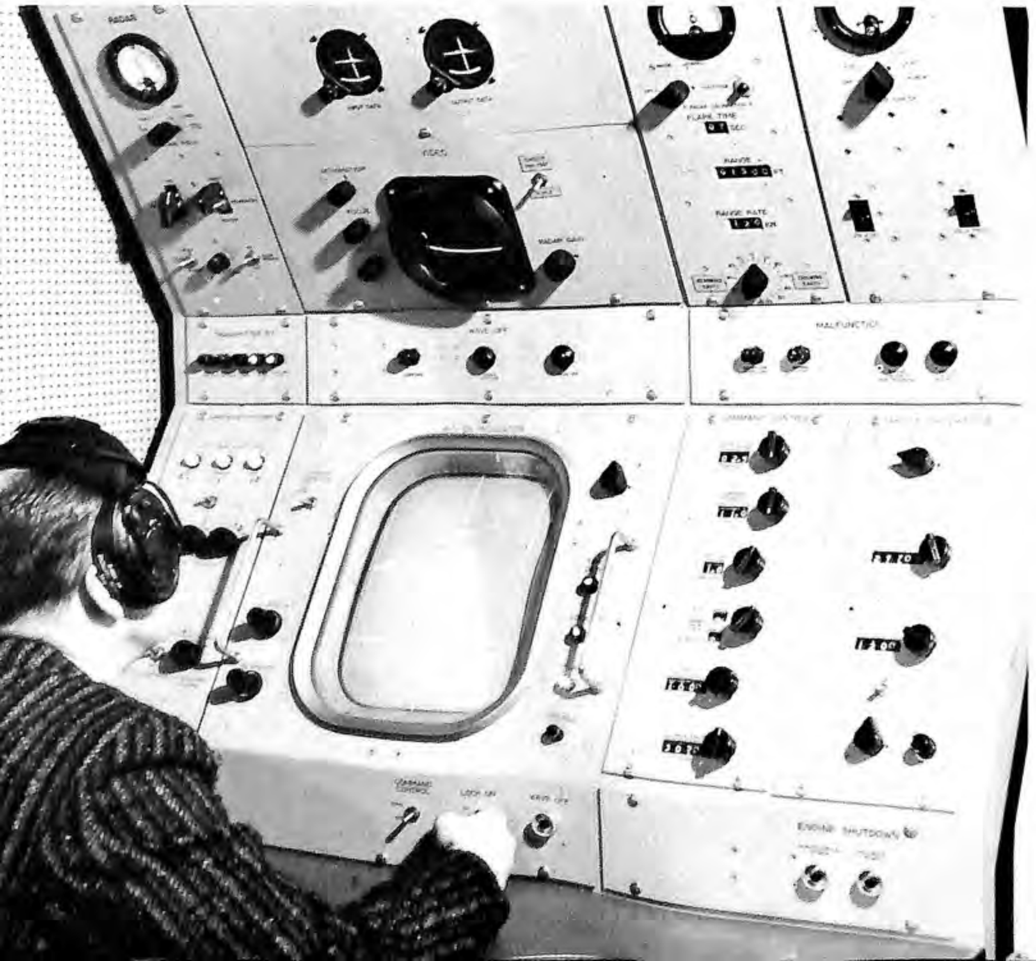
NEW SYSTEMS

Space limitations preclude listing all of the important developments in the field of systems and components. Those reviewed here are representative of developments throughout the industry.



LOCKHEED CARGO LOADING SYSTEM

Lockheed's Special Products Division (Atlanta) designed and built a high-speed cargo loading system for jet-liners which enables 10 tons of cargo to be loaded and off-loaded in 10 minutes. The new system uses a pre-loaded container which is locked to floor tracks in the plane during flight.

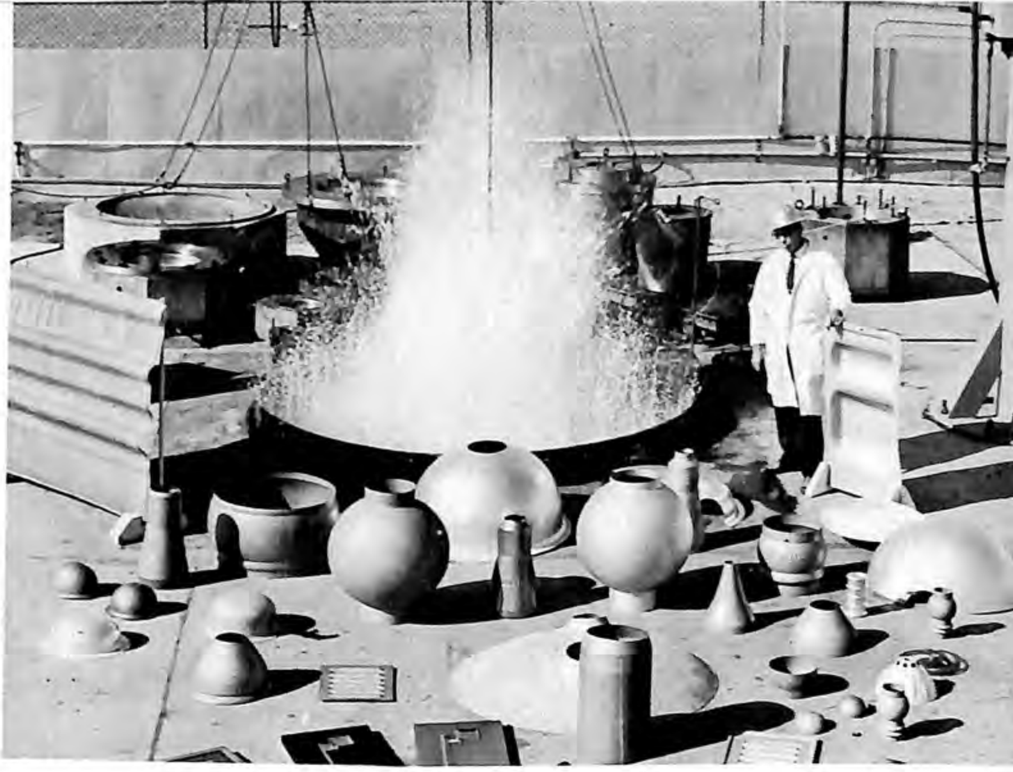


BELL AUTO-LANDING SYSTEM

An automatic all-weather landing system developed by Bell Aerosystems Company's Avionics Division was being evaluated in 1960 by the Federal Aviation Agency at its National Aviation Facilities Experimental Center, Atlantic City, N.J.

RYAN HIGH-ENERGY FORMING

Ryan Aeronautical Company started operating a new high-energy forming facility in 1960. In the facility, space age structures are formed explosively. Metal parts can be formed instantaneously against submerged with explosives in a new process.



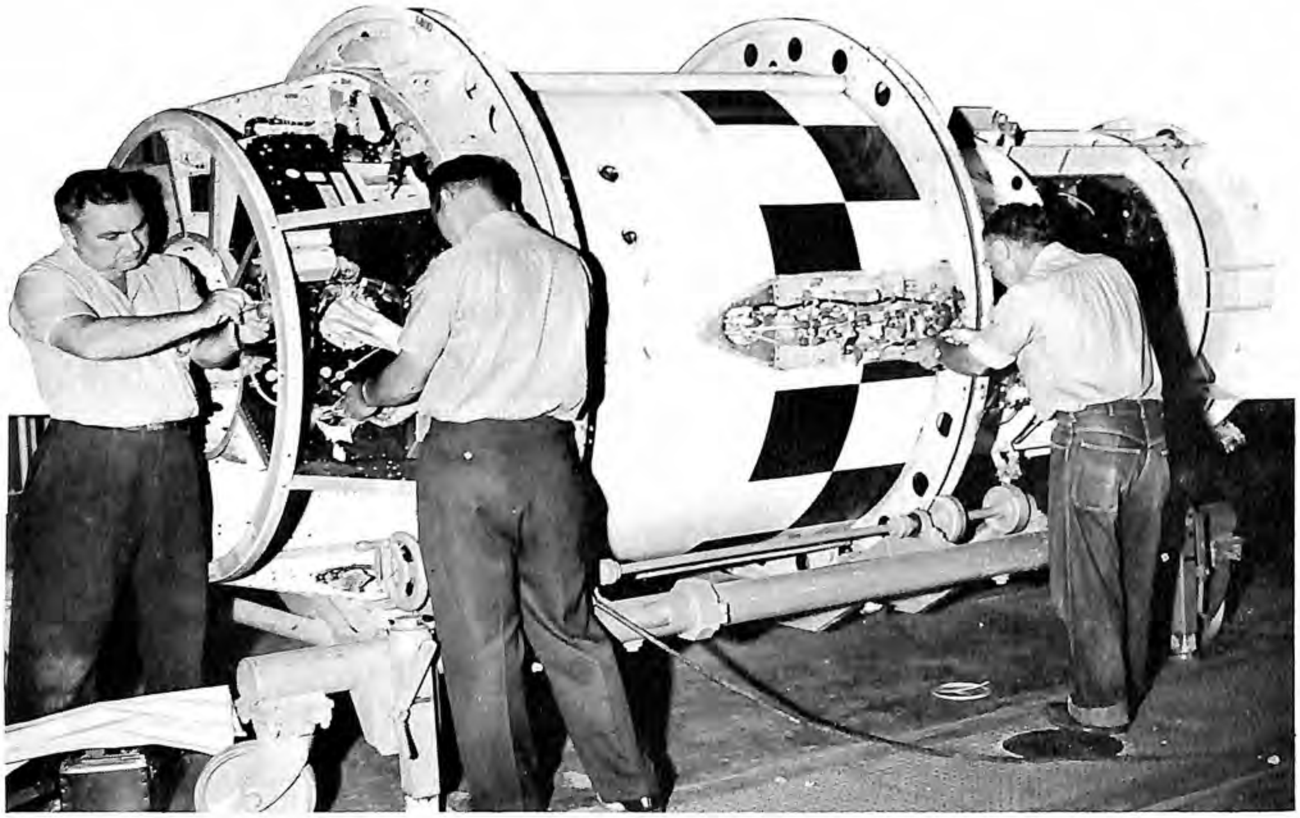
AVCO's VOLSCAN

AVCO Corporation's Electronics and Ordnance Division developed an air traffic control system which makes it possible for 120 aircraft to land and take off within a hour. Developed for the USAF, it was under test in 1960.

MARTIN SNAP 1-A

A technician applies finishing touches to The Martin Company's SNAP 1-A (Systems for Nuclear Auxiliary Power). The generator started electrical tests during 1960.

ASTRONAUTICS

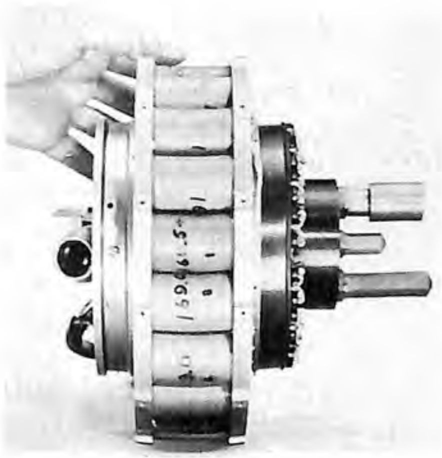


DISCOVERER

The Air Force's Discoverer program, started in 1959, met with singular success in 1960. On August 12, the United States accomplished the first recovery of an object from space orbit with Discoverer XIII. The 300-pound recovery capsule was picked up in the water near Hawaii 30 hours after launch from Vandenberg AFB, California. Later in the year, the USAF made a mid-air catch of the Discoverer XVI capsule with a C-119 cargo plane equipped with a long, trailing hook. The mid-air recovery was successfully repeated with Discoverer XVIII.

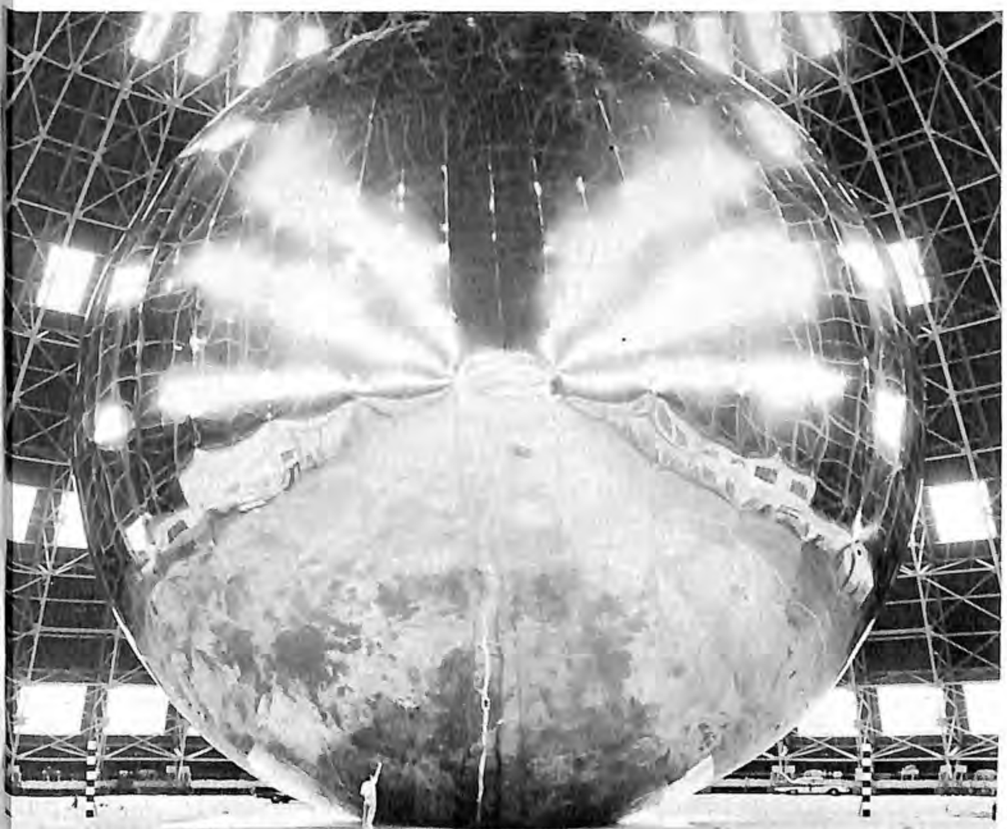
TRANSIT

Another U.S. first was the launching of two navigational satellites, designed for use as a method of fixing position of ships and aircraft. The Navy-directed program included two successful orbiting satellites, Transit 1B, launched on April 13, and Transit IIA, put in orbit on June 22. Transit III-A, launched November 30, failed to achieve orbit.



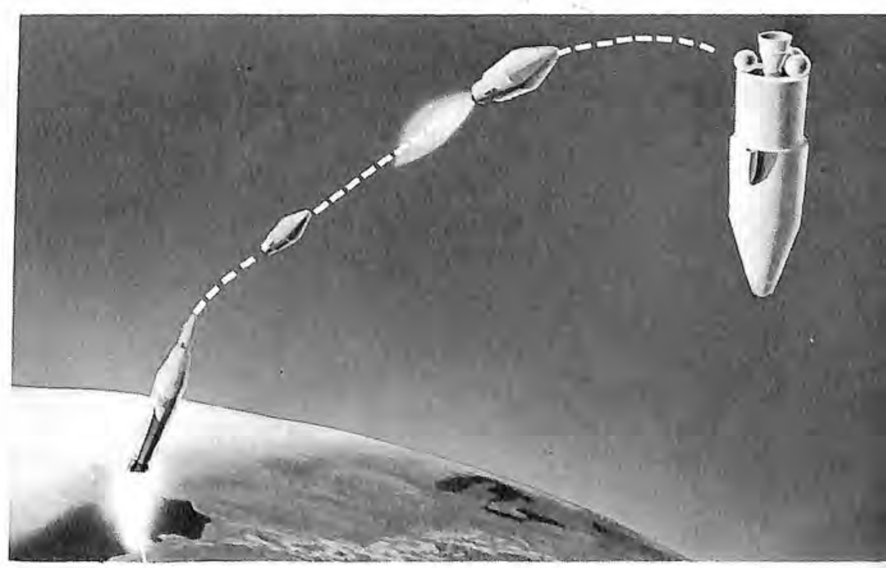
PIONEER

NASA, the Air Force and Space Technology Laboratories teamed on Pioneer V, an important 1960 space project which recorded the most distant radio transmission from Earth, 22,462,-115 miles. A probe designed to investigate space between Earth and its neighbor planet Venus, Pioneer V went into an orbit around the sun after a March 11 launch.



ECHO

A scientific experiment as a passive communications satellite, Echo I aroused international interest because it was the first orbiting satellite which could be seen by the naked eye. The 100-foot balloon, inflated after injection into orbit, was launched August 12 by the National Aeronautics and Space Administration.

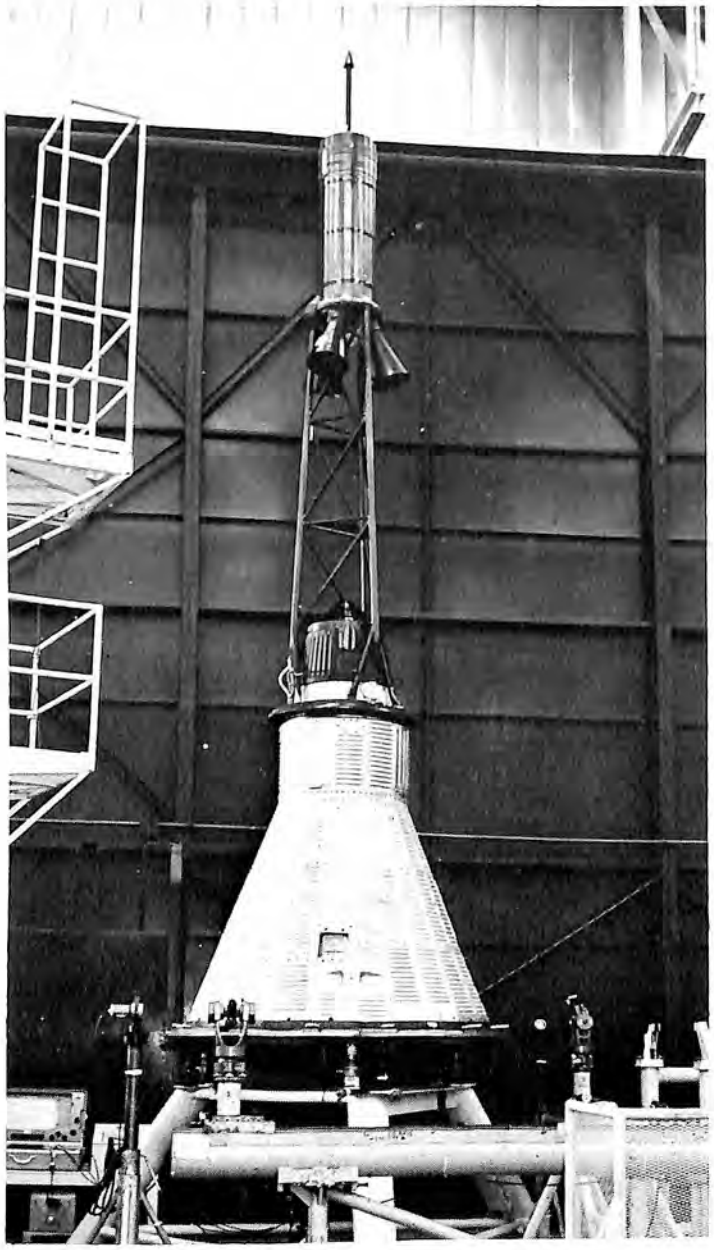


MIDAS

The first surveillance satellite, a prototype of a system to detect enemy missile launches, was placed in orbit on May 24 by the Air Force. The satellite was MIDAS II (the letters stand for Missile Defense Alarm System) built by Lockheed. An earlier MIDAS I, launched in February, failed to orbit.

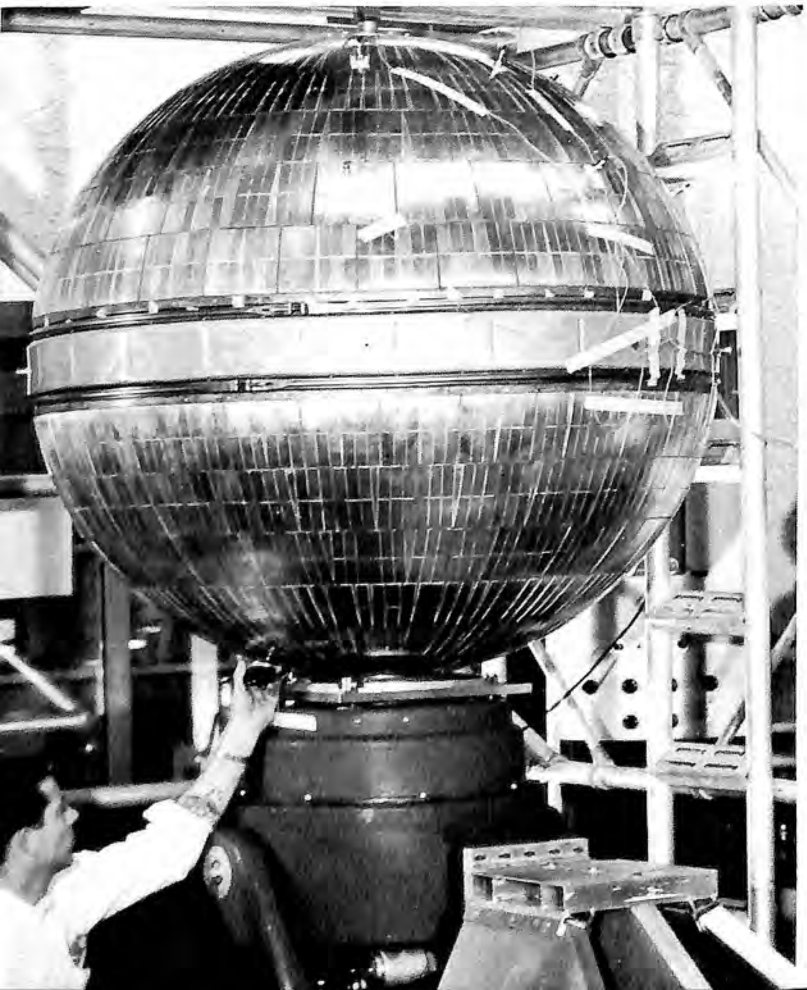
TIROS

NASA launched the world's first meteorological satellites during 1960, Tiros I and II. Equipped with television cameras, the satellites photographed the earth's cloud cover as a means of more accurately predicting global weather. Tiros I went up April 1, Tiros II on November 23.



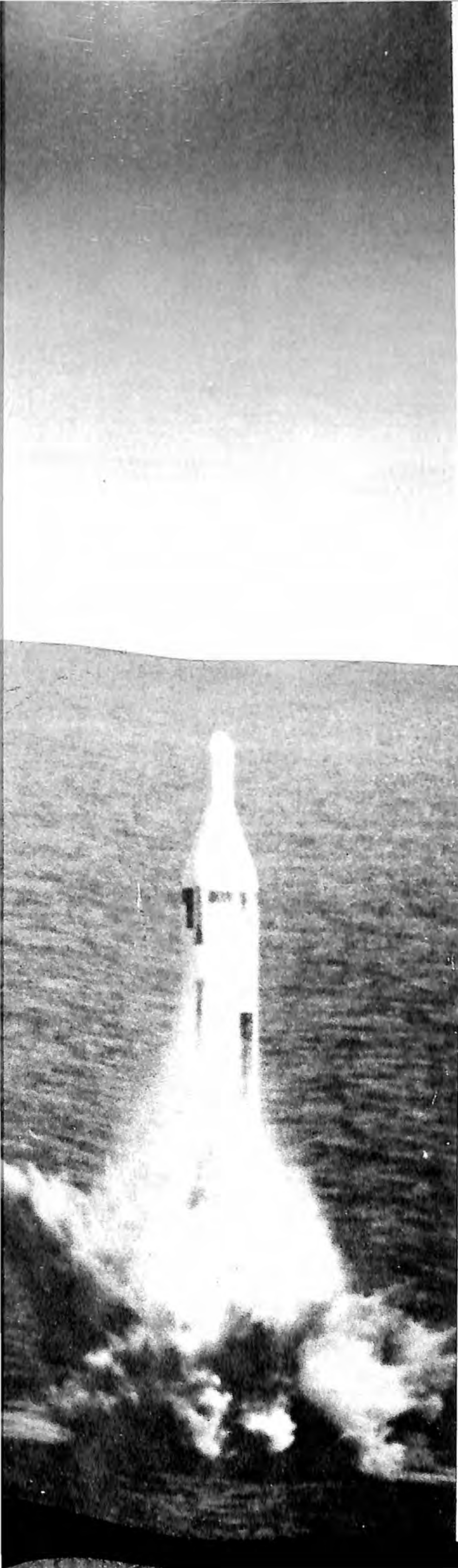
MERCURY

The NASA's program to put a man in space entered its final stages, with successful tests of all major components of the Project Mercury system. Preparations were being made for the first manned suborbital (ballistic trajectory rather than orbit) flight early in 1961, to be followed by manned orbital flight late in the year.



COURIER

An experiment in delayed-repeater communications, Courier 1B was placed in orbit on October 4 and was still transmitting at year-end. Courier was an active communications satellite, as opposed to the passive type like Echo 1. Courier 1A, launched August 18, failed to orbit.



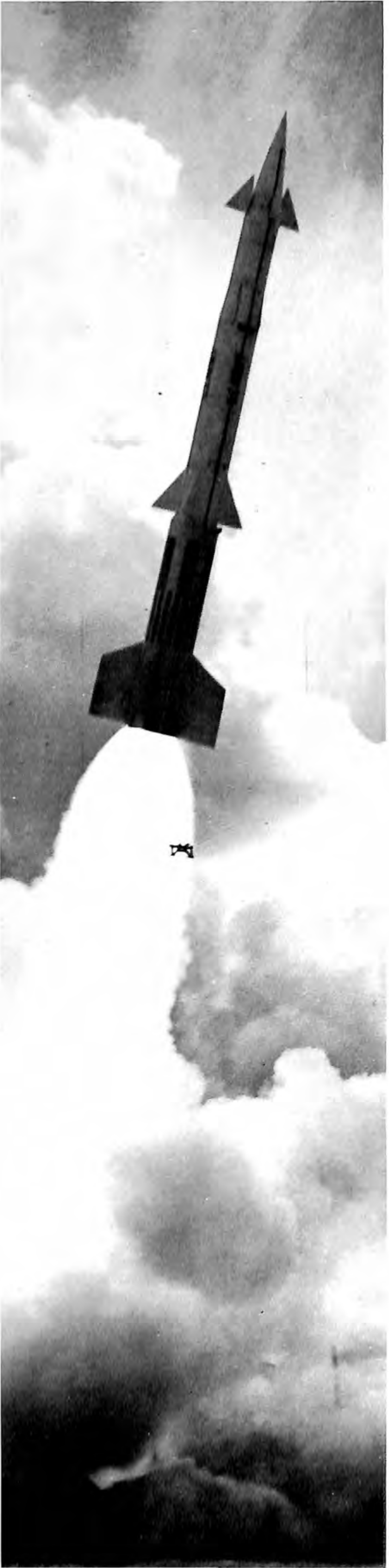
MISSILES

MINUTEMAN

Development of the Air Force's second generation ICBM, the Boeing Minuteman, was speeded during 1960 by an extraordinarily successful test program. The results of eight "tethered" firings, in which the missile was restrained from free flight by nylon ropes, eliminated the need for 10 additional tethered shots and the Minuteman moved on to its flight test program. The Minuteman mobility concept, which calls for operations from freight cars, was also tested in four train deployments during the year.

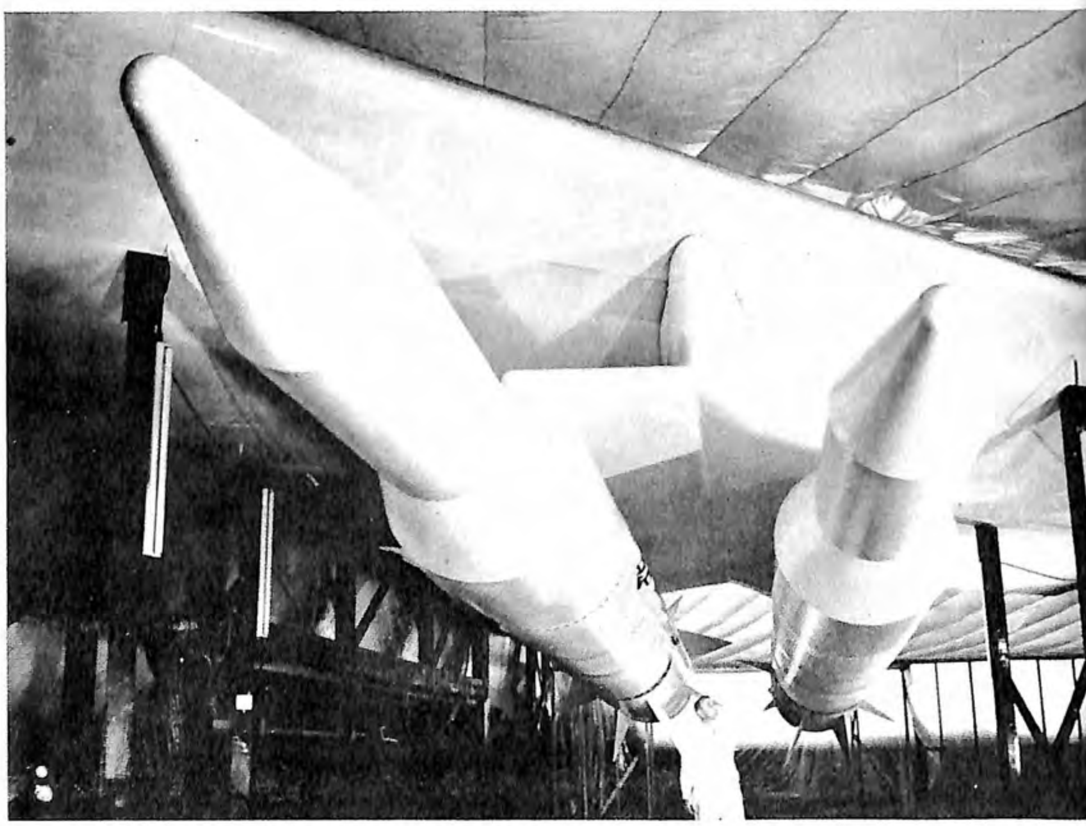
POLARIS

Highlight of the year's missile progress was the achievement of operational status by the Navy's sub-launched Fleet Ballistic Missile, the Lockheed Polaris. A full complement of 16 Polaris missiles went on station with the USS *George Washington* nuclear powered submarine in November, following a highly successful final test program earlier in the year.



NIKE-ZEUS

The first anti-missile missile, Nike-Zeus, moved into advanced test status. Operational tests against ICBM's were scheduled for 1961. Working on the program were Western Electric, Douglas Aircraft and Bell Telephone Laboratories.



SKY BOLT

The Department of Defense released first photos of the Douglas Sky Bolt, a 1,000-mile range air launched ballistic missile to be used in conjunction with the Boeing B-52H SAC bomber.

PERSHING

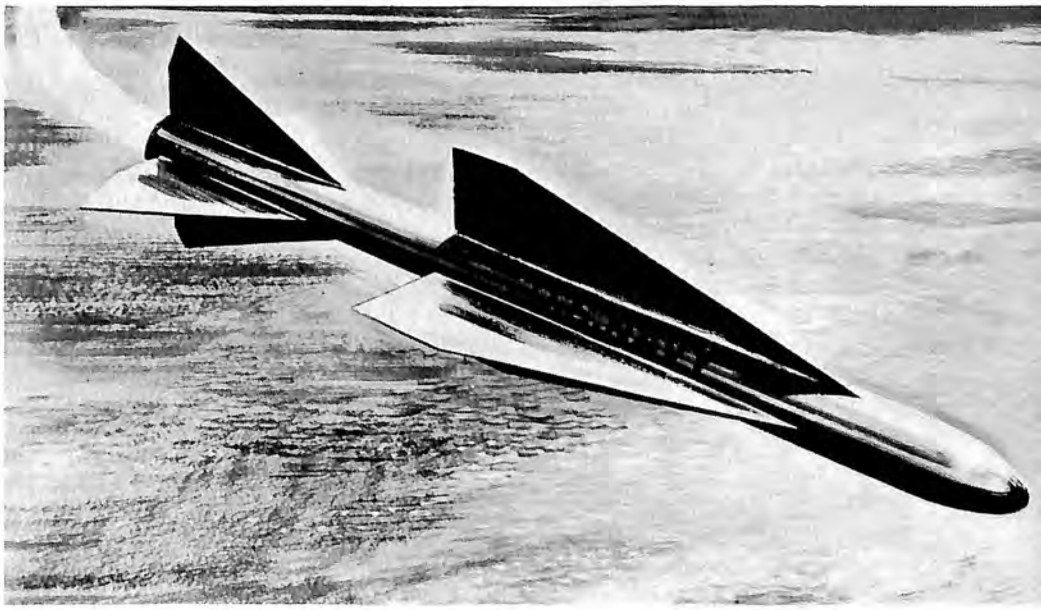
The Army's second generation solid-fueled ballistic missile Pershing (Martin-Orlando) started its flight test program during the year. Initial tests of the first stage with a dummy second stage were highly successful. Two-stage testing was started later in the year.

HOUND DOG

North American Aviation's GAM-77 Hound Dog, an air-to-surface weapon with a range of several hundred miles, became operational with Strategic Air Command in 1960. The Hound Dog is carried by the Boeing B-52G bomber.

EAGLE

The Navy released first photos of the Eagle, a new air-to-air missile in development status. Under development by Bendix Aviation Corporation, Eagle will be used with the new Douglas Missileer defense aircraft.



PHANTOM II: The world's most advanced fighter aircraft . . . a weapon system with performance and versatility to insure air supremacy today—and tomorrow

In creating the Phantom II, McDonnell has drawn upon the wealth of design, development and operational experience resulting from the Voodoo series. The two-place, twin-engine configuration which helped establish the combat supremacy of the F-101B has been refined and advanced in the Phantom II.

The Phantom II has attained a level-flight speed of 1500 mph and has climbed to an altitude of 98,560 feet. Its numerous store stations can accommodate a variety of air-to-air missiles as well as virtually every ground attack weapon in the Air Force arsenal. It combines excellent control characteristics throughout the flight envelope with the most advanced weapons-delivery techniques. The Phantom II is designed to master any ground or air combat situation.

With operational and armament capabilities for both limited and full-scale aerial warfare, Phantom II insures maximum defense for every defense dollar.

MCDONNELL

Designers and Builders of F-101 Voodoos • Project Mercury Space Capsules • Talos Airframes and Propulsion Systems • Quail Decoy Missiles • Rotorcraft • Electronics Systems

MCDONNELL AIRCRAFT ST. LOUIS, MO.

Hiller 12 E sets aviation record, lands and picks up payload at 18,000 ft.

12 E, first light copter to erect entire powerline; 40' poles, el. 5,000 ft.

34,500 lbs. of machinery to exploration mine in 8 hrs. mountain flying.

Microwave station on 4,000' ridge; all 8 tons material; 2 days flying.

You are invited to write for full details.

2½ mile powerline built in 6 hrs., 50 mins. with E's 305 hp at work.

El. 10,000 ft. Two 12 E's fly 80 gal. sprayloads; 60 flights in 4 hrs.

THE ARMY GROWS 'EM TOUGH

How the Hiller 12 E Became First Choice of Commercial Operators

From the day it went into commercial service, the Hiller 12 E had a head start. It had an Army-proved H-23D airframe and an Army-proved H-23D drive system that hadn't begun to exploit its full strength.

The next step rewrote the specs on what light utility helicopters can do. Capitalizing on the H-23D Raven's dynamic components with a 305 hp Lycoming engine's power, light helicopter "firsts" of the kind above were bound to happen. Similar profitable operations are flown every day, wherever there's an E.

That's why the 12 E has become first choice—it's the most economical helicopter purchase today.

Designs are one thing. Deliveries another. Both come from

HILLER AIRCRAFT CORPORATION

PALO ALTO, CALIFORNIA · WASHINGTON, D.C.
Adhesive Engineering Division · San Carlos, Calif.

H-23D

12 E

E4

Super E

LING-TEMCO ELECTRONICS, INC.

WIDENING ITS CIRCLE OF INFLUENCE IN THE ELECTRONICS • AEROSPACE INDUSTRY

Dallas-based Ling-Temco Electronics, Inc., is rapidly growing into a position of leadership in the electronics-aerospace industry. It is growing with vigor because Ling-Temco is a combination of two successful companies, now bonded together in greater strength and with greater total capabilities. And all of its growth is guided by a management team strongly determined to build Ling-Temco Electronics, Inc., into one of America's great companies. ■ Ling-Temco's world-wide activities include many areas of electronics—from miniature packages of electronic sub-systems to electronic installations that cover several square miles — from submarine devices to space systems. It is engaged in some of America's first-line defense programs, including the giant Ballistic Missile Early Warning System and is contributing to a number of other missile programs. ■ With its corporate offices in Dallas, Ling-Temco's sixteen divisions and subsidiaries are stretched across the heart of the nation from New England to California. And as its products and services grow in this vital area of electronics, Ling-Temco will add significant strength to the security and defense of America.

LING-TEMCO
ELECTRONICS, INC.

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The Ling-Temco Group

Altec Lansing Corporation, Subsidiary • Altec Service Company, Subsidiary • The Calidyne Company, Inc., Division • Continental Electronics Manufacturing Company, Subsidiary • The Electron Corporation, Subsidiary • Fenske, Fedrick & Miller, Inc., Subsidiary • Ling Electronics Division • Micromodular Components Division • Peerless Electrical Products Division • Temco Electronics & Missiles Company • Temco Overhaul & Aerosystems Division • Temco Electronics Division • Temco Industrial Division • Temco Missiles & Aircraft Division • United Electronics Company, Subsidiary • University Loudspeakers, Inc., Division

AEROSPACE INTELLECTS

2nd da.

1st da.

Creative technical intellects constitute a very substantial percentage of our nearly 5,000 employees. Our 15 or so really great scientists—national authorities on electronics, computers, propulsion, optics, magnetic phenomena, solid-state physics, applied mathematics and other phases of aerospace science—are only a small fraction of the full range of Kollsman brain power.

Our hundreds and hundreds of highly specialized engineers and technicians are an all-important part of it, and so are our master lens grinders who can hand-polish a lens to tolerances of a few millionths of an inch.

Some of these men can trace their career back to the days when Kollsman became a household word among fliers as **the** flight instrument company. We still are. But ever since the boundary between air and space disappeared, we have been finding ourselves more and more in the space part of the aerospace business.

Some people think, for example, that we are **the** astronavigation company today. And we may easily be **the** company for the particular aerospace business you have on **your** mind. Our best minds—the industry's leading aerospace intellects—are at your service.

Here is what we are delivering to our customers today: ▪ Astro Trackers ▪ Automatic Astro Compass ▪ Air Data Computers ▪ Electromechanical Systems ▪ Missile Components & Systems ▪ Jet Engine Instruments ▪ Flight Instruments ▪ Kollsman Integrated Flight Instrument System ▪ Optical Systems & Components ▪ Doppler Computation Systems ▪ Sextants (Periscopic, Handheld, Photoelectric) ▪ Controls for Aircraft, Missiles & Space Vehicles ▪ Flight Simulator Instruments ▪ Laboratory Test Instruments

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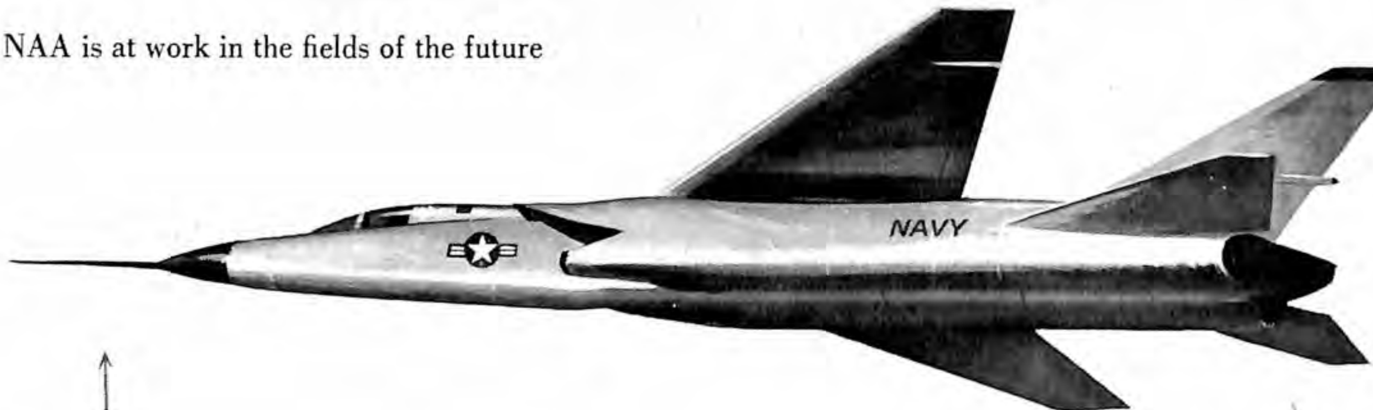
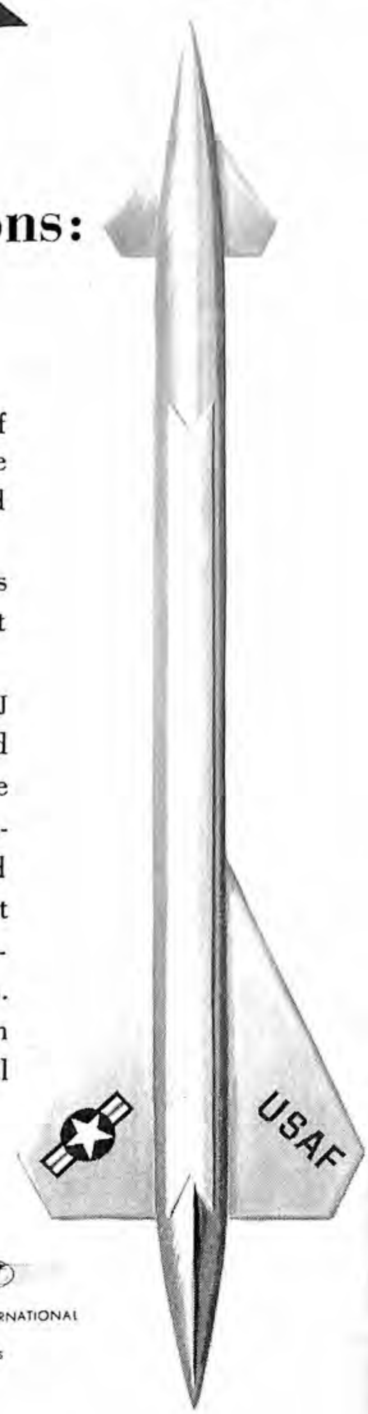
SUBSIDIARY OF **STANDARD KOLLSMAN** INDUSTRIES, INC.

NAA is at work in the fields of the future



Manned and Unmanned Weapons:



To serve the nation
from under the sea to Outer Space

THE DIVISIONS OF NORTH AMERICAN AVIATION form one of America's most versatile defense organizations—capable of assuming complete responsibility for the most advanced weapon system.

NAA is at work in many diversified fields on various aspects of advanced weapon systems—manned and unmanned—that will help build a balanced defense for America.

From NAA come the Navy's Mach 2 A3J Vigilante and the T2J Buckeye jet trainer...the GAM-77 Hound Dog air-to-ground missile for SAC's B-52 bomber...the B-70 Valkyrie multi-purpose bomber, 2000-mph successor to the B-52...the inertial navigation systems both for Polaris-carrying nuclear submarines and the Minuteman ICBM...and the large liquid propellant rocket engines that power Redstone, Thor, and Jupiter missiles, besides the Atlas, America's first ICBM to reach operational status.

North American scientists and engineers are at work in many "fields of the future" to meet the needs of national defense.

NORTH AMERICAN AVIATION, INC.

SERVING THE NATION'S INTEREST FIRST—THROUGH THESE DIVISIONS

LOS ANGELES AUTONETICS MISSILE ROCKETDYNE COLUMBUS ATOMICS INTERNATIONAL

Los Angeles, Canoga Park and Downey, California; Columbus, Ohio; Neosho, Missouri; McGregor, Texas

Will The Mission Succeed?

Ask . . .

DATS

(Dynamic Accuracy Test System)

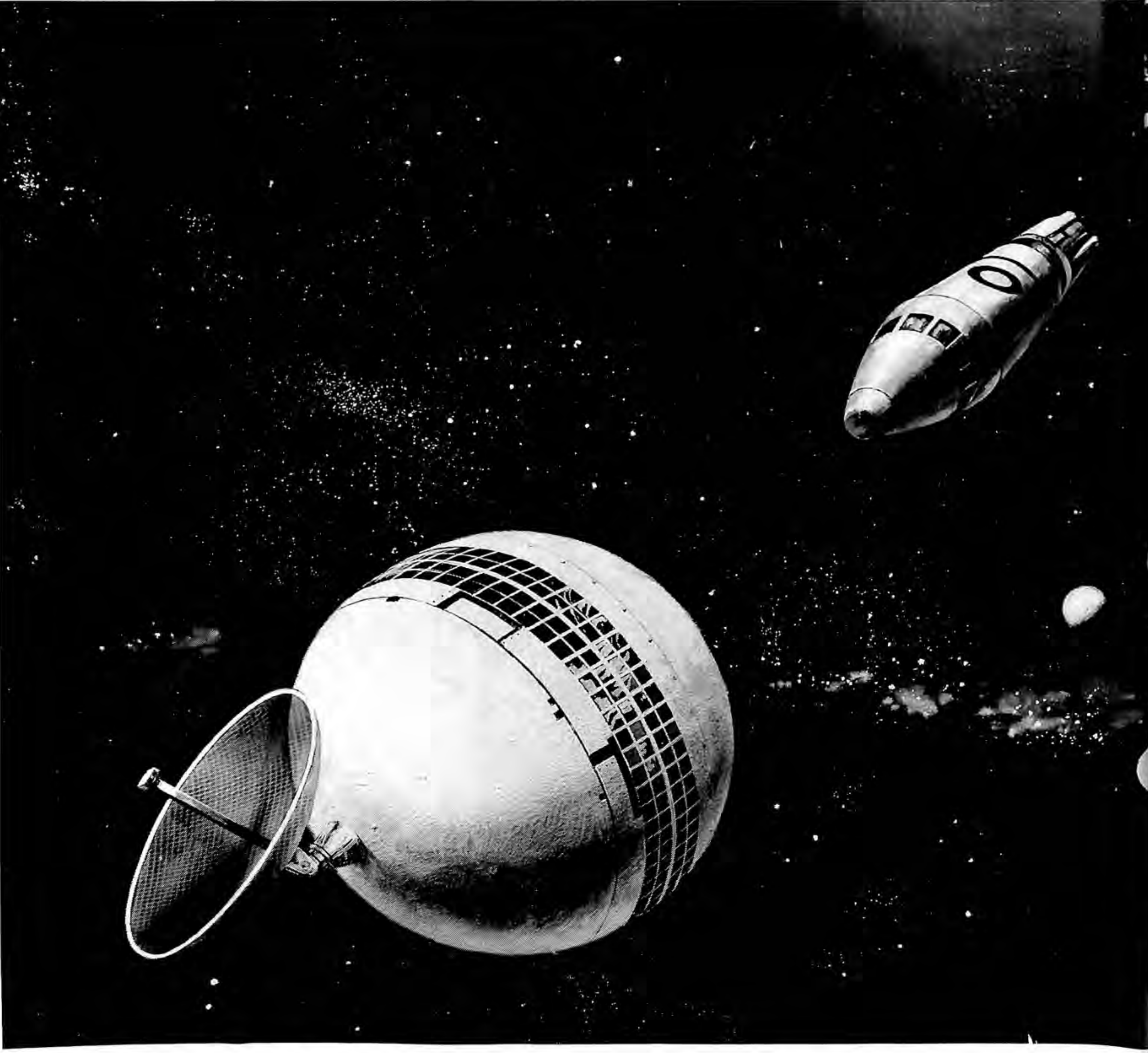
Flight-line checkout by DATS (Dynamic Accuracy Test System) tells the interceptor commander whether his aircraft and weapon control systems are completely ready for a successful mission. As a result of field evaluation tests, showing the effectiveness of DATS in improving weapon control performance, RCA has been awarded an Air Force production contract. Developed by RCA's Airborne Systems Division, Defense Electronic Products, Camden, New Jersey, DATS is a new approach to the evaluation of system readiness.

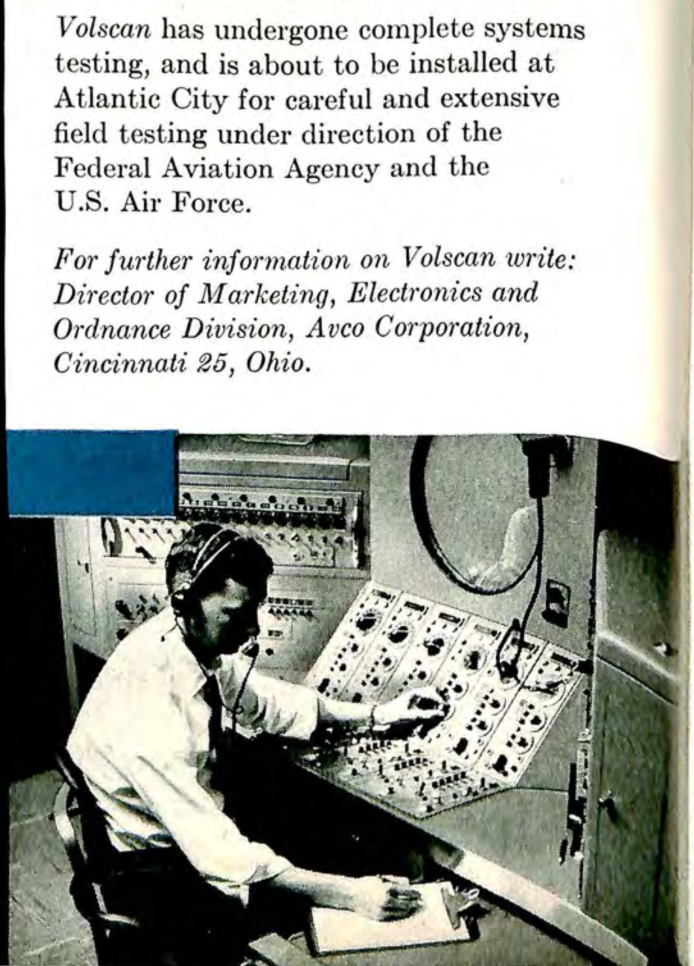
It makes certain that only aircraft with properly operating weapon control systems are sent on missions. Based on a building-block design employing the highest reliability factors, a mechanical programming device and self-test capability, DATS utilizes a series of synthesized attack runs typical of mission conditions. DATS could be made applicable to many interceptor types of aircraft.

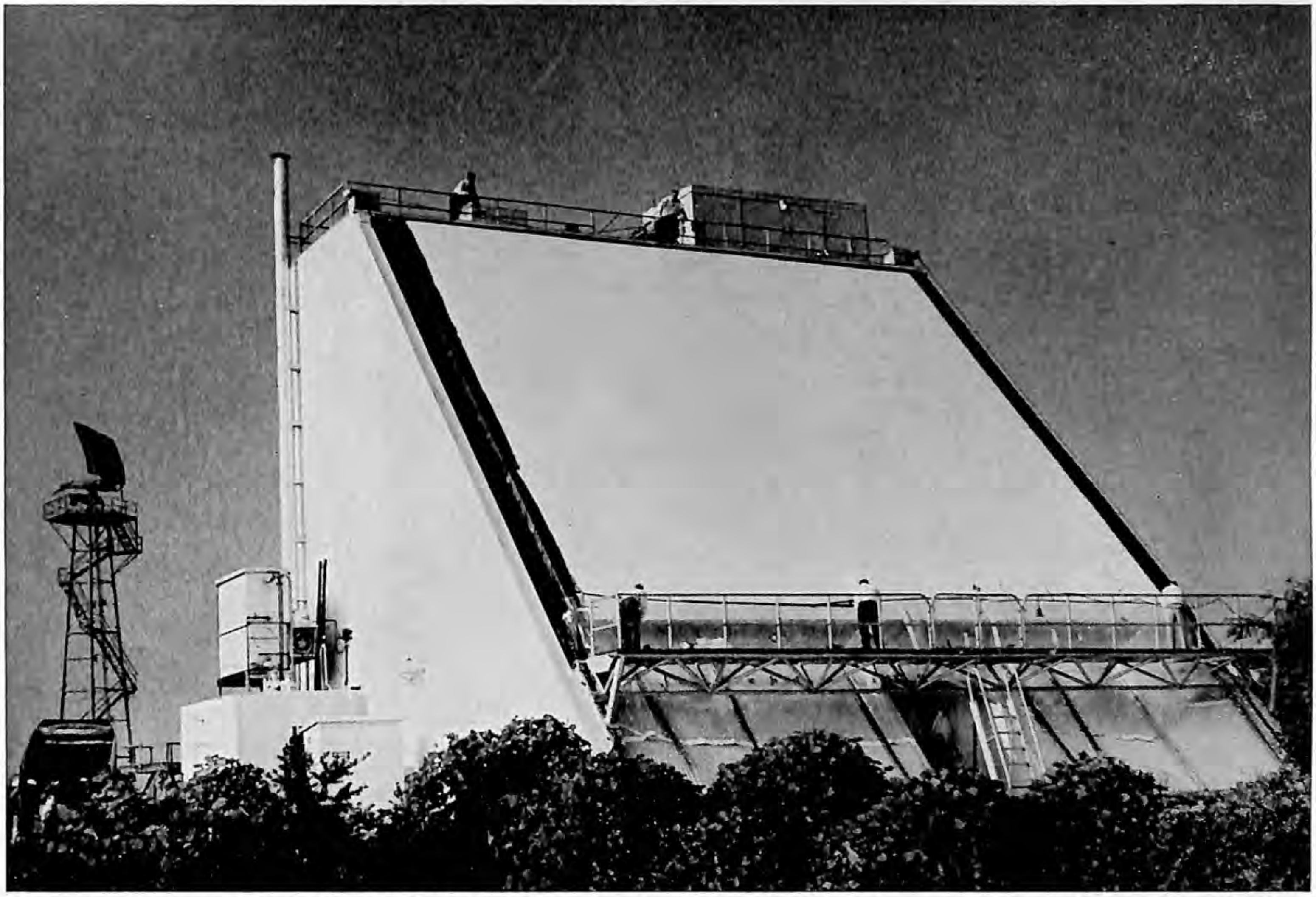
RCA®

The Most Trusted Name in Electronics

RADIO CORPORATION OF AMERICA







This new type Bendix radar, initiated by the United States Air Force, Rome Air Development Center, and now sponsored by the Advanced Research Projects Agency, Dept. of Defense, is the forerunner of radars promising unprecedented protection. Note how much it differs from conventional radar in background.

THIS ENTIRELY DIFFERENT RADAR PROMISES NEW PROTECTION

You are looking at an entirely different type of radar. One that we believe will, for the first time, be able to spot and track thousands of enemy ballistic missiles simultaneously.

It is known as ESAR (electronically steerable array radar). It contains no moving parts and it differs radically in performance and appearance from conventional radar which has rotating antennas.

The demonstration model, shown above, is located at our Radio Division, Baltimore, Maryland. Its great five-story face houses nearly 9,000 tiny, individual antennas whose "computer-steered" beams can be electronically shifted from target to target quicker than a wink. It will track rockets fired from the National Aeronautics and Space Administration launching site at Wallops Island, Va., and keep an alert watch on air traffic in the Baltimore-Washington area.

When development is successfully completed, larger ESAR type radars may also be used to keep tabs on thousands of earth-circling satellites, and to track and communicate with space vehicles launched on deep probes to the moon and other planets.

Bendix is a leading producer of all kinds of radar for civilian and military uses. Surveillance stations equipped with our radar include northern early warning installations, others throughout this country, as well as towers at sea and in distant lands—all in all watching over 25,000,000 square miles.

Because Bendix airborne weather radar provides an accurate picture of weather conditions 150 miles ahead, pilots of thirty-three domestic and foreign airlines are able to minimize the effects of storms and thus give their passengers smoother, safer rides. Bendix® Doppler Radar is an airborne navigation system that is adding greater safety to United Airlines overseas flights.

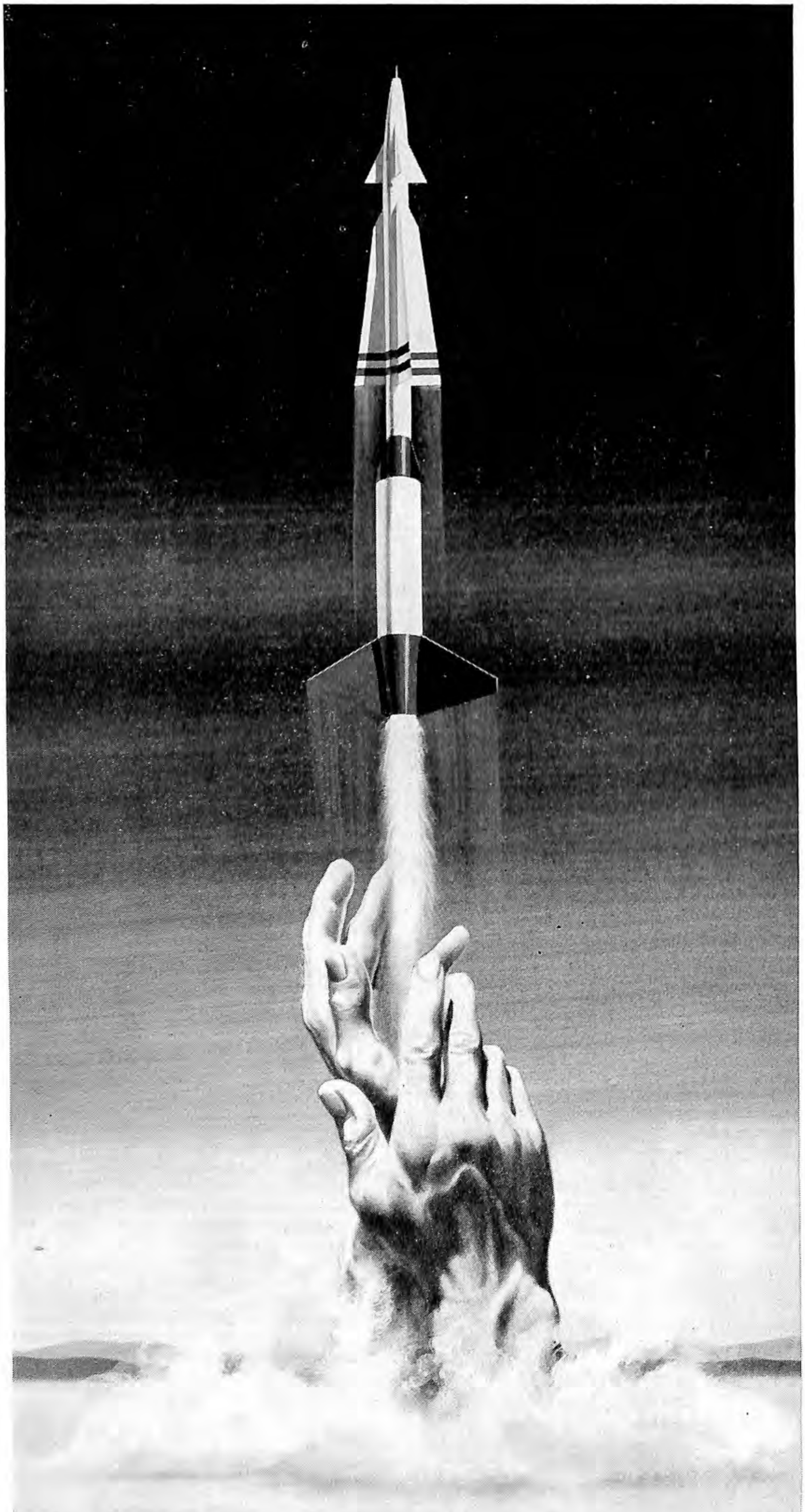
Other Bendix radar devices include: airport surveillance equipment, Ground Controlled Approach radar, radar systems for military helicopters, marine radar, proximity fuses, and TV weather-reporting radar.

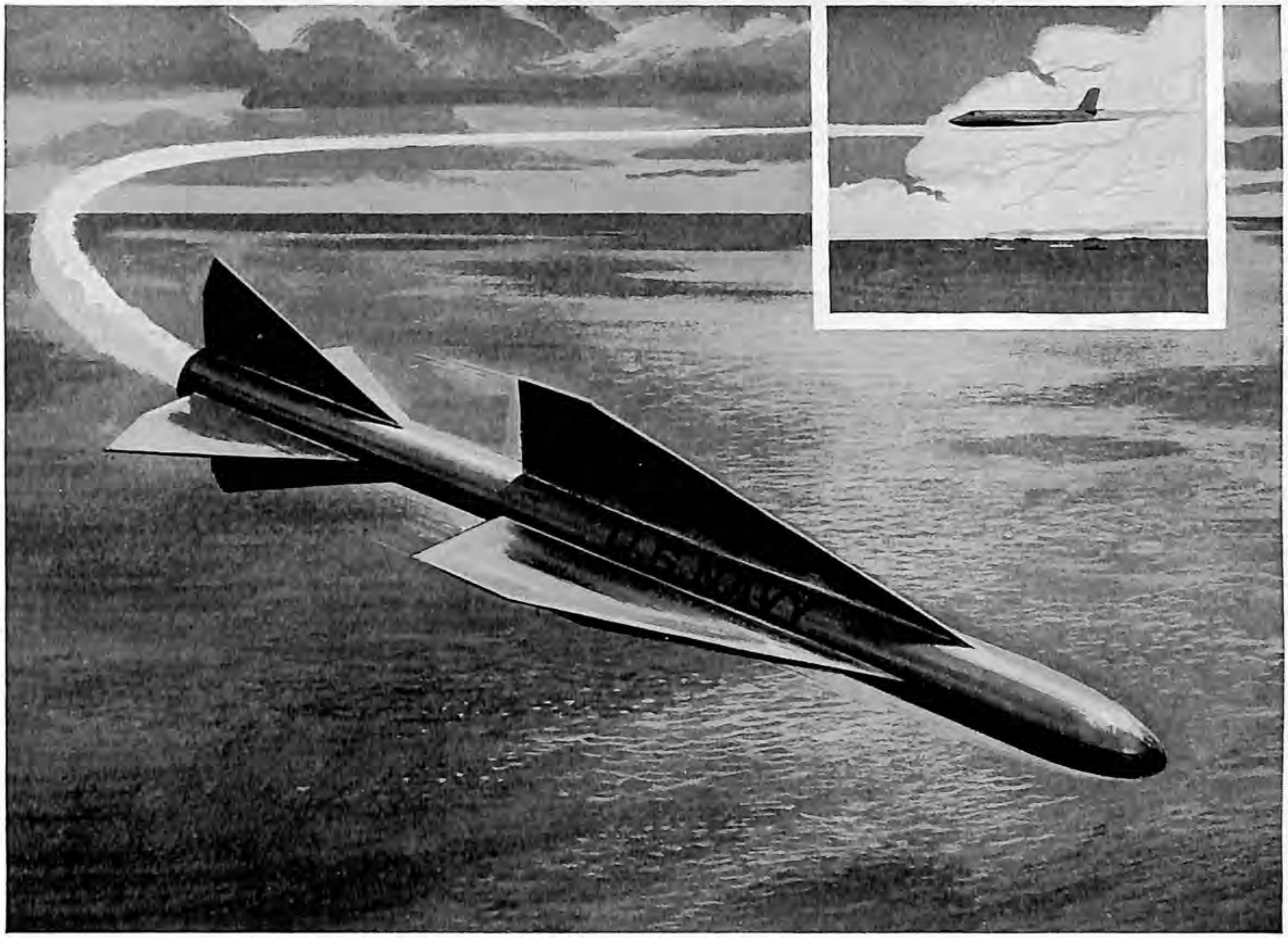
ESAR contains nearly 9,000 of these Christmas tree type antennas. "Electronically steerable," they can watch thousands of missiles, aircraft, and satellites simultaneously.

THE Bendix CORPORATION
Fisher Bldg., Detroit 2, Mich.

A THOUSAND DIVERSIFIED PRODUCTS SERVING THESE FIELDS:

automotive • electronics • missiles & space • aviation • nucleonics • computer • machine tools • sonar • marine





This is an artist's conception of the Eagle—the Navy's latest, long-range, air-to-air missile. It is shown being launched from a fleet aircraft (inset), and on its way to strike an enemy target.

MEET EAGLE—NAVY'S NEW AIR-TO-AIR POWERHOUSE

Eagle—the Navy's latest air-to-air missile for long-range defense—will surround task forces and marine landing operations with a veritable thicket of destructive power poised against any intruding enemy aircraft or aerodynamic missile. It will also make possible extended air control over a wide area beyond the fleet.

Eagle, for which Bendix is prime contractor, represents a new trend in that it can be launched from relatively slow aircraft, since the high performance is built into the guided missile itself rather than into the manned airplane.

Bendix is also prime contractor for Talos — the Navy's long-range surface-to-air missile. It is the principal armament of the new fleet of missile-carrying cruisers that have replaced the battleship.

Bendix is deeply involved in many other phases of this country's missile and space program. We build the inertial guidance systems that help provide the accuracy of Pershing, the Army's new, mobile, ground-to-ground guided missile. The global ground tracking, voice communications, and telemetry systems for Project Mercury—the U.S. man-in-space program—are other important Bendix responsibilities.

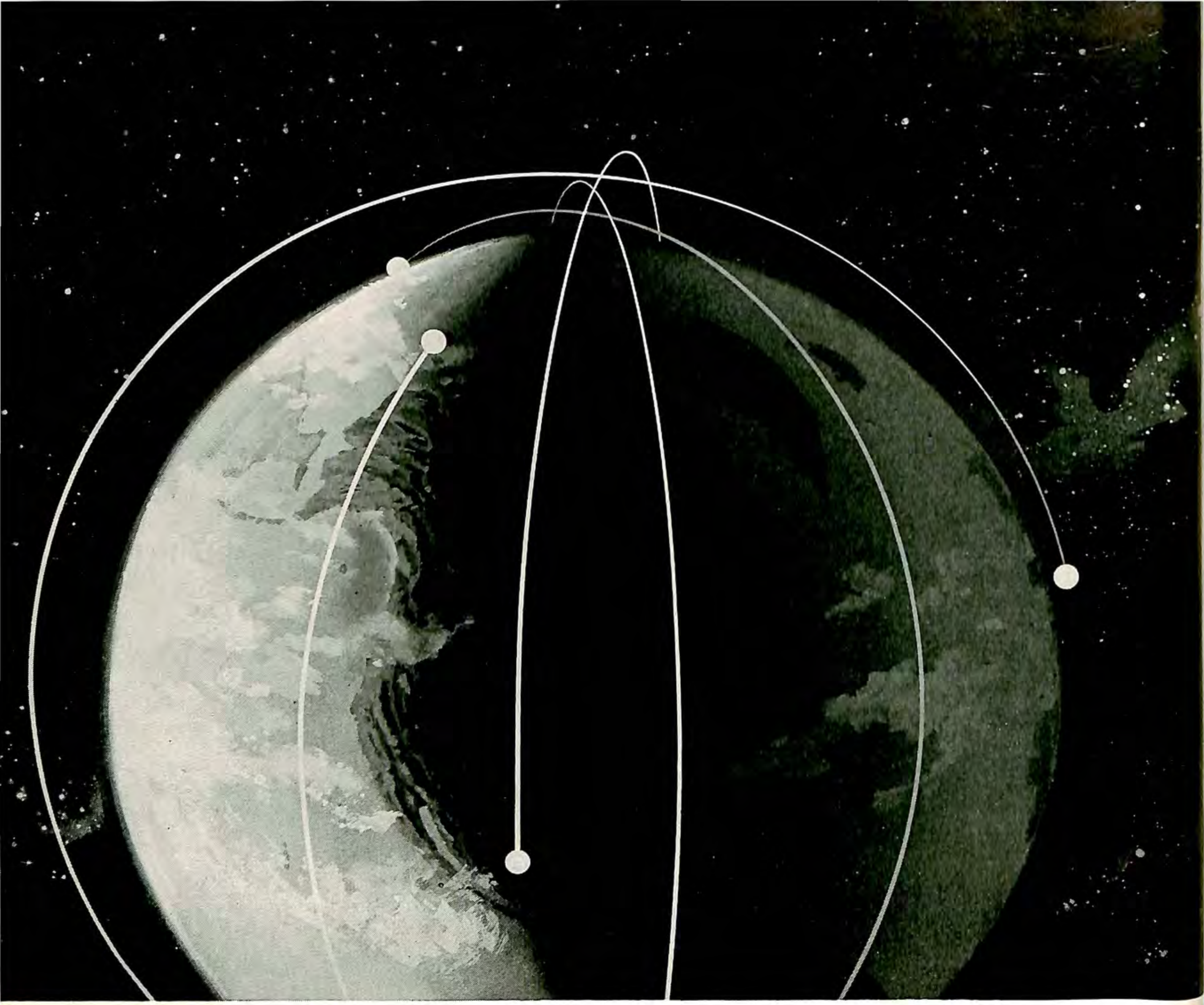
Bendix built two of the three U. S. satellite tracking systems and now operates and maintains them for the National Aeronautics and Space Administration. We have developed an ingenious device that steers and controls a satellite in space, and, in addition, helps remove it from orbit and directs it precisely to a designated recovery area; telemetering systems that can transmit 500 channels of information back to ground stations; general purpose digital computers that are widely used for many applications in the missile and space fields.

Bendix is also a leading supplier of vital components, such as warheads, target seekers, electrical connectors and cabling, internal power, and controls for practically every missile in the U. S. arsenal.

THE Bendix CORPORATION
Fisher Bldg., Detroit 2, Mich.

A THOUSAND DIVERSIFIED PRODUCTS SERVING THESE FIELDS:

automotive • electronics • missiles & space • aviation • nucleonics • computer • machine tools • sonar • marine

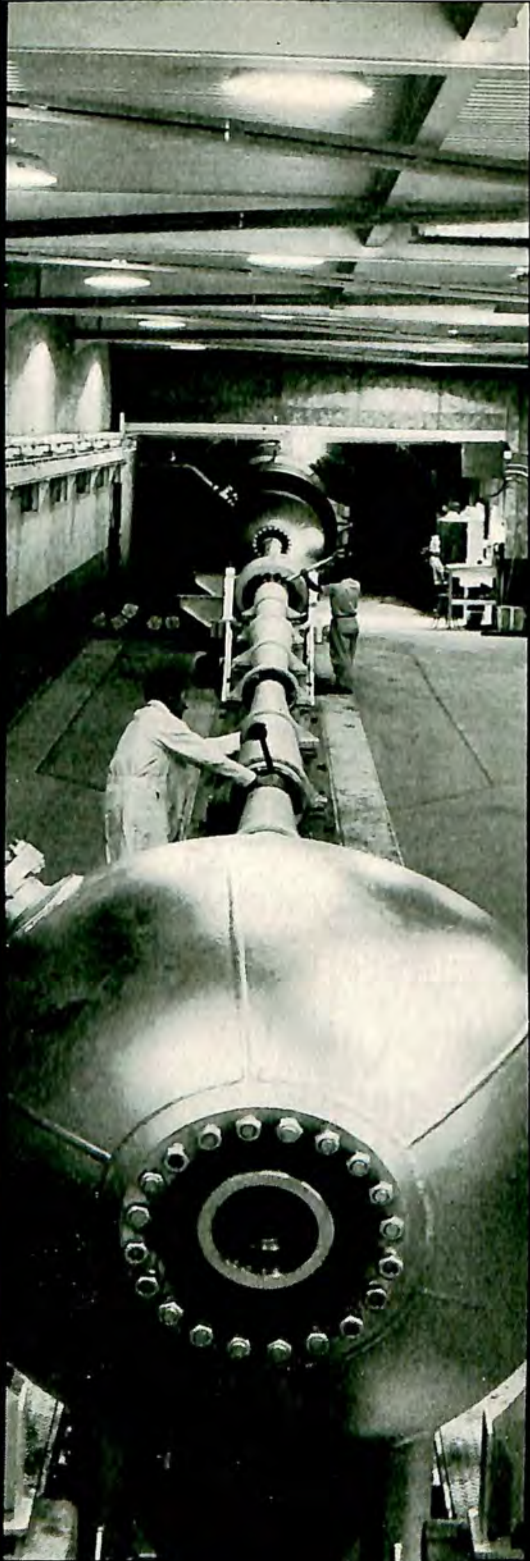


Midas satellites: our infrared eyes in space

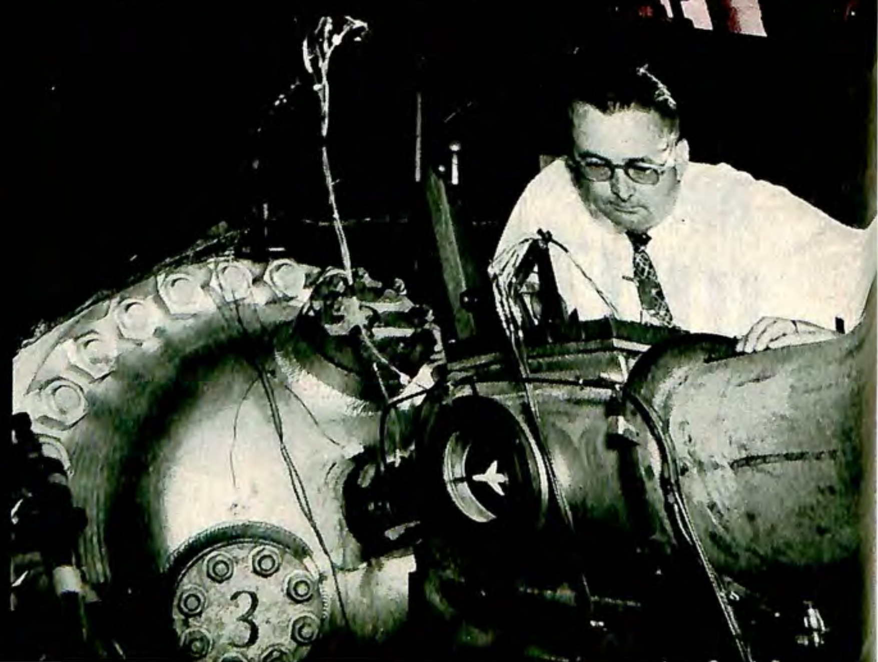
Should enemy missiles ever be launched against America, they would plunge down upon us in just thirty minutes. They would be halfway here before the first warning blip showed up on our earthbound radar screens. But our Midas satellites will warn us within seconds. Their infrared eyes will "see" any missile's white-hot exhaust as soon as it leaves the earth's atmosphere, even thousands of miles distant. Just a few of these satellites, circling the earth on pole-to-pole orbits, will be enough to keep every acre of land and sea under constant surveillance. By doubling our warning time, Midas will give us precious extra minutes to get our long-range bombers off the ground and our intercontinental missiles ready to launch—and thus render futile any hope of destroying our military might with one bold stroke. Midas will become a reality years sooner because it is based on the Agena satellite which Lockheed developed for the trail-blazing Discoverer program of the U.S. Air Force. Lockheed is now building Midas satellites for the Air Force at "Satellite Center, U.S.A."—its Missiles & Space Division at Sunnyvale, California.

LOCKHEED

DIVISIONS: CALIFORNIA • GEORGIA • MISSILES & SPACE • LOCKHEED ELECTRONICS CO. • LOCKHEED AIR TERMINAL • LOCKHEED AIRCRAFT SERVICE • LOCKHEED AIRCRAFT INTERNATIONAL • LOCKHEED, S. A. • PUGET SOUND BRIDGE AND DRY DOCK CO. **PRODUCTS:** ELECTRONICS • MISSILES • AIRCRAFT • NUCLEONICS • SATELLITES AND SPACE VEHICLES • ROCKET FUELS AND MOTORS • AIRCRAFT MAINTENANCE • AIRPORT MANAGEMENT • SHIPBUILDING • HEAVY CONSTRUCTION • STEEL FABRICATION AND CRANES



THE INDUSTRY

FURTHER ADJUSTMENT to technological change and a continuing increase in the rate of change marked the year 1960 for the aerospace industry, but despite the across-the-board shifts required to meet the demands of technological progress the industry scored notable gains during the year.

The year saw a highly successful American space exploration program, and industry's contributions to the program in "hardware" and technical services expanded considerably over the previous year. New missiles were turned over to the operating armed forces and refinements were made to a number of existing types. Production of manned aircraft and associated equipment, however, continued to be the major portion of the industry's workload.

Aerospace Industry Association estimated that 1960 sales would total about $11 billion, approximately the same as 1959, with increased missile and space activity offsetting a decline in production of military aircraft, which dropped to 1,200 units in 1960 from 1,700 in 1959. At the same time, expenditures for missile production rose to $4.1 billion.

Sales of commercial aircraft, engines, propellers and parts were estimated by AIA at about $2.2 billion, compared with $1.7 billion in 1959. The estimate of total commercial aircraft production, including helicopters, was placed at 8,000 units, slightly lower than 1959's 8,242. Year-end backlog for commercial turbine-powered transports alone was well over the billion-dollar mark.

A survey of nine major airframe companies, whose sales and earnings generally parallel those of the industry as a whole, indicated that the year's sales would show a slight increase over 1959, but that earnings would continue at the level of 2.4 per cent. The steady decline in industry backlog which had been evidenced in previous years was halted during 1960. As of September 30, the companies had $12.5 billion in backlog, an increase of $400,000,000 from the start of the year.

Exports of both civil and military aircraft climbed during 1960. During the first seven months of the fiscal year, an increase of 88.8 per cent was noted over the same period in 1959, reversing a declining trend in the years 1956-59.

Employment, however, continued to drop. At year-end it was down to 640,000 from approximately 700,000 at the start of the year. Average hourly wages increased from a 1959 annual average of $2.62 to $2.73 in September, 1960.

The contributions of the individual companies to aerospace progress in 1960 are detailed in the pages that follow. ■

AIRFRAME, ENGINE AND MISSILE MANUFACTURERS

AERO COMMANDER, INCORPORATED

DURING THE YEAR, the former Aero Design and Engineering Company changed its corporate name to Aero Commander, Inc., "to simplify corporate identity and to more closely associate the company with the product itself which has won world-wide acclaim for the Aero Commander name."

Four new models of the Aero Commander were announced at the 1960 International Distributor Meeting at the Bethany, Okla., factory. The new models were:

The Aero Commander 500A, powered by two 260 horsepower Continental 10-470-M fuel injection engines, with a cruising speed of 217 miles per hour and a range of 1,800 miles.

The Aero Commander 500B, powered by twin 290 horsepower Lycoming 10-540 engines, which cruises at 218 miles per hour and ranges 1,250 miles.

The 560F, powered by Lycoming 350 horsepower IGO-540 engines, which has a cruise speed of 232 miles per hour and a range of 1,500 miles.

The 680F, which cruises at 244 miles per hour and has a maximum speed of 290. It is powered by Lycoming IGSO-540 engines of 380 horsepower each.

A company highlight of 1960 was an altitude record of 37,010 feet for Class C-1.d (aircraft in the 3,858 to 6,613 pound class), set by Miss Jerrie Cobb in an Aero Commander model 680F on September 20.

AEROJET-GENERAL CORPORATION

DURING 1960, Aerojet-General Corporation was actively involved in more missile and space projects than any other U.S. rocket firm. The company's sales total was $412 million, compared to $364 million in 1959. Solid rocket motors accounted for 54 per cent of sales and liquid fueled engines for 24 per cent. The remainder comprised varied projects associated with rocketry or defense.

Aerojet continued work on two-stage liquid propulsion systems for the Titan ICBM and the two-stage solid fuel power plant for the Polaris. At the same time it was active in developing liquid rocket engines for Dyna-Soar and the solid fuel second-stage for Minuteman. Aerojet's new Spacecraft Division developed the Able-Star that put two satellites into orbit simultaneously. Aerojet also was providing propulsion for the Hawk, Tartar, Genie and other weapons systems. Development work progressed on Skybolt power plant. The company's infrared system furnished the eye of the Midas reconnaissance satellite.

The company also was engaged in plastics, nucleonics, ordnance, anti-submarine warfare and chemistry. Aerojet's Aerobee sounding rocket series was the most extensively used rocket during the year for upper-atmosphere research. Its AETRON Division, specializing in the design and construction of space-age launching complexes, industrial building and auxiliary services, worked on more than 500 contracts ranging from $10,000 into the millions.

Late in December, AETRON, associated with two San Francisco firms in a joint venture known as AETRON-BLUME-ATKINSON, was selected by the AEC to do architect-engineer-management work on a proposed $100,000,000 nuclear electron accelerator to be located at Stanford University. This will be the most advanced device of its kind in the free world and will take five to six years to complete.

Construction and plant acquisitions during the year brought Aerojet's total plant facilities to $150 million. New buildings included the largest chemical laboratory in the industry as well as an engineering building which doubled the previous engineering facility at Azusa.

Rocket power from Aerojet's Liquid Rocket Plant and the Solid Rocket Plant helped chart the United States path to the future. Solid fueled motors for the Navy Polaris A-1 provided the push as the fleet ballistic missile was launched for the first time from the submerged U.S.S. George Washington, and an improved first-stage motor boosted the advanced Polaris A-2 on its first 1,600 mile flight. The Polaris A-1 became operational and was on station. The Polaris A-1 first-stage motor successfully ignited under water, the largest solid propellant rocket ever so fired. Concepts for at-sea testing and launching were studied. Successful firings of flight-weight Minuteman solid fueled second-stage engines were accomplished, and units were shipped to Cape Canaveral for facility check-out and later flight testing.

The faster-than-sound Hawk with solid propellant propulsion from Aerojet intercepted an Honest John missile on the first try, the first known interception and kill of a ballistic missile.

Operational models of the Air Force Titan I, using Aerojet first and second-stage liquid fueled engine, were successfully flight tested for the first time in 1960. When the Air Force announced plans for the super Titan II in June, Aerojet stepped up its work on the more powerful, storable fueled engines. Work is being done to modify Titan engines for Dyna-Soar.

Aerojet's Liquid Rocket Plant also announced successful firing tests on the largest liquid hydrogen-liquid oxygen pump-fed rocket engine in existence; designed to generate approximately 200,000 pounds of thrust.

The Solid Rocket Plant received an Air Force contract of more than $8 million for development of large segmented rocket motor, eventually to develop in excess of one million pounds of thrust.

Aerojet also began work on an NASA study for solid booster phase of one million to nine million pounds gross weight space vehicles.

The Aerojet Senior, first-stage for NASA Scout, performed successfully four times in four attempts with motors ranging in age from one to two years.

Expansion program of facilities at Sacramento included $17,367,145 invested in buildings and equipment during 1960, bringing the combined total spent by year-end in Sacramento by Aerojet and the Department of Defense to $111,740,-255. The year 1960 saw full-scale operation begin on the first facility for continuous mixing of solid propellants, the installation of the largest vibration equipment for testing solid rockets, and new mixing and testing equipment for storable propellants for Titan II.

In February, the company established its Structural Materials Division at Azusa to meet the growing need in the missile industry for fuller exploitation of metallic and non-metallic materials and processes.

Newly designed Aerojet rocket sleds were put to testing the guidance system for Minuteman. The new model is the largest and fastest liquid-powered rocket sled in the free world.

The Gas-Cooled Reactor Experiment No. 1, designed and built by Aerojet's nuclear subsidiary, Aerojet-General Nucleonics, in conjunction with AETRON, for the Atomic Energy Commission, achieved criticality in February at the AEC's National Reactor Testing Station, Idaho Falls, Idaho.

AGN also announced progress in using nuclear energy to transform an inexpensive plentiful chemical into a powerful space-age fuel. Producing one compound from another by using nuclear energy is a new field called fissiochemistry.

Aerojet-General's Able-Star engine achieved a significant "first" in rocketry in April when it placed the Transit satellite in orbit and became

AEROJET'S Solid Rocket Plant, Sacramento, Calif.

the first United States rocket propulsion system ever to be restarted in space.

Five European NATO nations will produce the Aerojet-powered U. S. Army Hawk missile as the primary ground-to-air defense weapon in Western Europe. Aerojet will supply technical assistance and has named Dr. T. T. Omori as European Manager of the program, with headquarters in Paris.

The company's new Downey Plant completed its first full year of operation during 1960. Employment rose from 1900 to nearly 2,500 persons. Highly classified ordnance projects were being carried out at Downey in addition to production of the Army's SD-2 and SD-2X drones. The manufacturing division at Downey produces components for major missiles.

Aerojet won a Navy contract for the production of the Tartar surface-to-air guided missile solid propellant motor. In the Tartar motor, Aerojet engineers compressed the normal two-stage booster and sustainer into one compact unit, thereby producing a true dual-thrust solid rocket motor.

Aerojet's Avionics Division conceived the techniques and manufactured the infrared detection equipment of the Midas payload in cooperation with Lockheed.

Aerojet-General also provided two solid propellant rocket motors for the Air Force 609-A (Blue Scout) high environmental testing vehicle, representing the broad span of solid rocketry from the powerful booster type engine to a finely-tuned motor specifically designed for top performance in space.

In mid-1960, Aerojet purchased a controlling interest in Space Electronics Corporation, Glendale, California, from Pacific Automation Products, Inc. Space Electronics' considerable technical capabilities in the field of communication and guidance were expected to supplement the work of Aerojet's Spacecraft Division.

Work got under way during the year at Aerojet-General Corporation to provide pilot control of Titan ICBM engines, one of the major modifications leading to use of the engines in the Air Force man-in-space Dyna-Soar program. Aerojet also began study of a new Mach-5 Spacecraft.

Aerojet's Anti-Submarine Warfare Division began production of the Hydrocket during the year. The Hydrocket, a new water jet engine, will propel future boats at speeds never before thought possible. Theoretically, there is no limit to the speed that can be reached by vessels of any size using the Hydrocket, providing they have the proper hull design. In addition, the ASW Division was working at top speed on a multimillion contract from the Navy to develop and produce a new high-speed torpedo of radical design.

In 1960 new applications for JATO (take-off assist and in-flight thrust augmentation) rockets were developed. The devices were made operational equipment by several additional manufacturers of commercial and private aircraft. Aerojet has produced more than 800,000 JATO units in past 18 years.

Aerojet-General is a subsidary of The General Tire and Rubber Company of Akron, Ohio.

AEROSPACE CORPORATION

AEROSPACE Corporation, a new force engaged in accelerating the advancement of space science and technology, was formed in June 1960, to serve the Air Force in the scientific and technical planning and management of missile-space programs.

The immediate mission of Aerospace Corporation was "to aid the United States Air Force in applying the full reservoir of modern science and technology to the problem of achieving those continuing advances in ballistic missiles and military space systems which are basic to national security."

By the terms of its charter, Aerospace Corporation shall "engage in, assist, and contribute to the scientific activities and projects for, and perform and engage in research, development and advisory services to and for, the United States Government."

The establishment of the new non-profit public service corporation was announced at a conference in Inglewood, California, on June 25. The announcement followed the organization meeting of the corporation's eleven-man Board of Trustees, representing a cross-section of leaders from the fields of science industry, government administration and education.

In July, Roswell L. Gilpatric, Chairman of the Board of Trustees announced the appointment of Dr. Ivan A. Getting, as president of Aerospace Corporation. Prior to his resignation to accept the presidency, Dr. Getting was vice-president for engineering and research of the Raytheon Company. Dr. Getting assumed the position as chief executive on August 1.

A milestone of major significance in the progress of the corporation, was announced by Dr. Getting on September 20, of a complete slate of officers. Providing leadership are: Allen F. Donovan, senior vice president, technical; Jack H. Irving, vice president and general manager, Systems Research and Planning; Edward J. Barlow, vice president and general manager, Engineering Division; and Dr. Chalmers W. Sherwin, vice president and general manager, Laboratories Division.

The balance of the officer complement includes William W. Drake, Jr., vice president, administration.

The non-profit corporation was not chartered to enter manufacturing or production of hardware.

At the end of the year Aerospace Corporation was fully operational and employment totaled 1500 technical and administrative staff. Highly selective recruiting continued.

Typical systems projects included: advanced ballistic missiles; advanced military space boosters; recoverable boosters and satellites; space defense systems; early-warning satellites; reconnaissance satellites; communication satellites; and manned satellite maintenance vehicles.

Typical research programs: advanced propulsion; astrodynamics; inertial guidance; telecommunication and spaceframe structural research.

Aerospace's facilities are adjacent to Los Angeles International Airport and the spacious, modern research and development center is located on El Segundo Boulevard.

ALLISON DIVISION

GENERAL MOTORS CORPORATION

RESEARCH AND DEVELOPMENT work on aerospace power and propulsion systems highlighted 1960 for the Allison Division of General Motors Corporation.

Allison stepped up development and deliveries of first- and second-stage rocket motor cases for the solid-propellant Minuteman intercontinental ballistic missile under sub-contracts to Thiokol Chemical Corporation and Aerojet-General Corporation. These rocket motor cases at year's end continued to compile a 100 percent reliability record in repeated test firings.

Preliminary design and development of a compact nuclear powerplant for military applications got underway. Allison and Nuclear Development Corporation of America were named by the Atomic Energy Commission to design and develop an extremely mobile, lightweight powerplant with a rating of 2,000 to 3,000 kilowatts. Nuclear units of this type would find application in the field as versatile powerplants capable of operating over extended periods in areas isolated from other power sources.

Allison and NDA along with Thiokol and Linde Company began joint study work on a nuclear rocket propulsion system under an Air Force contract. Basis for the studies was to develop future nuclear power concepts that would replace chemical combustion processes to provide thermal energy.

In another area, the closed-cycle external combustion engine was being adapted for modern-day auxiliary power that can dependably operate satellite accessories unattended for as long as two years. As a closed-cycle engine, this Stirling powerplant being developed under Army contract is an ideal power system for upper atmosphere and space applications.

Also undergoing prototype testing was a small attitude control rocket built by Allison for use as a vernier stabilizer to maintain predetermined trajectories of lunar shots, space probes and orbital vehicles.

ALLISON Minuteman rocket engine case

Other studies that gained impetus during 1960 included regenerative fuel cell systems and a magneto propulsion device that could serve as an electro-magnetic shock accelerator to create extremely high exhaust velocities. Researchers were placing increased emphasis on heat transfer investigations, utilizing as a research tool the liquid metal loop.

A major break-through in metallurgical achievement came with invention by Allison of a process whereby tungsten in a semi-solid state can be sprayed inside the throats of rocket nozzles. The plasma spray technique has exceptional potential as a method of forming, from highly refractory materials such as tungsten, the relatively complicated shapes required for other aerospace components besides rocket nozzles.

Allison in 1960 began development of the Aeroproducts Aero-Mech, an electro-mechanical guidance unit for drones and missiles.

Developing under Navy contract was the unique Aero 45 Reel-Launcher supersonic target tow system that was first unveiled during the USAF's Worldwide Fighter Weapons Meet at Nellis Air Force Base in October. This ram-air-driven unit which can stow, launch, tow and retrieve a 12-foot target for gunnery practice, can release or retrieve cable at the rate of 5000 feet per minute.

Prop-jet engines continued to be a major production item during 1960. Not only were a quantity of engines produced for the Lockheed Electra, but for the military as well.

A sizeable Air Force contract for prop-jet aircraft engines extended production of the T56 Series well into 1962. Covered under the contract are T56-A-7 engines for the USAF combat-cargo transport, the Lockheed C-130, and T56-A-10W powerplants for the Navy Anti-Submarine Warfare aircraft, the Lockheed P3V-1. Contracts also were received for production of T56-A-8 engines for the Navy's W2F Airborne Early Warning radar plane and T56-A-7 engines for the Lockheed GV-1, a dual-purpose aerial tanker and global assault transport that will be a major contributing factor to the success of "Operation Deep Freeze '61."

Continued emphasis was placed on sales of prop-jet engines to the nation's airline and corporate operators of Convair 340/440 airliners as conversion units to replace outdated piston engines.

Allison during 1960 designed, developed and began assembling mobile test stands which will enable the Navy to inspect the operation of Allison Prop-jet powerplants "on location" at far-flung shore installations. Initial deliveries of the trailer-borne test stands are scheduled to begin in January, 1961. The stands are capable of handling prop-jets up to 4,500 horsepower, yet at 15,000 pounds are light enough to be airlifted to naval installations anywhere in the world.

Development also continued on the prop-jet and turbo-shaft versions of the Allison T63, and the GMT-305 vehicular-type gas turbine engine.

The Engineering Product Design function of the division's Aeroproducts Operations was phased into the Allison Research and Development Center at Indianapolis to take advantage of existing design and development facilities

Employment stood at 11,000 at year's end.

ICBM nose cone reenters atmosphere at speed of 12,000 miles per hour after flight aboard Titan missile.

AVCO CORPORATION

AVCO CORPORATION during 1960 continued to make significant contributions to aviation and aerospace programs in fields of gas turbine and reciprocating aircraft engines, advanced research and development in atmospheric re-entry problems and techniques, production of ICBM re-entry vehicles, materials, space propulsion and environmental support equipment.

In 1960 the corporation established a Defense and Industrial Products Group to further integrate its development, production and marketing capacities with particular respect to the company's increasing weapons systems work for the armed forces. The group includes the Electronics and Ordnance Division (formerly Crosley Division), Lycoming Division, Nashville Division and the Research and Advanced Development Division. The Avco Everett Research Laboratory was administered as a separate division of Avco.

AVCO EVERETT RESEARCH LABORATORY

The Avco Everett Research Laboratory, Everett, Mass., conducted programs in basic and applied research in the field of high temperature gas dynamics. The Laboratory's broadening scope of activities necessitated the expansion of facilities by some 80,000 square feet of floor space. AERL's work in producing interplanetary shock waves in the Laboratory is considered to be an important step in contributing to the understanding of "solar flares" and their possible effect in disrupting communications all over the earth.

Another project of great importance is the AERL drag brake system for re-entering satellites. This represents one facet in the extensive program carried on at the Laboratory toward continuously better understanding of atmospheric re-entry and its practical implications. It was early work at AERL that produced the first answers in the solution of the re-entry program. The system employs a drag brake device resembling an upside down umbrella to control a satellite's orbit and lower it to earth. The drag brake is the simplest method of satellite recovery.

Basic research was underway during 1960 in the application of magnetohydrodynamics (MHD)—the interaction of an ionized gas with a magnetic field—as a possible method of space propulsion. The Laboratory also conducted an extensive program in monitoring incoming re-entry vehicles downrange. This work, using optical and electronic equipment was contributing to two goals—the development of improved re-entry vehicles and the study of possible defense measures against enemy missiles.

RESEARCH AND ADVANCED DEVELOPMENT DIVISION

The Research and Advanced Development Division, Wilmington, Mass., held prime contracts for the development of re-entry vehicles for the Titan and Minuteman ICBMs. RAD-developed re-entry vehicles were also being flown on some Atlas ICBMs. In conjunction with this important work, RAD-staff Avco-Florida Missile Test Station at Cape Canaveral during the year conducted an extensive series of re-entry vehicle test flights aboard both Titan and Atlas. The flight test program included the following:

January 26, 1960. Avco re-entry vehicle flown downrange from Cape Canaveral on first flight aboard USAF Atlas ICBM.

February 24, 1960. Avco advanced design re-entry vehicle impacts near the South Atlantic island of Ascension, and data capsule is recovered following flight on USAF Titan ICBM.

March 22, 1960. Second flight success for Avco advanced vehicle flown on Titan. Also, second consecutive recovery made of data capsule bringing back taped data recorded during "blackout" phase of re-entry.

April 21, 1960. Third straight re-entry success reported for Avco R/V in Titan flight. Data cassette recovered.

May 13, 1960. Another advanced design Avco R/V passes Titan flight test. Data cassette recovered.

May 27, 1960. Aboard Titan, successful.

June 24, 1960. Aboard Titan, successful. Data cassette recovered.

August 10, 1960. Aboard Titan, successful.

August 30, 1960. Aboard Titan, successful.

September 16, 1960. Aboard Atlas, successful.

September 28, 1960. Aboard Titan, successful. Data cassette recovered.

September 29, 1960. Aboard Titan, successful. Data cassette recovered.

October 7, 1960. Aboard Titan, successful. Data cassette recovered.

RAD was also developing a flight test program at Cape Canaveral for the Minuteman ICBM.

In October the RVX-1 re-entry vehicle—the first ICBM re-entry vehicle to be recovered after a flight at the full ICBM range of 5,500 miles—was presented to the Smithsonian Institution in Washington, D. C. This vehicle was protected during re-entry by Avcoite, an ablative ceramic material developed at the Avco Everett Research Laboratory and Research and Advanced Development Division.

The division's materials program was developing an entirely new series of high temperature materials based on plastics and ceramics. One of these, Avcoat, was being sold in large quantities. Another program at RAD was the development of rocket nozzles using exotic materials for advanced-design solid propellant missiles.

There was also a comprehensive program underway in electric arc jet technology, including arc research, application of arc jets as materials testing tools, as an industrial spray coating device and as a space engine.

During the summer of 1960 RAD announced an electric arc jet engine weighing only 3½ pounds, being developed to propel vehicles in space. The miniature power plant was operated in the laboratory continuously for two days producing ¾ of a pound of thrust. The engine eventually will produce power to move satellites about in space for a period of several months.

RAD was also working on a re-entry vehicle for a Mars probe in conjunction with the Massachusetts Institute of Technology. Under another program, RAD will develop a re-entry heat shield for a satellite being developed by Lockheed Aircraft.

The division during the year established an industrial products subdivision to serve as a marketing vehicle for product lines as part of the division's efforts to find new tools for use in its re-entry programs. Among the industrial products being marketed were arc jets, shock test machines, high speed photographic equipment and other environmental devices.

ELECTRONICS AND ORDNANCE DIVISION

In 1960 Avco Corporation changed the name of its Crosley Division to Electronics and Ordnance Division. The change reflected the work done by the division which is engaged almost entirely in the design, development and production of electronics and ordnance items for the armed services.

During the year, the Electronics and Ordnance Division received prime contracts on highly classified ordnance items, missile range safety devices, and a new mobile transistorized communications system, the AN/VRC-12.

The division also continued and expanded its work in the infrared field, conducting "state-of-the-art" research into systems and concepts.

The Electronics and Ordnance Division also was involved in air traffic control, radar and human factors engineering.

NASHVILLE DIVISION

Avco's Nashville Division was engaged during 1960 in manufacturing tail and wing structural parts made of aluminum honeycomb for the Convair 880 and 990 jet transports. The division was also producing aluminum tail structures for the Lockheed C-130 turboprop transport used by the Air Force.

In addition, the Nashville Division held a contract with North American Aviation, Inc., to provide sections of the aft fuselage and some of the bulkheads for the B-70 *Valkyrie* bomber.

During the year, the division announced that it had developed a new and more economical method for producing stainless steel honeycomb. Known as the Avcoramic tooling method, the new technique makes possible the production of very large pieces of stainless steel honeycomb in almost any shape or size and to exacting specifications.

Stainless steel honeycomb is used where high heat resistance and high strength-to-weight ratios are required, such as high Mach aircraft and missiles of the future.

LYCOMING DIVISION

Missile activities were stepped up considerably during the past year by the Lycoming Division, which at the same time expanded development and production of its outstanding lines of reciprocating and gas turbine aircraft engines.

The Division's missile activity was centered in its Stratford, Connecticut plant where work proceeded on nine different programs involving eight different missiles. The Stratford plant also expanded both its T53 and T55 gas turbine programs, while the Williamsport, Pennsylvania facility pioneered further advances in "small" reciprocating engines for the utility aircraft fleet.

Highlighting Lycoming's missile work was production of re-entry vehicles for all three of America's intercontinental ballistic missiles—the Titan, Atlas and Minuteman. Mark IV vehicles for Titan and Atlas were the first to enter production, followed by Mark V vehicles for the solid-fuel Minuteman.

All of these re-entry vehicles are of the high-speed ablation type, as contrasted with the earlier blunt-nosed heat sink models which re-enter the atmosphere at slower speeds. The Stratford plant developed suitable production techniques for the advanced ablation heat shield materials which are employed.

Numerous intercontinental range test firings of Lycoming-built re-entry vehicles were made from Titan and Atlas missiles during the year. The first Minuteman test flights were scheduled for 1961.

Other missile programs included production of rocket chambers for second and third stage Minuteman and second stage Polaris, all under subcontract with Aerojet-General Corporation. Several hundred of these chambers have been produced by Lycoming, with not a single failure during hydrostatic testing.

In addition, Lycoming was also manufacturing Nike-Hercules nose cones, Talos diffusers, Bullpup center sections, and Saturn bulkheads.

In the gas turbine field, two additional models were placed in production—the 960 shp T53-L-5 and the 2200 shp T55-L-5. This brought to four the number of gas turbines being produced at the Stratford plant, the others being the T53-L-1 and the T53-L-3 rated at 860 shp and 960 shp respectively.

The T53-L-5 will power the Bell HU-1B Iroquois, while the T55-L-5 is for the Army's three ton Chinook helicopter now being developed by Vertol Division of Boeing. The latter engine passed its 50 hour preliminary flight rating test in April, a month ahead of schedule, and deliveries to Vertol commenced in August. Its 150 hour qualification test was completed in September. With a weight of 570 pounds, the T55-L-5 provides a power-to-weight ratio of 3.87, the highest of any engine in its class.

Lycoming also received a contract calling for development of two more powerful versions of the T53. The engines are designated T53-L-7 in turboprop configuration and T53-L-9 in helicopter configuration. Both are rated at 1100 shp, and are scheduled to be in production early in 1961. The helicopter engine will be used in the advanced Bell HU-1D and the Bell 204B, commercial version of the Iroquois. The turboprop's first application will in the Grumman AO-1, currently powered by the T53-L-3.

Weight of the T53-L-9 is 485 pounds. Equivalent specific fuel consumption is .652 and output shaft speed is 6610 rpm at takeoff. The turboprop engine weighs 522 pounds complete and has an equivalent specific fuel consumption of .641. Propeller shaft speed at takeoff is 1700 rpm. Both engines incorporate the Lycoming "universal" concept which allows for complete interchangeability of parts except for the reduction gear.

Further growth models of the T53 up to 1400 shp are in the advanced planning stage.

The pace-setting T53-L-1, meanwhile, played a major role in the establishment of eight world records for helicopters. Seven assorted marks for speed, distance and rate of climb were set by a Bell HU-1A, while a Kaman H-43B Huskie climbed to a new altitude record of almost 30,000 feet. Four of the eight records were previously held by Russian helicopters.

The T53-L-1 was awarded commercial certification by the FAA in June, receiving certificate number 1E-6. Commercial designation of the engine is LTC1B-1. Lycoming has also submitted qualification data on the T53-L-3 and T53-L-5 to the FAA.

On the reciprocating engine side, Lycoming's Williamsport plant continued development of several new models for fixed wing, helicopter and drone applications.

The first of these new engines to be introduced was the IO-540, a six cylinder fuel injection model rated at 290 horsepower. The IO-540 was awarded certificate number 1E-4 by the FAA. Its first use is in the new Aero Commander 500B.

Also certificated by the FAA, receiving certificate number 1E-7, was the 380 horsepower IGSO-540. First installation for this geared, supercharged model is in the Aero Commander 680F. Soon after certification, a pair of IGSO-540's powered a 680F to a new world altitude record for class C-1.d aircraft of 37,010 feet.

A third model in this series, a normally aspirated geared version, was also nearing certification and was scheduled for use in the Aero Commander 560F.

Another new development was the IMO-360-B1B engine, designed specifically for drone applications. Rated at 230 horsepower, the engine powers Aerojet-General's SD-2 surveillance drone.

Other developments undertaken by Lycoming included turbo-supercharging of existing engines for improved high altitude performance in both helicopter and fixed wing applications. Turbo-supercharged engines were expected to be available to airframe manufacturers in 1961. Work also proceeded on the IGSO-720, an eight cylinder fuel injection, geared and supercharged engine that develops 520 horsepower.

Progress was made in the company's mechanical constant speed drive program, featuring receipt of the first production contracts. The initial contract called for a number of LG3-1 gear boxes, incorporating a 40 KVA constant speed drive, for the Air Force's Lockheed RC-121 aircraft.

Production also started on 15 KVA LD6-1 drives for the Navy's Douglas A4D5 aircraft, and the LS1-1 AC-DC power system for the Republic SD-4 Swallow surveillance drone. The LS-1 system incorporates a scaled down version of Lycoming's LD3-3 20 KVA drive. As part of the Air Force HotElect program, the company also delivered initial prototype units of a high temperature 40 KVA drive to North American Aviation Corporation. Designated as model XLD4, this drive and its entire electronic system were designed by Lycoming to perform satisfactorily with system components at ambients from —65 degrees F to 600 degrees F.

An entire family of mechanical drives ranging from 10 to 120 KVA was being developed by Lycoming, including some designed for industrial and automotive applications.

Lycoming also performed a number of subcontract jobs for other aerospace companies during the year, including production of main frames for the Republic F-105, missile launching rails for McDonnell jet fighters, and rotor hub assemblies for Vertol Division of Boeing.

The company also continued its development activities in the amphibious hydrofoil vehicle field and achieved exceptionally favorable results from an extensive test program of the famed "Flying Duck."

BEECHCRAFT Super 18 executive transport.

BEECH AIRCRAFT CORPORATION

BEECH AIRCRAFT Corporation in fiscal year 1960, ending September 30, saw Beechcraft business airplane sales soar to a new all-time high of approximately $46.5 million—an increase of more than 22 percent over the previous commercial sales record set in fiscal 1959. Combined commercial and military sales in fiscal '60 were in excess of $98 million, up some $8 million over the total fiscal 1959 volume. Sales of contract products and services in 1960 accounted for more than $51 million of the total.

Contributing to sharp gains in commercial airplane sales were two new models added to the Beechcraft line in 1960—the twin-engine Beechcraft Queen Air executive transport and the new single-engine Beechcraft Debonair. Significantly, continued acceptance of the time-tested Beechcraft Super GI8 was noted by a 37 percent increase in unit sales since 1958.

Other models in Beech Aircraft's 1960 business airplane fleet included the M35 Bonanza, B95 Travel Air, high performance H50 Twin-Bonanza and the standard D50C Twin-Bonanza. By year-end some 1,100 units of all Beechcraft models had been delivered—about 300 more units than shipped in fiscal '59.

Noteworthy achievements in 1960 included a new world altitude record of 34,862 feet for Class C-1.d category airplanes which was established on February 8 by a stock model Beechcraft Queen Air. The year was also highlighted by the unveiling in mid-November of new Beechcraft business airplanes for 1961, the largest executive line in the company's 29-year history. They are 1961 versions of the Super G18, Queen Air, Twin-Bonanza, Travel Air, Bonanza, Debonair and the new Beechcraft Model 55 Baron.

A completely new twin-engine business airplane, the Beechcraft Baron in the fall of 1960 successfully concluded final phases of its test and certification program, following first flight of a production model in September. Powered by two new 260 horsepower Continental (IO-470-L) fuel injection engines, the new Baron will be introduced to the business aviation market in 1961. It is designed to fill a niche between the Beechcraft Travel Air and Twin-Bonanza as a new fast, light twin executive plane, seating four or five persons.

The first transatlantic airlift of Beechcraft business planes occurred in July when three Bonanzas and a Debonair were shipped from the factory in Wichita to Bremen, West Germany, aboard a Lufthansa Airlines Super Constellation which had been converted from passenger transport to cargo carrier. This pioneering airlift was arranged by Travelaire G.M.-B.H., Beech distributor in Bremen, because of economic advantages over ferry flights.

Orders from Beechcraft distributors abroad, for both single-engine and twin-engine models, swelled export sales in 1960 to more than $8.3 million, representing an increase of 60 percent over total foreign sales in 1959.

Creation of a new Marketing Division having responsibility for the worldwide merchandising and marketing of all Beechcraft commercial airplanes and products was announced in September. This change in organizational structure is aimed at strengthening, enlarging and combining within one division all segments of Beech Aircraft's commercial sales effort.

To help meet the challenge of expanding business aircraft markets, the company during the year increased its domestic sales outlets from some 90 to more than 120. Beech export distributors also added new dealers, bringing to over 60 the sales outlets abroad. At year-end plans were being formulated to increase substantially the total number of Beechcraft certified sales and service centers throughout the free world.

In addition to commercial and military production of hardware, Beech in 1960 made important contributions in the fields of product development and space research. For example, at its Boulder (Colorado) Division, the company placed in operation the only "transient heat laboratory" of its kind in America—a unique $1 million facility capable of thermal testing liquid hydrogen fuel systems.

Erected under an Air Force contract, the heavily instrumented heat tower ground-tests complete cryogenic fuel systems in an environment simulating rapidly changing temperature extremes encountered by rockets and missiles in high velocity flight through the atmosphere.

Construction of a new Boulder Division headquarters building on the company's 1,500-acre tract north of Boulder was completed in June. It now houses all division engineering and administration offices. A pioneer in cryogenic engineering, Beech in 1960 conducted production environmental tests of Atlas and Titan ICBM propulsion system components. These tests simulated conditions of vibration, temperatures and pressures produced in flight.

Aerospace programs at Boulder during the year embraced missile component testing, cryogenic engineering and space vehicle propellant system design studies. The work involved contracts with the armed services and other manufacturers and agencies concerned with advanced weapon systems and space technology. Projects included preparation of an advanced design proposal for the Saturn man-in-space program.

In May the Army announced that it had ordered a substantial quantity of new twin-engine Beechcraft L-23F multi-purpose command transports. Initial units delivered under an earlier contract were in Army service in the U.S. and Europe. Earlier in the year the Federal Aviation Agency acquired its second L-23F for use in FAA's continuing program of inflight evaluation of its air traffic control system.

Also in May the Army awarded Beech an order for additional RL-23D Seminole aircraft incorporating new side-looking airborne radar (SLAR) combat surveillance systems. Beech in 1960 continued to build new RL-23D aircraft and modify existing L-23D Seminole transports to the SLAR configuration. Army RL-23Ds previously modified by Beech were carrying out radar observation and radar photographic missions in the U.S., Far East and Europe.

First flight of the new Beechcraft PD 75-4-1 remote-controlled missile target was completed successfully in September at the White Sands Missile Range in New Mexico. Similar in configuration to the Beech-built KDB-1 operational with the Navy and Army, the PD 75-4-1 mounts a new Continental 145 horsepower four-cylinder engine, as compared with the McCulloch 120 horsepower engine that powers the KDB-1.

Privately financed under a research and development program sponsored jointly by Beech and Continental Motors, the PD 75-4-1 is designed to improve performance of the basic KDB-1 target with no increase in unit cost. Other economic benefits are realized because the PD 75-4-1 is compatible with existing KDB-1 ground support equipment and many parts of the two vehicles are interchangeable.

The company in July received a $3 million Army contract for a large quantity of Beechcraft Model 1025 missile targets, a slightly modified KDB-1 system which was originally developed for the Navy. Deliveries under the new order were scheduled to begin in February, 1961. The Army also placed a $1.4 million order for additional KDB-1 targets, supplementing an earlier $1.5 million contract. Production of Navy KDB-1 missile targets also continued through 1960.

At year-end final preparations were being made for the first powered flight of the supersonic XKD2B-1 rocket-powered missile target, in development for both Air Force and Navy. Scheduled to become operational in 1962, the 600-pound XKD2B-1 (USAF designation Q-12) will simulate the radar appearance and performance of enemy threat aircraft. It will fly twice the speed of sound and at altitudes as high as 70,000 feet or more.

Production of aft fuselage sections and ailerons for the USAF Republic F-105 fighter-bomber was continued through mid-1962 under a new $7.7 million follow-on contract awarded by Republic Aviation in August. The order brought to $17 million the total dollar volume of work assigned Beech thus far in connection with the F-105 program.

Other important military projects announced in 1960 included a $1 million Navy contract for development of a high performance jet fighter, ram-air driven inflight refueling system. Beech during the year also furnished dummies, instrumentation and technical services for rocket sled tests of B-58 seat ejection emergency escape systems.

Beech in 1960 was engaged in over 100 different aerospace projects, including prime contracts with the military and subcontracts with other leading manufacturers, such as Convair, Lockheed, Martin, McDonnell, North American and Republic. Production during the year included major assemblies and subsystems for the F-101, F-104 and F-106 jet fighter-interceptors.

BELL AEROSYSTEMS COMPANY

BELL AEROSYSTEMS Company in 1960 celebrated its 25th anniversary and coincidentally experienced a radical change in organization.

In July the three companies representing the defense business of Bell Aircraft Corporation were purchased by Textron Inc., of Providence, R. I. Among them was the Niagara Frontier Division which was renamed Bell Aerosystems Company to reflect the changing nature of the industry. Bell Aerosystems, with Bell Helicopter Company of Fort Worth, Tex., and Hydraulic Research and Manufacturing Company of Burbank, Calif., are now divisions of Bell Aerospace Corp., a wholly owned subsidiary of Textron Inc. The corporate offices are located at the Bell Aerosystems Company plant near Buffalo, New York.

Conforming to the industry shift from the mass production of aircraft requiring large manufacturing areas to specialized facilities, Bell Aerosystems concentrated its efforts in one modern main plant, retaining the ability to support a large productive capacity and an extensive research and development activity as well.

The Aerospace-rockets division expanded its production facilities for the highly reliable Agena rocket engine which is being manufactured for the Discoverer program and the Midas and Samos early-warning and reconnaissance satellites as well as the Ranger moon vehicle and Mariner, planned for travel to Mars and Venus. The Bell engine is adaptable to new high energy fuels and is being continually refined.

The company's research in the area of high-energy fuels for rocket engines has great import for national defense. Having shown the practicability of fluorine as a rocket oxidizer, Bell fired the first complete rocket engine using liquid fluorine and liquid hydrogen, paving the way for the nation to double the payload capacity of present-day space and satellite vehicles.

More than 600 rocket firings were made during Air Force sponsored programs initiated four years ago to evaluate liquid fluorine when used with ammonia and hydrazine as well as hydrogen.

Many of the components used in the fluorine-hydrogen rocket engine are nearly identical to those developed for current space and satellite programs and demonstrate that present day materials, processes and systems can be adapted to fluorine technology under conditions once thought impossible.

Such rocket engines can now be combined with present-day space propulsion systems to show a significant reduction in size and weight with no decrease in performance.

Bell successfully developed precise controls to take the place of conventional control surfaces in the outer reaches of the atmosphere and in the void of space. These small, chemically-activated steam jets are being used in the experimental X-15, the Mercury manned-satellite program, the Agena, Midas and Samos satellites and the Centaur moon vehicle.

Bell organized a new research department whose activities were being developed as a company-wide effort to lead an advance in major areas of aerospace development by defining future requirements, maintaining adequate scientific knowledge, and carrying out certain advanced studies in individual problem areas: propulsion, power, structures and materials, space and vehicle dynamics, biosciences, controls and instrumentation.

The company also was concerned with improving man's capabilities in space by augmenting his physical performance with artificial aids. Studies were underway in the research department on the use of physical devices, the support and augmentation of vision using conversion devices which would allow spacemen to see on different wavelengths, and the retention of images or the amplification of images received from starlight or moonlit terrain.

Bell Aerosystems laboratories were also considering the practicability of limb-motion aids and personal computers to extend to the future man in space new ranges of freedom and survival enabling him to enter environments otherwise inaccessible.

Bell's "human engineers" also conducted studies in the area of pilot comfort and efficiency for manned flight within the atmosphere and

D-188 V/STOL tactical fighter weapon system.

planned further work in this important area.

Extensive and original research in the field of Buck Rogers-type rocket belts for military use has won the company a development contract in this area. Such units would be of inestimable value in field maneuvers providing great freedom and mobility for combat infantry men.

Bell Avionics department, begun more than 15 years ago with a small group of engineers assigned to guidance and servo-mechanism design, has seen spectacular growth and an impressive number of Bell electronic products are now used in missiles and satellites and specialized automatic equipment has been developed for military and commercial aircraft.

Bell-developed miniature accelerometers, unique in the industry, will be used in guidance systems of the Air Force Skybolt air-launched ballistic missile, the Army's Sergeant tactical surface-to-surface missile and the Air Force Midas and Samos satellites. These last two, plus the Discoverer program, also will make use of Bell digital velocity meters, devices which permit precise control of satellite-bearing missiles. High Performance Navigation systems were developed to provide complete guidance and navigation systems for strategic and tactical missiles, aircraft and aerospace vehicles, ship and submarine navigation and drone recovery. These systems use Bell's precise gyros and accelerometers.

The Avionics Division was also responsible this year for the development of a target locater system for the Army which would permit pinpoint location of enemy units. Other developments include air traffic beacon control equipment, radar systems, missile and drone recovery systems, interference-free transmission systems, automatic flight controls and many classified products.

The company's Automatic Landing System, being evaluated by the Federal Aviation Agency for commercial use, was accepted for Navy use aboard fleet carriers and was considered to have great potential for the future.

The serious problem of radio intereference with Army combat units was the subject of intensive study by Bell's Avionics Division. This division was operating a test facility in Arizona to evaluate existing and potential radio interference which handicaps all kinds of Army communications under combat conditions.

For several years Bell Aerosystems has been concerned with the development of V/STOL airplanes. The principle was established with successful flights of the first Bell experimental VTOL test vehicle, now in the Smithsonian Institution in Washington. The concept was further proved with the Bell X-14 which has been undergoing extensive testing by the National Aeronautics and Space Administration.

An advanced, jet-powered, operational VTOL fighter was designed and a complete mock-up constructed in the company's Wheatfield plant. Further studies are underway in this area and on a similar concept utilizing the "ducted propeller" principle for utility and transport aircraft.

Following independent research, Bell was selected by the Navy to design and build a "hydroskimmer," one of a new family of craft which are supported over water by a cushion of air. Hydroskimmers, which have great potential for commercial use as well as military, are capable of high speed with low horsepower since they operate above the water surface with resulting reduction in wave and frictional drag. The company has also successfully tested a commercial vehicle which can operate over land or water.

BELL HELICOPTER COMPANY

THE BELL helicopter organization became Bell Helicopter *Company* on July 2, 1960.

From Jan. 1, 1957, until that date it had been Bell Helicopter *Corporation,* a wholly-owned subsidiary of Bell *Aircraft* Corporation of Buffalo, N.Y.

In 1960, Textron Inc. of Providence, R.I., bought Bell Helicopter Corporation and two other Bell *Aircraft* Corporation operations.

Then Textron organized Bell *Aerospace* Corporation and put it over the helicopter operation (which was renamed Bell Helicopter *Company*) and the two other firms.

Harvey Gaylord, chief executive of Bell's helicopter operation from the time it was moved from Buffalo to Texas in 1951 until July 2, 1960, became on the latter date president of the new Bell *Aerospace* Corporation.

During 1960, about 75 per cent of Bell's business was military, the major portion of it being Army. The company's largest single project was production of the turbine-powered HU-1 Iroquois series, one of which set seven world rotary-wing records in categories of speed, distance and speed-climb in 1960.

Late in the year Bell was filling Army contracts for Model HU-1A and had started on the production-line HU-1B.

A commercial version of the Iroquois, called Model 204B, made a world-wide introductory tour late in 1960. The 204B can carry ten persons. Details were not final, but Bell indicated it might sell for approximately $285,000.

For 1961, Bell planned to produce two three-place models of its popular 47 Series, the 47G-2A and the 47G-3, and the deluxe, four-place 47J-2. Bell 47's were in use throughout the United States and in more than 50 foreign countries.

The firm built ships for the Navy, Air Force, Coast Guard and Marine Corps and was continuing with development, for the Army, of the XV-3 convertiplane. Bell also was operating the world's first helicopter dynamic flight simulator and was doing other pioneering under the Army-Navy Instrumentation Program (ANIP) for which it is rotary-wing industry coordinator.

At close of 1960 Bell Helicopter Company employed approximately 3,200 persons and predicted its business for the year would gross about $50,000,000—biggest volume since 1956.

Company headquarters and main factory are at Hurst, between Fort Worth and Dallas.

MACHINED SURFACES of Nik

BOEING AIRPLANE COMPANY

FURTHER STRIDES into the space age, continued leadership in the commercial and military jet era, advancement in its missile programs and expansion into new fields led the list of Boeing highlights for 1960.

Leading the lot was the go-ahead from the Air Force in April for Dyna-Soar, a program to send an earth-launched manned vehicle into space and, through a controlled re-entry bring it back to earth. The program is being developed by the Air Force with cooperation of the National Aeronautics and Space Administration.

Boeing, as system contractor, is responsible for the manufacture of the vehicle portion of the system. This vehicle will be a delta-winged glider which will be able to orbit the earth, descend through the atmosphere and land like a conventional airplane at an air field of the pilot's choosing.

Under direction of the Air Force Wright Air Development Division, Boeing also will be responsible for tying in the vehicle sub-systems, integrating vehicle and booster, and assembly and test.

Rocket power to hurl the glider skyward will be provided by a modified Titan intercon-

Zeus missile tracking system part.

tinental ballistic missile supplied by the Martin Company.

Dyna-Soar will combine the high speed of a ballistic missile with the controlled and accurate flight of a manned airplane. It will provide the crucial element of human discretion along with an almost infinite choice of flight paths. The Dyna-Soar pilot will be able to shorten or lengthen his range by thousands of miles and to maneuver thousands of miles to the left or right of his flight path to reach his landing site.

The Air Force has labeled Dyna-Soar its "most important research and development project." Both the Air Force and NASA expect to benefit from the testing of Dyna-Soar. It will help the Air Force determine the military use of space and will aid NASA in space research. As a test bed, the vehicle will furnish the opportunity to test military sub-systems under actual space conditions and to determine the capability of man to operate them.

Flight tests of an unmanned Dyna-Soar glider are expected to begin within the next three years. These, and the manned flights which will follow, will be sub-orbital. Later, as the concept and design are proven, it will have a true orbital capability.

Looking still farther into space, Boeing also announced during the year a long-range program for exploring the secrets of space and the vehicles to perform them. This is the PARSECS program—"Program for Astronomical Research and Scientific Experiments Concerning Space."

Intended to take up where presently scheduled national space exploration programs leave off, PARSECS outlines a logical sequence of eight missions and the vehicles necessary to begin basic research within the universe.

Second only to the Dyna-Soar go-ahead was the announcement in December that Boeing will proceed with production of the new model 727 short-to-medium range jet transport. Contracts totalling more than $350,000,000 were signed with Eastern Airlines and United Air Lines, with 40 airplanes to go to each. The two orders were believed to constitute the largest transaction in the history of the transportation industry.

The new 727, designed specifically to bring jet age speed and comfort to the shorter range air routes of the world, will be powered by three Pratt & Whitney JT8D turbofan engines mounted at the rear of the fuselage. It will have a maximum gross weight of 142,000 pounds, and will carry from 70 to 114 passengers, depending upon interior configuration.

It will have a normal cruising speed of from 550 to 600 miles an hour and will operate from 5,000-foot runways with full payload. Deliveries to both Eastern and United will be made beginning in late 1963.

The 727 orders brought the Boeing jet airliner family total sales to 337 aircraft, purchased by 21 airlines and the U.S. Air Force. More than 170 had been delivered to 19 airlines of the world by December, carrying some 32,000 passengers a total of approximately 500,000 miles daily.

Meanwhile, 707 and 720 jet transports continued to roll off the production lines at the Transport Division plant in Renton, Wash., near Seattle, and to go into service on schedule.

In their two years of service the big Boeings established more than 150 speed marks, flew more than 173,000,000 miles, and accumulated some 14,600,000,000 passenger-miles.

Early in the year, the short-to-intermediate range 720 was successfully flight tested to Mach .95 and placed in service, and the first of the 707-120B and 720B turbofan airliners later made their initial appearance. These new models, the world's first turbofan-powered jetliners, are equipped with Pratt & Whitney JT3D engines each producing 17,000 pounds of thrust at take-off and giving improved performance and efficiency. The turbofan engine differs from earlier turbojets in having a large fan, powered by the engine turbines, at the front of the engine. Like an enclosed, many-bladed propeller, the fan pushes air back past the engine as well as through it.

In addition to the new engine, the "B" models incorporate aerodynamic improvements including increased wing sweep-back between the fuselage and inboard engines, for better high speed performance, and added leading edge flap segments which help the wing provide more lift at low speeds. American Airlines and Qantas Empire Airways will have their entire Boeing fleets converted to the turbofan versions, while Avianca, Ethiopian and Lufthansa have them on order.

The year also saw entry into service of the Boeing 707-420 Intercontinentals using Rolls Royce Conway by-pass engines. They were put to work by BOAC, Air-India, Lufthansa and Varig, with El Al to follow.

Meanwhile, alongside the 707/720 production line, KC-135 jet tanker-transports continued to roll from the factory on schedule, with the 400th delivered to the United States Air Force Strategic Air Command in August. One of the Stratotankers also was modified as a zero-gravity test bed to determine how man will fare in an outer space vehicle without the pull of gravity to help him keep his balance.

At the Boeing Wichita Division, conversion to B-52H missile bomber production highlighted the year's activities, with the last B-52G model rolling from the factory on September 23. Deliveries of the B-52G, first of the missile-launching bombers in SAC, were made to a total of 10 bases during 1960.

One of the major changes in the new B-52H called for Pratt & Whitney TF33 turbofan engines which stretched the global bomber's "more than 9,000 miles" unrefueled range by a good margin. Power generated by each of the eight engines was increased by several thousand pounds of thrust.

In addition to B-52 activities, a drive launched in 1958 for diversification of products and services began to pay off during 1960. The new venture, called Boeing Applied Computing Services, offers both large and small firms computer services and increased production capabilities through use of the most advanced large computers and automatic machines. They are operated by commands recorded on specially prepared tape.

In other new business, the Wichita Division made its first venture into missile production with contracts from the U.S. Army Corps of Engineers for manufacture of hardware items to be used in the launching sites of the Atlas ICBM. In addition, work on prototype components of a tracking system for the Army's Nike-Zeus missile defense project was performed on a subcontract.

Another contract, from the Office of Naval Research, involves a study to determine what effects certain vibrations have on the performance of air and space crewmen of the future.

ICBM silo parts.

In the Aero-Space Division missile field, the Minuteman ICBM silo development program, which proved the practicality of a "simple hole silo launcher, was concluded in May when the eighth successful tethered firing occurred at Edwards Air Force Base, Calif. Success of the eight firings eliminated the need for ten additional test shots, saving valuable development time and approximately $10,000,000. The Minuteman is under development by the Air Research and Development Command's Ballistic Missile Division for SAC, with Boeing responsible for assembly, test, launch control and ground support systems.

The fourth train deployment from Hill Air Force Base, Utah, also was completed in August, proving mobility concept of the Minuteman and eliminating the need for two additional test runs. The Air Force announced it will be capable of moving and launching the missiles from any point along the vast United States rail network.

Completion of the Edwards program shifted emphasis to Cape Canaveral, Fla., where the first Minuteman untethered firing was scheduled for late 1960. Construction also was started on a complete Air Force Minuteman launch complex at the Boeing plant in Seattle, where the complete weapon system will be tested to determine the compatibility of the missile and all support equipment. No missiles will be fired from the site, however.

Assembly of the Minuteman will be accomplished at centrally located sites, under conditions conducive to precision assembly and checkout procedures. After assembly, the missile will be transported as a fully checked out unit to the operational site and installed as a unit. Selection of Malmstrom Air Force Base, Montana, as the site of the first Minuteman hardened and dispersed launch complex was announced by the Air Force in March, and ground was broken in September at Hill Air Force Base, Utah, for an assembly facility to be operated by Boeing.

Also still very much in the Boeing missile picture, Bomarc production continued in Seattle, both of the liquid fuel IM-99A and the solid fuel IM-99B. The 100th IM-99A was delivered to the Air Force in March and late in 1960 Bomarc bases were operational in five sites in the United States.

Numerous successful test firings were reported during the year, including direct hits on both supersonic and subsonic targets.

The Bomarc has repeatedly demonstrated its widespread capabilities as an area defense weapon. In flight tests the missile has differentiated between decoys and the assigned target and carried out target reassignment maneuvers. In these maneuvers missiles were redirected from their original programmed targets to secondary drones while in mid-course cruise.

The model "B" test program, although still in its infancy as missile testing is measured, indicates a high probability of surpassing the record attained by the "A" model. Included in the flights of the "B" were successful interceptions of supersonic drone missiles and the longest Bomarc flight to date for either model: a record of 345 miles.

In addition to the missiles slated for the test ranges, nearly 180 tactical "A" missiles have been delivered to the five Bomarc bases now operational with the Air Defense Command. Tactical "B" missiles also are moving off the production line at the Boeing Missile Production Center in Seattle, destined for the eight sites now under construction to handle this advanced weapon in the United States and Canada.

In another area of activity, one long associated with aircraft and missiles, Boeing decided in 1960 to design and manufacture antennas as a separate Boeing product line. Scientific, military and industrial antenna work will be undertaken. An Antenna department was formed to seek antenna business in the fields of deep space tracking, radio telescope observatories, early warning radar and other large-scale, special purpose applications.

Branching into new fields, Boeing acquired Vertol Aircraft Corporation, effective March 31, and the Morton, Pa., firm became the Vertol Division of Boeing Airplane Company. The acquisition included two Vertol subsidiaries—Canadian Vertol Aircraft Co. Ltd., of Arnprior, Ont., and Allied Research Associates, Inc., with laboratories at Boston and a weapons system analysis group at Albuquerque, N.M. Both became Boeing subsidiaries.

Earlier in the year New York Airways announced a contract to purchase a fleet of 10 twin-turbine Vertol 107 helicopters. Production of these 25-passenger carriers was begun to meet a delivery schedule of the first five by mid-1961.

Production also was started during 1960 on the twin-turbine Vertol HC-1B Chinook helicopter which the Army has selected to replace its current fleet of piston engine powered transport helicopters. The initial contract for five YHC-1Bs was supplemented in April for an order for five HC-1Bs, bringing the value of the contract to approximately $36,000,000. First delivery was scheduled for 1961.

In July, the Royal Swedish Naval Administration signed an option agreement for 20 Vertol 107 Model II transport helicopters, with deliveries due to begin in the fall of 1961. The aircraft will be operated by both the Royal Swedish Navy and the Royal Swedish Army.

During 1960 Vertol continued its flight test programs of the Vertol 76 (Army VZ-2) tilt-wing VTOL aircraft in cooperation with the National Aeronautics and Space Administration. Studies in the broad field of VTOL and STOL aircraft continued. In September an Army contract was received to continue a study of an aircraft which would use the ground effect phenomena as a means of supporting the plane at takeoff and landing, with wings providing aerodynamic lift while in cruise.

The Vertol Division also announced plans during the year to build a $2,000,000 engineering research and test facility on a 15-acre tract adjacent to its present flight test facilities near Philadelphia's International Airport.

Another step in a new direction was taken in June when Boeing received a fixed price contract from the Navy to build a hydrofoil craft. Length of the craft will be 115 feet with a full load displacement of 110 tons. It will be powered by two 3,000-horsepower gas turbine engines during foil operation.

Still another step to move in several other directions was announced in September with the formation of Boeing Associated Products within the company. The company said it planned to capitalize outside the aerospace industry on research discoveries and manufacturing processes which have potential commercial application. It was stressed, however, that the new organizations' major interest lies in the area of by-products developed from Boeing effort and that the company has no interest in the manufacture or sale of products which it presently obtains from outside sources.

In Seattle, research continued during the year, highlighted in August by the dedication of the new $2,250,000 Boeing Scientific Research Laboratories which houses scientists conducting basic research in the fields of mathematics, flight sciences, plasma physics, solid state physics and geo-astrophysics.

A number of research endeavors drew considerable attention. These included a method of producing white algae for use as food in space travel, and a new type of altimeter designed for increased accuracy at high cruise altitudes, developed by Boeing for high-performance missiles and jet aircraft. Called a radioisotope density altimeter, the device measures radioactive back-scatter proportional to atmospheric density. Still another was an experimental ceramic graphite-base material which spontaneously forms its own protective coating against heat and oxidization.

In the small gas turbine field, the Boeing Industrial Products Division put new 400-500 shaft horsepower Model 520 engines into production, and propeller tests began on the turboprop 520 and a new 325 horsepower engine. The 325-pound 520 (military T60) passed its 50-hour preliminary flight rating run in September and became the first free-shaft turbine in its class to pass this test. It is designed for helicopter use.

Boeing also received a contract for T50 gas turbines for use in the Navy's new anti-submarine drone helicopter. Engines of 325-horsepower rating also were installed in the world's first gas turbine powered fire trucks in Seattle and San Francisco.

Sales of gas turbine driven compressors used for aircraft pneumatic ground support passed the 200-unit mark during the year, with customers including 12 world airlines and four aircraft service firms.

Boeing sales for the first nine months of 1960 totaled $1,202,225,628, with net earnings of $16,167,061, or $2.03 a share. Sales for the first nine months of 1959 had been $1,160,634,984 with net earnings of $8,276,239 or $1.06. The Boeing Board of Directors discontinued the annual stock dividend and changed the quarterly cash dividend rate to 40 cents per share. Since 1956 company policy provided for a quarterly cash dividend of 25 cents, supplemented annually by a stock dividend. The Boeing backlog at September 30 amounted to $1.8 billion and included $416 million of commercial jet transport orders.

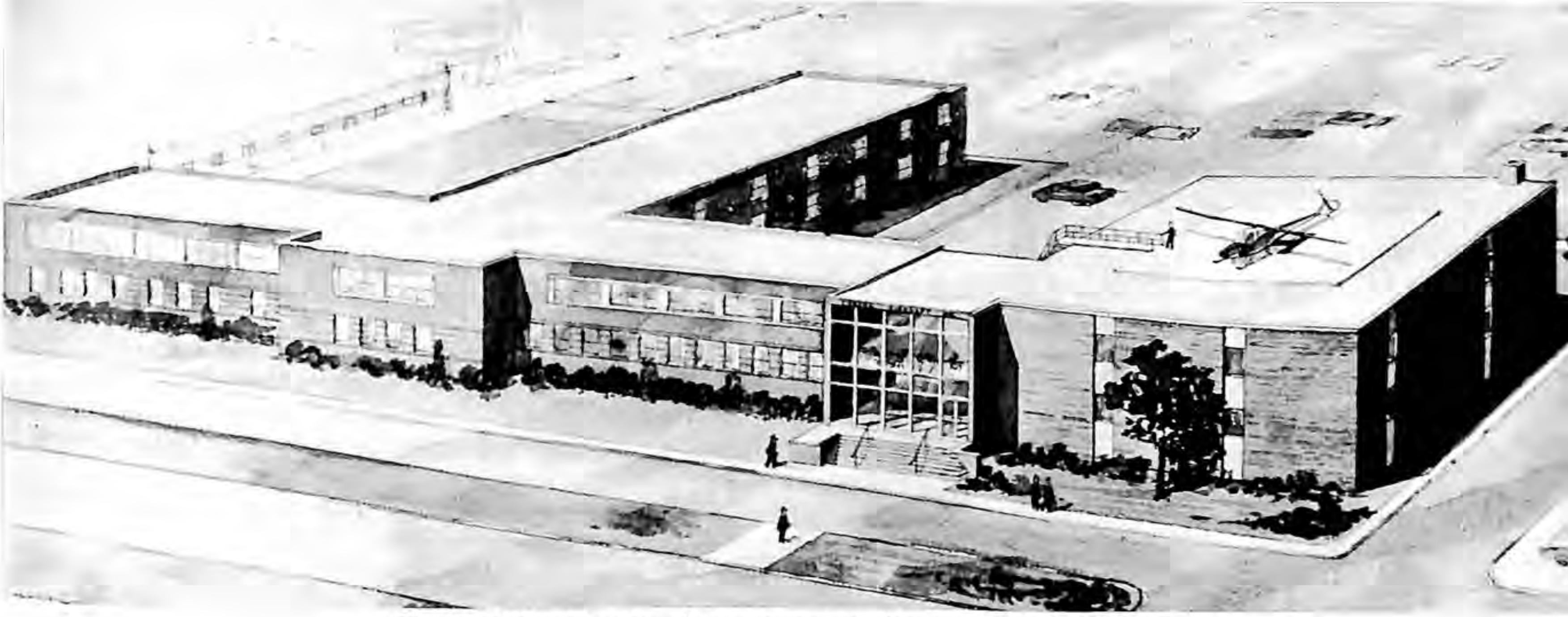
CESSNA AIRCRAFT COMPANY

TOTAL SALES for Cessna Aircraft Company during the 1960 fiscal year were $103,-278,000, second highest in the company's 33-year history. Commercial aircraft sales were $56,104,000, an increase of 20 percent over record sales of $46,623,000 in 1959.

During 1960, Cessna marketed a total of nine commercial airplanes ranging in price from $7,250 to $59,950. The company added three new models to its 1961 line for a total of 12 models.

The three new additions to the 1961 commercial product line included the Skyhawk, a deluxe version of the popular Model 172 which during 1960 outsold any other airplane; the Skywagon, a six-place aerial station wagon with conventional gear designed to carry heavy loads, and the Skyhook, an advanced new four-place rotary-wing aircraft. Other models in the commercial aircraft line include the 150, 172, 175, Skylark, 180, 182, Skylane, 210 and 310F.

During 1960, Cessna completed a multimillion dollar expansion of its Industrial Products Division at Hutchinson, Kansas, which manufacturer hydraulic pumps, valves and cylinders for farm machinery and mobile industrial equipment. The expansion included a new 130,000 square foot addition to the main factory building, plus a new 18,000 square foot



DRAWING of proposed new two-story Cessna office building.

experimental laboratory and a 10,000 square foot engineering building.

In January, 1960, shareholders approved an increase in authorized capital which resulted in a three-for-one stock split. Additional shares of common stock were issued on March 4 to stockholders of record February 8.

Cessna acquired a minority interest in the French aircraft firm of Avions Max Holste in February. This interest brought together an impressive inventory of engineering and production skills that are expected to be of great mutual benefit to the future of both companies.

In June, Cessna announced the formation of a fourth operating division known as the marketing division, which will be responsible for the worldwide merchandising and marketing of all commercial aircraft products.

The Air Force placed an order in July for 35 additional U-3 aircraft which is the military version of the commercial Model 310. Deliveries on the new contract start in December, 1960 and continue through June, 1961.

On July 22 the FAA announced the approval and certification of the world's first helicopter for flight under instrument flight rules (IFR) conditions. The machine was the Cessna CH-1C which had previously been certificated for VFR (visual flight rules) operation.

On July 25, Cessna announced plans to enter the light-light twin market with a new business plane of completely different design. The new model is expected to be on the commercial market in 1962 and will represent a basic new approach to twin-engine aircraft philosophy. It is expected to make its maiden flight early in 1961.

In August, Cessna acquired McCauley Industrial Corporation of Dayton, Ohio as a wholly-owned subsidiary. The McCauley firm is a leading manufacturer of propellers for business and private planes.

During August, Cessna received a $3,800,000 contract from Republic for follow-on production of stabilizer, fin and rudder components for the F-105 Thunderchief. The new contract extended production through mid-1962.

On September 8, the first transporter-erector container for the Air Force Minuteman ICBM was completed at Cessna and flown to Bendix Pacific Division in Los Angeles. After additional equipment installation, the container was to undergo extensive operational emplacement cycling testing. The container is a special air conditioned atmospherically controlled trailer-tractor designed to house missiles while they are being transported to launching or storage sites and for erecting and lowering the missile into an underground silo. The complete unit has been developed by Cessna, Bendix and General Motors for Boeing, the prime contractor on the Minuteman program.

On October 11, the company announced it was entering the commercial rotary-wing aircraft market with the Skyhook, which is the first rotary-wing vehicle in aviation history to be supported by a wold-wide organization to provide readily available parts and service to every owner.

In November, 15 new Model 180's were delivered to the U.S. Army Aviation Center at Fort Rucker, Alabama to be used by Army student pilots for testing an unusual concept in basic flight instruction.

The new training method will combine visual flight techniques with basic instrument flying during the early days of student training to teach students the importance of making both visual and instrument techniques a part of their normal flying habtis.

A record mass flyaway of new commercial airplanes got 1961 off to a good start when a total of 350 new airplanes worth about $4,000,000 were delivered at the October International Sales Meeting.

CHANCE VOUGHT CORPORATION

THE NATION's third oldest aero-space company began 1961 as Chance Vought Corporation, dropping the word "aircraft" from its former name—Chance Vought Aircraft, Incorporated—to reflect its diversity more accurately.

Approved by company shareholders at a special meeting November 22, 1960, the change became effective December 31.

"Diversification activities of the past two years have seen us outgrow our present name," said F. O. Detweiler, president. "Far from meaning that we intend to relinquish our position in the aircraft field, the name change simply means that our operations have expanded beyond the point where one product line is completely descriptive."

"Aircraft and related activities continue to form the largest portion of our business but the company now is functioning also in such significant and diverse fields as electronics, astronautics, industrial automation, business data processing, mobile homes, and missile and satellite range systems. The name Chance Vought Corporation will be more descriptive of our present business."

Chance Vought's 1960 operations were geared to the development of weapons, systems and vehicles designed to operate in areas ranging from outer space to the ocean depths.

The organizational structure incorporated five divisions doing business with the government—Aeronautics, Astronautics, Range Systems, Electronics and Research. Each had specific responsibilities for meeting the challenges created by tremendous technological advances which have taken place.

In addition to its five divisions, Chance Vought in 1959 formed Vought Industries, Inc., a wholly-owned subsidiary operating in the mobile homes market and headquartered in Dallas, and acquired a majority interest in National Data Processing Corporation of Dallas, manufacturer of data processing equipment.

In a move further to diversify the company's operations, Chance Vought early in 1960 formed Information Systems, Inc., operating in the field of industrial automation. Information Systems, Inc., with headquarters in Los Angeles, absorbed Genesys Corporation, established in 1958 as a Chance Vought subsidiary.

While making advances into diversified fields, Chance Vought continued as a builder of high performance aircraft. The Aeronautics Division had delivered more than 750 of its record-breaking Crusader fighters to the Navy and Marine Corps and orders for advanced versions extended production schedules through 1962.

Mainstay of the division's production activities was the F8U-2N, latest in the Crusader line. Reaching the fleet during 1960, it joined the F8U-1, the F8U-1 photographic airplane and the F8U-2.

In the missile field, the Aeronautics Division was active on its supersonic low-altitude missile —"Project SLAM"—under an Air Force study contract received in August, 1958. A nuclear-powered, low-altitude intercontinental missile, SLAM could deliver devastating nuclear weapons anywhere on the globe with extreme accuracy.

In addition, the division in October, 1960 revealed details of a unique propulsion/control system concept for VTOL/STOL aircraft utilizing power from four jet engines driving ducted fans. The concept was identified by the name ADAM, standing for Air Deflection and Modulation. The division had been working on the design of its ADAM concept since 1958, using company funds.

The Aeronautics Division was developing under an Air Force contract an advanced, self-contained guidance system which will direct missiles or manned aircraft to their targets with extreme accuracy. Other projects include anti-submarine warfare, new types of land and sea vehicles, nuclear and radioisotope projects, battlefield missiles, advanced crew accommodations, new emergency escape systems, material and fabrication advances.

The Astronautics Division was named prime vehicle contractor for Scout, the solid-propellant research rocket expected to become a "work horse" in the National Aeronautics and Space Administration's research programs. Since the outset of the program, the division had produced the transition sections between stages, the stage separation devices, the jet vanes and fin assemblies, wiring and other components which make possible the uniting of the rocket motors into an effective research vehicle. Under the new program Chance Vought Astronautics responsibility also will include final assembly and launch of the vehicles.

Also, the division was airframe contractor for the Air Force's technically designated 609A test systems, popularly called "Blue Scouts" to distinguish them from their NASA counterparts. It fabricates for three stages of Blue Scout components similar to those it supplies for the NASA Scout.

During 1960 the Astronautics Division remained active in man-in-space work and in conceptual designs for unmanned payloads. Areas of endeavor included rockets, various types of satellites, satellite interceptors, new materials for space vehicles and components, guidance and instrumentation systems, optical and radar reconnaissance systems, life sciences, simulators for astronautical training, crew restraint systems, fabrication of propulsion components, launch operations and numerous other facets of space conquest.

Chance Vought's Electronics Division developed new types of highly advanced actuators for the Minuteman intercontinental ballistic missile, the nation's first solid-propellant ICBM, and produced them under contract to Autonetics, a division of North American Aviation, Inc. A pioneer in the field of powered control systems, the division also produced prototype actuators for the Saturn space rocket.

In addition, it contributed new antenna concepts, produced autopilot and guidance systems, ground support and checkout equipment and played a key role in the company's antisubmarine warfare and guidance system projects.

Among new products were: a video correlator, which greatly increases the effectiveness of radar for aircraft, ships or land bases; antenna couplers, which can quadruple the volume of messages handled by transmitter and receiver units and reduce the number of antennas required by airports in high density traffic areas; a relatively simple twin-gyro controller, which provides the "muscle power" to keep a space vehicle in the desired location; and a small, light-weight C band beacon for use in missiles and aircraft for tracking purposes.

A new multi-polarized antenna which can do the work of four separate types of antennas in operating with missiles or space vehicles was also developed by the Electronics Division.

When the first U.S. astronaut is lofted into orbit around the earth in a Project Mercury space capsule, the Range Systems Division will be operating one of 17 ground tracking stations incorporated in a worldwide network. The division signed a contract with the Pacific Missile Range, acting for the National Aeronautics and Space Administration, to operate and maintain an instrumentation facility at Kokee Park on the Hawaiian island of Kauai.

The division was supplying drone services for the Bomarc test program at Eglin Air Force Base, Florida, using the KD2U-1, a Mach 2-plus target vehicle based on the design of the submarine-launched Regulus II.

At El Centro, California, under Air Force contract, the division was operating a whirl tower for high speed testing of parachutes as well as a radar and photographic tracking complex to record high and low-altitude drop tests of various parachute designs for planes, missiles and space vehicles. Here it also tracks and photographs satellites for the Air Force.

Range Systems was called upon by the Air Force to make a study to determine range space needed for space vehicle operations. It also was given the contract for instrumenting the USNS *Range Tracker,* the Pacific Missile Range's first tracking vessel.

Chance Vought's Research Division was working toward providing the "tools" engineers will need to solve re-entry problems of the future, dealing with speeds in the realm of 70,000 feet per second or nearly three times escape velocity. Principal areas include aero-physics, electronic sciences, energy sources, life sciences and materials which will withstand the extreme high temperatures of space flight.

Application of these areas includes solutions of re-entry problems for space vehicles, detection methods for missiles, submarines and aircraft, space vehicle auxiliary power and control, life support systems and development of high temperature materials and coatings for nose cones, vanes and other space vehicle components.

The company, in its 1960 nine-month financial report, reported sales totaling $169,753,012 and net income of $2,727,340, or $2.29 a share. Unfilled orders at September 30, 1960, including orders represented by letters of intent, amounted to $211,000,000.

CONTINENTAL AVIATION AND ENGINEERING CORPORATION

THROUGHOUT 1960 two J69 engine models were in production at Continental, namely the J69-T-25 for the Cessna T-37B twin-jet trainer and the J69-T-29 for the Q-2C, Ryan's latest

FASTEST BOMBER, the delta-wing B-58 Hustler.

"Firebee" model. The Production Division also expanded its program of subcontracting activities compatible to its excellent capability and available capacity for close tolerance, multi-operation machining of highly refined precision parts for industry.

The J69 proved itself to be an important item in American powerplant inventory. At the end of 1960, over 900,000 engine operating hours had been logged in the USAF Primary Jet Training Program. This was exclusive of production, research, overhaul and airplane flight test operations which coupled with the "Firebee" target drone programs would extend total J69 operation hours to date over the 1,000,000 hour mark.

Research and development programs in turbine powerplants and their application were continuing with increasing scope and optimism for the future. Many advanced models growing out of the J69 program were developed and were awaiting industry application. These included aircraft turbojets of 1400 and 2400 pounds thrust, turbofan engines of the "aft-fan" type at 2600 and 4000 pounds thrust, a target-missile turbojet of 2550 pounds thrust, altitude thrust augmentation devices for existing turbojets, and the J69-T-35 air pump for boundary layer control on large transport aircraft. In addition to gas turbine engine powerplant system technology, Continental simultaneously continued its pioneering in advancing the art of the solid fuel ramjet engine and its application as the propulsion device for various weapon systems concepts.

A company sponsored development program produced a completely new series of turboshaft and turboprop engines in the 500-600 horsepower class. One of these, the 217-5A, 6000 RPM, 500 horsepower turboshaft engine was designated T72-T-2 by the Navy.

The ten year license and sales agreement between Continental and Turbomeca, S.A. of France for the exclusive sale and production of Turbomeca engines in the U.S. was extended. Under the agreement close coordination will be maintained for the sale and manufacture of each company's gas turbine engines.

CONVAIR

A DIVISION OF GENERAL DYNAMICS CORPORATION

CHIEF AMONG the research, development and product achievements of the Convair Division of General Dynamics Corporation during 1960 were these:

Remarkable flight performance of the Atlas intercontinental ballistic missile, including two flights of more than 9,000 miles;

Setting of a world speed record of 1,525.95 miles per hour by an F-106 advanced all-weather interceptor;

Inauguration of scheduled passenger service by Delta Air Lines with its Convair 880 jet transports, subsequent to setting of a transcontinental speed record by an 880;

Start of Convair 880 service December 15th by Northeast Airlines;

Roll out of the first Convair 990 November 20, 1960 (formerly the 600).

Start of flight tests of the Convair 880-M and continued output of basic 880.

Commissioning of the first Navy ship, the USS Dewey, to be armed with advanced Terrier guided missiles, and of the first ship, the USS Adams, to be equipped with Tartar missiles;

Continued development of the Army Redeye shoulder-fired missile system;

Announcement of development of Mauler, an Army, mobile, battlefield air defense missile system;

Continued production of B-58 Hustler bomber and Air Force announcement that the B-58 was operational;

Initial flight of TB-58, bomber-trainer version of the B-58.

On the executive level, R. C. Loomis was appointed vice president and manager of the San Diego operating division, succeeding B. F. Coggan.

Total Convair employment in the General Office, the Scientific Research Laboratory and the five operating divisions in California and Texas was 65,548 on October 3, 1960, compared with 67,232 on September 25, 1959.

CONVAIR-ASTRONAUTICS

Several important firsts were attributed to the Atlas intercontinental ballistic missile during 1960, including the first successful space vehicle launching using Atlas as the main booster. The division expanded its inventory of space testing facilities and capital equipment, and the Atlas base activation program gained momentum.

Tempo of early Atlas flight testing increased during the last half of 1959, and by early March, 1960 a remarkable record had been achieved. In less than nine months, 21 Atlas missiles were launched consecutively and successfully. The 17th and 18th missiles of this group were flown on January 24, one by an Air Force Strategic Air Command operational crew across the Pacific Missile Range, and one by a Convair-Astronautics test crew down the Atlantic Missile Range. Three of the 21 flights traveled 6,300 miles; most of the others averaged about 5,500 miles.

Atlas employed a new inertial guidance system for the first time in a successful flight March 8, 1960. The new system is under development by American Bosch Arma Corporation. Subsequently all-inertially guided shots took place June 11, 1960, and on October 13, 1960.

The October 13 firing was the one in which three mice were tucked away in a life cell of the Atlas nose cone, boosted 700 miles into space, and landed near the bull's-eye impact area. During this shot, the Air Force's new Azusa Mark II missile tracking system built by Convair-Astronautics tracked the nose cone. So accurate was the predicted impact point that the mouse-carrying nose cone was picked up within minutes after landing, the occupants still alive, to bring the United States closer to its goal of manned space flight.

On May 20, 1960, Atlas 56-D placed an operational-type nose cone on target more than 9,000 miles from Cape Canaveral, Florida. This historic flight ended beyond the southern tip of Africa in the Indian Ocean. Missile 56-D was not a "super" Atlas, for it was identical in power to D-series missiles in the nation's operational inventory. The extended journey—some 2,675 miles beyond the usual range—was made possible by reprogramming the Atlas flight path. The missile could have flown much farther, for it carried an additional 1,000 pounds of test instrumentation not normally installed in operational Atlas nose cones. Another Atlas flew 9,000 miles on September 19.

The series E Atlas, with its 30,000-pounds' more thrust than the D series (360,000 pounds), was tested for the first time this year. Eventually scheduled for launching from underground silo emplacements, Atlas Es are equipped with the powerful MA-3 engine, produced by North American Aviation, Inc.'s Rocketdyne Division. The series E Atlas is capable of even greater ranges than the 9,000-plus-mile series D Atlas.

Convair-Astronautics, as principal associate contractor for Atlas, also was responsible for establishing technical criteria for Atlas launch complexes, integrating installation of ground support equipment, activating Atlas bases, and turning them over to the Strategic Air Command in operational condition. Thirteen operational squadrons are assigned to SAC, involving construction of some 129 launching pads extending from Washington to New York.

Since Vandenberg Air Force Base, California, attained operational status in September 1959, several Atlases have been added to the base's complement. All three types of Atlas launch complexes were in use or under construction at Vandenberg: the early vertical tower arrangement; the hardened horizontal, or "coffin," arrangement; and the underground silo.

First Atlas squadron for Warren AFB, Cheyenne, Wyoming, was activated in August 1960. The second complex, Warren II, was to be completed in early 1961, and work was progressing at other Atlas launching sites. Thirty months are required to construct each launch pad and install and check out equipment.

The National Aeronautics and Space Administration (NASA) announced that Atlas will be used in more than 100 different major scientific space launchings during the 1960s. Atlas is booster for Project Mercury (man-in-space) and for the Atlas-Able lunar probe. On May 24, 1960, Atlas served as booster in the first successful launching of a Lockheed-built Midas early warning test satellite. The shot placed the satellite into as near a circular orbit as had ever been attained. Atlas also boosts the Samos advanced satellite reconnaissance system.

ARTIST's concept of U.S. Army's Mauler.

Production of the Atlas-Centaur high-energy liquid-hydrogen space vehicle was well under way in 1960. Centaur, the nation's first space vehicle, is capable of sending a 4½-ton satellite into low orbit, soft-landing a 750-pound spacecraft on the moon, or sending probes into deep space. Centaur also is the first space vehicle in the free world to utilize liquid-hydrogen engines. They were developed for the project by United Aircraft Corporation's Pratt & Whitney Aircraft Division.

During the year the division completed a \$1-million electronics manufacturing building and an aerospace laboratory, the latter featuring a pair of 35-ton high-vacuum tanks capable of duplicating space and near-space environments at altitudes up to 100 miles. The division installed a new IBM 7090 electronic data processing system for use in studying nose cone reentry problems and ballistic trajectories, and to help determine probable courses for Atlas-Centaur.

Division employment on November 1, 1960, totaled nearly 22,800 persons, including off-site personnel, as against approximately 17,000 on November 1, 1959.

CONVAIR-DAINGERFIELD

Research and developmental testing of full-scale supersonic jet engines for missiles and aircraft was achieved during 1960 by the Ordnance Aerophysics Laboratory at Daingerfield, Texas, operated by Convair for the Bureau of Naval Weapons, Department of the Navy. This work was conducted primarily for BuWeps' Bumblebee Program. Work was also accomplished for other Department of Defense programs.

Daingerfield test facilities included two cells for testing full-scale jet engines under simulated flight conditions from sea level to altitudes above 120,000 feet and at speeds up to Mach 5. Two sea-level cells and a part-scale cell were also in operation. Supporting facilities included instrumentation, high-speed data processing, shops and maintenance equipment. Employment remained essentially constant at 225.

CONVAIR-FORT WORTH

Advancements along seven aerospace fronts in research, development and production were achieved at Convair-Fort Worth during 1960.

These included continued production of the B-58 Hustler supersonic bomber, which was officially declared operational August 1, 1960, and which only 45 days later won first place in high and low-level bombing in Strategic Air Command's 1960 combat competition; continued production of TB-58s, trainer-bomber versions of the B-58; continued conversion of early test B-58s to latest SAC operational configuration; continued production of F-106 fuselage sections for Convair-San Diego's assembly line; continued limited output of revolutionary new nose cones for the Atlas-Centaur space vehicle; continued research and development leading to building the nation's first atomic-powered aircraft, the Convair NX-2; and design and development of a new advanced-type airborne all-weather reconnaissance system to be flight-tested in B-58s.

For builders of the B-58, the year's high point was the capturing of first place in SAC's bombing competition by the 43rd Bomb Wing, 19th Air Division, Carswell Air Force Base at Fort Worth. The 43rd Bomb Wing won the competition against 12 other bombers, all of which had many years of operational experience. It was the B-58's first competition, and this with an aircraft that only 45 days earlier had been declared operational. Never before had a newly operational bombardment weapon system won this event.

During the year, the division continued delivering B-58s to the Air Force to round out the nation's first supersonic bomb wing, the 43rd. After the 43rd is fully equipped, B-58s will be assigned to the 305th Bomb Wing at Bunker Hill AFB, near Peru, Indiana.

The division also turned out reworked B-58s that had already gone through extensive flight testing. Instrumentation first was removed and the aircraft then worked over to make it equivalent to the latest production configuration. This gave the Air Force 13 combat-ready B-58s at a fraction of the cost of building 13 B-58s from the beginning.

On May 10, 1960, date of its first flight, Convair-Fort Worth unveiled the first TB-58, the B-58 trainer-bomber version. Four TB-58s were on order, each to be produced by converting earlier B-58s. In the TB-58 configuration, identical externally to the B-58 except for added window area, the airplane can be flown from either the forward crew compartment (housing the pilot in the bomber version), or the second crew station (housing the bombardier-navigator in the bomber version). In the TB-58, twin flight controls are provided in both the first and second stations. USAF will use TB-58s to expedite jet transition and proficiency training for pilots due to fly B-58 missions for SAC.

Among more advanced work performed by the division was that on nose cones for Atlas-Centaur and on the nuclear-powered NX-2 for USAF.

The first nose cone for Atlas-Centaur was delivered in October to Convair-Astronautics at San Diego for tests to prove that its fiberglass sandwich construction is adequate to protect the space vehicle's payload as it travels through the earth's atmosphere. It is designed to be jettisoned in space after passing through the atmosphere. Subsequent nose cones were for actual Atlas-Centaur vehicles to be used in flight tests.

Though the division has been working nine years toward a nuclear-powered aircraft for USAF, it was only in 1960 that design studies of two possible versions of the aircraft were released for publication. Division drawings showed two swept-wing aircraft basically the same except for changes required to accommodate two different nuclear powerplants. Each has the same swept wing and each shows a cluster of jet-like engines mounted in the fuselage tail. The canard-type planes lack conventional tails. At each wing tip is a vertical stabilizer-rudder assembly. Horizontal stabilizer-elevator surfaces are placed forward on the fuselage, like stubby wings. One design calls for direct-air-cycle nuclear engines being developed by General Electric Company. The other is for indirect-cycle engines under development by Pratt & Whitney. Which type will be used in the first plane had not been determined.

Convair-Fort Worth employment was 17,828 on October 3, 1960, as against 19,660 on September 25, 1959.

CONVAIR-POMONA

Production of advanced Terrier and Tartar supersonic surface-to-air guided missiles continued during 1960 at the Naval Weapons Industrial Reserve Plant operated by Convair at Pomona, California.

Three Bureau of Naval Weapons contracts for production of both missiles were announced: one for \$25.2 million for advanced Terrier; one for \$41.3 million for Tartar; and the third for \$32.5 million for advanced Terrier and Tartar.

The advanced version of the original Terrier significantly increases the Navy's defense capability against air attack. The new Terrier series has greatly improved effectiveness against low-flying aircraft and multiple targets, and extends the missile's current anti-aircraft capability to provide defense for surface targets and land installations. Advanced Terrier will have considerably more transistorization than the original Terrier.

First ship to be armed with advanced Terrier is the USS Dewey, commissioned late in 1959 as the first Navy guided missile destroyer leader (frigate).

Original Terriers have been operational in the fleet since January, 1956. At present, Terrier and advanced Terrier-armed ships include the guided missile cruisers Boston, Canberra, Providence, Topeka and Springfield; the guided missile destroyer Gyatt, and guided missile de-

CONVAIR's new rocket-powered ejection seat.

stroyer leaders (frigates) Dewey, Mahan, Coontz and Preble. Additional advanced Terrier-equipped ships will be commissioned during the next two years, including two conventional carriers and several guided missile frigates.

Eventually advanced Terrier will be installed in the nuclear-powered guided missile cruiser USS Long Beach, and in the nuclear-powered guided missile frigate USS Bainbridge.

Terrier also is suitable for beachhead operations by the Marine Corps. The 1st Medium Anti-Aircraft Missile Battalion, stationed at the USMC base, Twentynine Palms, California, is equipped with mobile Terrier missiles.

Tartar will serve as primary anti-aircraft batteries aboard destroyers and secondary batteries on cruisers. This missile first appeared in the fleet with the commissioning of the destroyer USS Adams, in September 1960, and will eventually be installed on 21 destroyers and three cruisers now under construction or conversion. Fifteen feet long and slightly more than a foot in diameter, Tartar contains in a minimum of space a complex homing system, a dual-thrust rocket motor, and a new type auxiliary power supply. Tartar's homing guidance system is composed of several inter-related units so constructed they form the missile's basic airframe. Each unit houses a major part of the homing and control system and can be easily replaced if necessary.

Tartar's solid-grain, dual-thrust rocket motor provides high thrust for a short duration to launch and accelerate the missile to supersonic speed. A lower-thrust, long-duration rocket maintains the supersonic speed until target interception. The dual-thrust rocket motor is an integral part of the missile, and no external booster is required. This design helps conserve space aboard small ships like destroyers. The missile's tail fins fold down during shipboard storage, another space-conservation measure. When Tartar is moved on to the launcher, the tail surfaces automatically "pop" into position. An improved warhead, which detonates at close proximity to the target, increases Tartar's effectiveness.

During 1960, research and development work continued on Redeye, an infra-red, shoulder-fired, surface-to-air, guided missile system, with Convair-Pomona receiving an additional Redeye research and development contract totaling $6.3 million. A joint Army-Marine weapon, the readily man-transportable Redeye is being developed under the direction of the Army Rocket and Guided Missile Agency's Ordnance Missile Command. Redeye will give combat troops the capability of destroying low strafing or bombing aircraft. The missile launcher is about 4 feet long and 3 inches in diameter, and weighs about 20 pounds. It is a composite structure containing propellant, an electronic guidance system, and a highly explosive warhead.

In March 1960, the Army designated Convair-Pomona the prime contractor for Mauler, a battlefield air defense missile system, and subsequently awarded the division two Mauler research and development contracts totaling more than $13.7 million. Mauler is a compact, highly mobile weapon. It will use solid-fuel, radar-guided missiles to destroy short-range, enemy tactical missiles and high performance aircraft that bomb, strafe, harass or reconnoiter near forward battle areas. Each Mauler unit will be contained entirely in a single-tracked vehicle of standard design, fully mobile and able to deliver accurate fire while moving.

Mauler units will be light enough to be carried by fixed-wing aircraft or helicopters, and to be dropped by parachute into battle positions. Each Mauler unit will contain its own power supply, target detection and electronic computer fire-control equipment, and its own battery of missiles. One man may operate the Mauler system, but each Mauler unit normally will carry a crew of two or three men: the operator, a driver/radioman, and, when required, a commander.

In October, Convair-Pomona was awarded one of six study contracts by the U. S. Army for FABMDS, or Field Army Ballistic Missile Defense System. FABMDS is a proposed missile system capable of moving with and protecting Army units in the field from threats posed by a variety of ballistic and guided missiles.

The division continued support programs for other phases of Convair production and worked on various ground support equipment projects. The division developed and built a set of training panels for the U. S. Navy Training Device Center, Port Washington, New York, and conducted a second study for the Federal Aviation Agency, one covering FAA communication operations in the Miami, Florida, area.

Convair-Pomona employment totaled 6,433 on October 31, 1960, as compared with 5,987 a year earlier.

CONVAIR-SAN DIEGO

Major production programs at Convair-San Diego were concentrated during 1960 on F-106A/B advanced all-weather supersonic jet interceptors for the Air Force and Convair 880 and 990 jet transports for domestic and foreign airlines. Electronics output increased substantially over that of previous years.

An F-106A production aircraft set a new world's speed record December 15, 1959, at Edwards Air Force Base, California. Maj. Joseph W. Rogers, Air Defense Command pilot, streaked 1,525.95 mph over a straight course at 40,500 feet, in east-to-west and west-to-east runs to conform with Federation Aeronautique Internationale requirements.

Another F-106 flew itself non-stop across the continent March 23, 1960. Maj. Frank Forsyth, chief F-106 acceptance pilot for Air Materiel Command, lifted the interceptor off the Palmdale, California, runway. A minute later, the F-106 picked up an electronic signal from the ground, Forsyth took his hands off the controls, and the F-106 flew itself to Jacksonville, Florida.

Still another F-106 demonstrated its low-level striking capability skimming at tree-top height over 300 miles of Southern California desert at 700 mph. C. E. "Chuck" Myers, Convair engineering test pilot, made the run during a test mission out of Edwards AFB. Nearly all the flight was made in turbulent air at elevations of 50 to 300 feet above the ground. The performance demonstrated the interceptor's suitability for low-level tactical missions in addition to its normal interception assignment at altitudes above 50,000 feet.

The conversion of 35 Air Force F-106 test aircraft to tactical configuration was initiated early in the year to include replacing nose and cockpit with new components and installing new equipment and systems. Program cost was to total nearly $20 million.

Nearing the end of a four-year intensive program, the testing of the Convair-designed ejection seat for supersonic aircraft was in its final stages at Edwards AFB and at Holloman AFB, New Mexico. In an entirely new concept, the system propels the pilot and seat vertically from the plane's cockpit. Dummies were successfully ejected from the aft cockpit of an F-106B at speeds up to Mach 1.74. Test ejection of human beings was scheduled early in 1961.

In the field of commercial jet transports, a Convair 880 flown by a Delta Air Lines crew set a transcontinental speed record February 10, 1960, spanning the continent from San Diego to Miami in 3 hours 31 minutes, 54 seconds. The 880 was Delta's first of 13 Convair jet transports on order. Delta was first to inaugurate 880 passenger service in a New York-to-Houston flight on May 15, 1960.

Convair's newest jetliner version, the 880-M, made its first flight in San Diego on October 3, 1960. The first 880-M is the No. 1 Convair 880, modified to its new configuration. Leading edge slats were added to create additional lift. Powering the 880-M are four General Electric CJ-805-3B engines, each providing 450 more pounds' thrust at sea level than the basic 880 engines. The 880-M landing gear was designed for heavier operating weights to permit installation of additional fuel tanks to carry an extra 1,850 gallons of fuel. Fourteen 880-Ms were on order.

Deliveries of the medium-to-long-range Convair 990 jet transport (formerly the Model 600) will begin in 1961.

A $400,000 shock-driven wind tunnel was completed at Convair's seaplane ramp. This hypersonic laboratory operates from Mach 7 speeds to Mach numbers of 25 (approximately 18,750 miles per hour) at altitudes of 350,000 feet.

A $90,000 ultra-high-vacuum test chamber began operating in July. Designed to duplicate space conditions at altitudes as high as 250 miles above the earth, the chamber consists of a 10-ft.-in-diameter stainless steel chamber, a pumping system to create ultra-high vacuum, a 1200-gallon tank for liquid nitrogen, and a control panel. Within-chamber temperatures may range from minus 300 degrees to plus 700 degrees Fahrenheit.

Final unit of a high-temperature structures research laboratory was installed to complete the $1-million electronically controlled information system for the inter-division facility.

Construction of a $500,000 cafeteria was completed in August.

Convair-San Diego's Engineering Department included approximately 3,500 personnel at the end of October 1960. Research and development programs under way included studies of space vehicles, anti-missile projects, electronics projects, supersonic transports, and other types of aircraft.

Convair-San Diego employment dropped from 24,440 on October 1, 1959, to 19,423 on October 1, 1960.

CONVAIR SCIENTIFIC RESEARCH LABORATORY

Among the 30 projects carried on during 1960 by the Convair Scientific Research Laboratory was a high-altitude physics program using large sky-hook balloons to make measurements from sea level to 120,000 feet. The program concentrated on gamma ray flux and the energy spectrum of the sun during period of abnormal activity. To achieve this, procedures called for launching specialized Convair-developed instrumentation on 12-hours' notice. Coordination with the High Altitude Observatory at Boulder, Colorado, provides the advance warning to insure obtaining the greatest amount of useful data from each flight.

The laboratory's operation of the radio astronomy site at Clark Dry Lake near Borrego Springs, California, yielded a provocative set of observations. Measurements taken during the occultation of the Crab Nebula by the solar corona during June 1959 and again in 1960 tend to prove that models of the solar corona advanced to date are incorrect. Import of this discovery with respect to space flight in the solar system and its effect upon the earth's environment was being studied.

The laboratory developed two new refinements of techniques for measuring surface tension. One, employing measurements of magnetic permeability, is adaptable to high-temperature systems. The other is an adaptation of the bubble-pressure method to the measurement of surface tension at liquid-liquid interfaces. Results of experiments using each method established the validity of a new theory for adhesion previously proposed by the laboratory.

Theoretical studies included calculation of the absolute energy spectrum of the earth's neutron albedo and the probable injection source of the inner Van Allen radiation belt. Studies of non-equilibrium flow and the effects of chemical reactions in high-temperature gas dynamics were conducted. Of especial interest in connection with the latter study was the observance of the structure of strong normal shock waves, the effects of burning in the boundary layer on laminar and turbulent boundary layer characteristics, and the non-equilibrium structure of wakes.

The laboratory, with 60 staff members, of whom 48 are scientific and technical personnel, continued to support and monitor many other basic research programs in Convair operating divisions and for universities throughout the country.

CURTISS-WRIGHT CORPORATION

CURTISS-WRIGHT Corporation continued to place increasing emphasis on propulsion and electronic programs during 1960. Research and development efforts were intensified in the aerospace field, supplementing products being produced for the military services and industry generally.

In April, 1960, announcement was made of a VTOL type aircraft which utilizes new radial lift type propellers to both lift the airplane vertically and provide thrust for horizontal flight. The test airplane, using the radial lift propeller principle developed by the Curtiss-Wright Propeller Division, was flown successfully at 5,000 feet altitude, at high speeds. Vertical landings were made from 4,000 feet. Future versions of the airplane were being designed for vertical landing and takeoff, speeds up to 400 miles per hour and operation at 17,500 feet altitude.

Development work continued at the Wright Aeronautical Division on various versions of the Curtiss-Wright Rotating Combustion Engine which was revealed in November, 1959. Developed jointly by Curtiss-Wright Corporation and NSU Werke, of West Germany, this entirely new type of internal combustion engine has only two major moving parts and offers an excellent weight to horsepower ratio. Several versions of the engine, suitable for both aircraft and industrial uses, were undergoing extensive operational tests.

Flight tests have been completed by the Propeller Division on mechanical controls and actuation systems for aircraft and missile use. Culminating several years of development work, the mechanical servo and actuation systems withstand extreme temperatures, eliminate all fluids and provide fast response. Contracts were received by the division for the production of the "power-hinge" which will be used in the Air Force B-70 bomber. Designs were completed for an all mechanical flight control system for present day aircraft and thrust-vector actuation systems for missiles.

CURTISS-WRIGHT VTOL type aircraft.

Development and advanced engineering work continued at the Wright Aeronautical Division on a family of prepackaged throttable liquid rockets, ramjets, supersonic turbojets, turbofan and dual cycle engines which are projected for future aircraft developments. Production also continued on versions of the Curtiss-Wright Turbojet engines which are in use in first line Navy carrier-based aircraft.

Turbo Compound engines manufactured by the Wright Aeronautical Division, continued to carry the major portion of commercial air travel on both domestic and overseas routes. The Turbo Compound also continued in use on current long-range military patrol aircraft.

In the electronics field, several important contributions were made by the Electronics Division during 1960. Under Navy and Air Force development contracts, the Photran Land Mass Simulator was designed and built to train radar operators in navigation, bombing and tactical missions. Photran provides a realistic radar image of any land mass, 400 miles by 600 miles, through the use of a unique 7 inch by 10 inch photographic transparency map that reproduces exactly the radar reflectivity characteristics of any selected area. Through use of Photran, radar operators can be trained to recognize any target in the world from altitudes ranging from treetop to the maximum capability of current aircraft.

Another training device, the Radar Maintenance Trainer, was placed in use by the Army Signal School's Radar Division, at Fort Monmouth, New Jersey. This unit economically and efficiently trains radar maintenance and repair personnel to maintain and repair current complex radar sets now in use and provides for familiarization in new radar developments.

To facilitate transition by flight crews and maintenance personnel from piston to jet engine operations, the Curtiss-Wright Electronics Division produced a Jet Engine and Systems Crew Trainer. This new trainer, introduced in 1959, provides economical and thorough visual training in jet engine operation, cockpit control relationships and malfunction analysis. The Jet Engine Trainer can be built to include any appropriate jet aircraft engine system which substantially increases the capability of the unit.

The Electronics Division also announced development of a C-Band Meteorological Radar set, a high powered, precision land-based radar designed to detect and analyze weather phenomena. The distinguishing feature of this special purpose meteorological radar is increased cloud penetration that develops more accurate data than can now be obtained with standard radar units.

Extensive work was done during 1960 at both Wright Aeronautical Division and Metals Processing Division to develop new metallurgical and manufacturing techniques for the manufacture of space age metal products.

Contracts were received at Wright Aeronautical Division for the production of rocket motor cases, utilizing new metal spinning, welding and fabricating techniques, for the Minuteman and Pershing missiles. Nozzles and other missile components were also produced.

At the Metals Processing Division, the world's largest steel extrusion press was used to produce special steel alloy launching rails for the Atlas missile. Special alloy steels were also extruded into 40-foot long T-sections, which are fabricated into structural members for the U.S. Navy's newest type nuclear powered submarines.

During 1960, the Research Division of Curtiss-Wright emerged as one of the largest producers of beryllium oxide components for nuclear applications. Fabricated beryllium oxide components are essential to the construction of high temperature nuclear reactors, since it will give high performance at temperatures up to 3,000 degrees Fahrenheit. Curtiss-Wright produced beryllium oxide components were being used in several nuclear reactor systems currently being designed and engineered, including the Tory II-A program.

Production of products in the nuclear field were concentrated in the Princeton Division of Curtiss-Wright Corporation. A nuclear system department was specializing in the design and manufacture of rod control systems for reactors and the division is now the largest supplier of such controls for nuclear submarines.

Design and construction of a Food Process Development Irradiator for the Army was being done at the Princeton Division, and contracts were received to supply irradiator equipment to South America.

The division was also producing a broad line of isotopic control and testing equipment for industry.

Production of the Swench, the first manual impact wrench that works, was begun by the Marquette Division during 1960. Used to loosen the most stubborn "frozen" nuts or for precision tightening, the Swench is a compact, hand operated impact wrench that multiplies torque applied to the handle more than 15 times, and delivers it as torsional impact each time the handle is advanced 30 degrees. Swench has wide application in many industries for loosening nuts that were previously burned or sledged off.

DOUGLAS AIRCRAFT COMPANY

STEADY PRODUCTION of commercial and military aircraft, manufacture of a variety of missiles and boosters for space vehicles, plus the award of four major new contracts highlighted activity at the Douglas Aircraft Co. during 1960.

Early in the year, Douglas received the go-ahead for development of the Skybolt air-launched ballistic missile, a "stand-off" weapon with 1000-mile range, to be added by 1964 to the arsenals of the Strategic Air Command, USAF, and Bomber Command, Royal Air Force.

The company was nominated in May to develop and produce the S-IV second stage of the C-1 three stage Saturn space vehicle for the National Aeronautics and Space Administration. Contract cost of development and production of 10 second stages is more than $65 million, including spares.

The company was awarded a Navy order for the new and improved version of the Skyhawk, to be designated A4D-5. In addition, Douglas received a $71.5 million contract from the Navy for additional production of the A4D-2N version of the Skyhawk, Navy's lightest attack aircraft. Douglas had previously received three contracts totalling approximately $232 million for A4D-2N production at the El Segundo Division.

Finally, Douglas was named in July by the Navy as prime contractor for the development of the Missileer, launching aircraft for the Eagle, a long range air-to-air missile. Missileer will be produced at the Douglas El Segundo Division.

The company's Long Beach Division delivered to domestic and foreign airlines during 1960 more than 90 DC-8 Jetliners, valued at nearly $500 million. Long Beach also produced nearly 50 C-133A and B type transports for the USAF.

In February, Douglas and Sud Aviation of Toulouse, France, reached a working agreement whereby Douglas would represent Sud in all matters pertaining to the Caravelle medium range jet transport in large areas of the world and have rights to its manufacture in the United States.

Research and development was proceeding on Nike-Zeus, an anti-missile missile, which Douglas will produce in partnership with Western Electric, Bell Telephone Laboratories, and others. It was announced during the year that operational tests would be conducted over the Pacific Missile Range, in which Zeus, from sites on Kwajalein in the Marshall Islands, would intercept intercontinental ballistic missiles fired from Vandenberg AFB or Point Arguello on the California mainland.

The Douglas-built Thor IRBM was reordered by the Air Force. An additional 21 of the rockets will be delivered for continuing satellite and space probe programs. The Thors will be modified to accommodate the Agena B second stage vehicle carrying assorted scientific and military payloads. In October, Thor became the first intermediate-range ballistic missile to reach the 100-launch milestone when it successfully blasted the Courier satellite into space.

The deployment of three tactical squadrons

SPIDER WEB NET used as separator for bulk loading of new Speedfreighter.

of Thor ICBM's to the United Kingdom was completed during 1960.

The Air Force placed with Douglas additional orders for the air-to-air MB-1 Genie rocket, bringing to $100 million the total value of Douglas awards for the nuclear weapon since the program was started.

During the year, employment at Douglas showed an appreciable decline, due in part to the continued transition in missile and rocket work, and in part to deceleration in some delivery programs.

CHARLOTTE DIVISION

In 1960 the Charlotte (N.C.) Division became a fully integrated facility with the assignment of research and development responsibility for free-flight rocketry. The organization was further strengthened by the transfer of Weapon System management and technical responsibility for the Nike Hercules missile and Ground Support Equipment. Throughout 1960 delivery of Hercules missiles and airframe components for the XM-50 (Improved Honest John Missile) was maintained at a steady rate.

TULSA DIVISION

The Douglas Tulsa (Okla.) Division, in 1960 named the overhaul, modification and repair center for the company, was engaged in maintenance work for the Air Force, Navy, and Army.

Modification work for the Air Force included awards on the B-47 and B-50; Navy, TV-2; and for the Army, target missiles. Over 3,000 aircraft have been modified at the Oklahoma facility.

Tulsa was also doing missile engineering and fabrication assignments for the company's other divisions. In 1959, the plant received from Santa Monica the project of designing, fabricating and assembling second and third stage missiles for the National Aeronautics and Space Administration's Delta series. It was a Delta vehicle that placed the huge Echo communication sphere in orbit.

THE GARRETT CORPORATION

EXTENSIVE RESEARCH and development programs enabled The Garrett Corporation to report at the end of fiscal 1960 the highest sales and profits in nearly 25 years of company operations.

Sales for the fiscal year 1960 were recorded in the amount of $223,824,326 and net profit after taxes was $5,776,584 or $5.42 per share. These figures compared to sales of $193,641,345 for the previous year and earnings of $4,767,796 or $4.48 per share.

J. C. Garrett, president, explained the record sales and profit picture as a direct result of large expenditures for research and development made out of prior year's profit.

The figures indicated that Garrett's 10,000 employees working in eight divisions and two subsidiaries responded to a formidable challenge as technological demands increased in intensity and scope. The diversity of Garrett's area was indicated by the fact that nearly 300,000 purchase orders were processed to record its sales record.

Garrett's largest division, AiResearch Manufacturing Division of Los Angeles, continued to pioneer the field of environmental controls and avionic instruments.

AiResearch continued to work on production orders for environmental equipment and systems for such aircraft as the Boeing 707, 720; Lockheed Electra; Grumman Gulfstream; Fokker Friendship; Northrop T-38; Caravelle; Lockheed C-130; and others. Its cabin compressors recorded more than 40 million hours of operation aboard aircraft.

It also added the B-52H to the list of aircraft air conditioned by AiResearch.

One of the largest single sales efforts in the history of AiResearch Los Angeles centered around the various versions of the F-104. As a result, AiResearch's central air data product line and air conditioning and pressurization equipment was sold for almost every version of the famed all-weather fighter. In addition, air data systems were produced for the A3J and F4H aircraft.

For space, AiResearch technology produced environmental control systems for Project Mercury and North American's X-15. AiResearch developed a unique space capsule which enabled the Air Force to simulate space flight on the ground. At the end of the year it was proposing on Dyna-Soar and Apollo projects.

In the areas of heat transfer equipment, electromechanical systems, missile power systems and air conditioning systems, AiResearch's products found increasing application and acceptance. In each of these areas AiResearch recorded many engineering breakthroughs. It was also awarded a variety of research and development contracts in these areas.

AiResearch's capability and experience in the environmental field was clearly demonstrated by the end of fiscal 1960 when the company announced it had designed or produced environmental equipment capable of sustaining man at every level of existence—from the bottom of the ocean, in hostile environments on earth, or at extreme altitudes in space.

Garrett's AiResearch Manufacturing Company of Arizona, the free world's largest producer of small gas turbines, announced during the year that its 9000th turbine was delivered.

AiResearch Phoenix found even more applications for gas turbines in the automotive industry, oil industry, and marine industry. The Arizona division today produces highly reliable gas turbines in the 30 to 1000 horsepower range.

Largest user of the AiResearch turbines was the Air Force. The compact units are mounted in carts, on tractors or in such craft as the C-130 and C-133 transports, or KC-135 jet tankers as airborne auxiliary power units.

Other AiResearch turbines power missile systems such as the Army's Sergeant, and provide main propulsion for helicopters. Airborne turbines also serve in the Grumman Gulfstream and other business aircraft.

More than 200 AiResearch turbines were in use at year-end by foreign and domestic commercial airlines. Airlines using turbines for main engine starting and ground electrical power included: American, Braniff, Continental, Eastern, National, Pan American-Grace, TWA, Western, KLM, and Qantas and Northeast.

Two significant space contracts were awarded AiResearch during the year. The Air Force's Wright Air Development Division selected AiResearch as the prime contract for the SPUR project, the nation's largest nuclear space power system.

The SPUR project will produce a 300 Kilowatt space power system.

AiResearch also received a contract to produce a power system using solar power. The solar contract calls for the first test of a space boiler and heat storage unit actually using the sun as a heat source.

Traditional AiResearch Phoenix products continued to find broad use in the aerospace industry. Starters, constant speed drives, valves and controls were sold to both military and commercial airliners.

Of special note is the success in selling starters to the Air Force and commercial manufacturers despite intense competitive efforts. These highly reliable and efficient units enable a jet to start independent of ground support equipment.

AiResearch Aviation Service Division entered a new area of aircraft modification with a contract to convert Convairs from piston power to Napier prop-jet engines. Several completed planes have already been delivered to Napier Engines, Inc., and will ultimately go into service with Allegheny Airlines.

Development of a unique "stinger" power system, designed to make prop-jet powered Convairs completely independent of ground support equipment, was announced. Hub of the installation is an AiResearch gas turbine mounted in a depressurized section of the airplane's tailcone.

AiResearch was fully prepared for the 1961 advent of the Lockheed JetStar as a business executive aircraft. First-hand information relative to executive interior requirements was obtained by visits to Lockheed's Marietta (Ga.) plant, a cabin mockup fully equipped for business use was built at AiResearch, and interior designs were being worked out with future owners. Underway was a program for installation of passenger interiors into North American's military T-39 jet (Sabreliner).

During 1960, Viscounts, Gulfstreams and F-27s were modified with AiResearch executive interiors.

An improved type of aircraft escape slide, designed specifically for jet powered airliners, was developed by the Air Cruisers Division, Belmar, N.J. Flexibility of the slide reduces rate of passenger's descent near the ground. The division went into production of air springs, or inflated containers, to provide a riding cushion for missiles during transportation. Also developed were impact deceleration bags to absorb landing shock for operational recovery of missile drones. In line with its life vest and life raft production, Air Cruisers gained an exclusive contract for sales of a new, water-activated CO_2 inflator developed by Henry Engineering Co. of Burbank, Calif.

These developments carried on in Garrett's divisions resulted in not only expansion of interest area and technology but also facilities and areas of operation.

Three divisions of Garrett increased their facilities during the year. In addition, a number of agreements in Europe were entered into, further establishing the "Garrett" name in France, Germany, England, the Netherlands, Switzerland, Belgium, Australia, and Italy. In Japan, Garrett (Japan) Ltd. was established. All these foreign activities were directed by Garrett International S.A., a wholly owned subsidiary of The Garrett Corporation.

GENERAL ELECTRIC

FLIGHT PROPULSION DIVISION
LARGE JET ENGINE DEPARTMENT

THE FLIGHT Propulsion Division's Production Engine and Jet Engine Departments were consolidated to become the Large Jet Engine Department, early in 1960.

The multi-record breaking J79 turbojet, which has powered more than half of the free world's Mach 2 flight, passed its 100,000th hour of flight time. The J79 at year-end was powering the Lockheed F-104 Starfighter, North American's A3J Vigilante, the McDonnell F4H Phantom II and the Convair B-58 Hustler. The four-engined Hustler, America's first supersonic bomber, became operational with the Strategic Air Command in August.

In September, twin J79's powered the F4H to two unofficial closed course speed records. The Navy's F4H averaged 1216.78 miles per hour in the 500 kilometer closed course run, bettering by 400 miles an hour the former record held by an Air Force RF-101 Voodoo. A Phantom II also claimed the 100 kilometer closed course record by averaging 1390.21 miles per hour; bettering both the official course record of 1167.35 mph held by the Air Force's F-105B, and an as-yet-unrecognized Russian claim of 1298.7 miles per hour by a T-405 aircraft.

The first production models of the J79-8 were delivered to the Navy in September. These engines were to power the F4H and the A3J in fleet deployment, when these Mach 2 aircraft become operational in 1961.

In the foreign programs area, General Electric completed shipment of J79-7 engines for West Germany's F-104F trainer-fighter aircraft. The West German F-104G's produced in Lockheed's American plants will be powered by American-built J79-11 and -11A engines. The improved J79-11 and the F-104 airframe will be produced in West Germany under licensing agreements with General Electric and Lockheed.

In December, the Large Jet Engine Department began shipment of "Dash 11A" engines to the Air Force for delivery to Japan.

Development activity on the Mach 3 J93 turbojet, scheduled to power the North American B-70 Valkyrie, continued through 1960, with a significant step-up in the latter part of the year following renewed interest in the B-70 weapons system by the Department of Defense. The engine incorporates such proven J79 design principles as the variable stator compressor, single shaft design, and a converging-diverging exhaust nozzle.

In 1960, the Large Jet Engine Department entered the marine and industrial gas turbine market with the Model 240 turboshaft engine. The first model of the 240, a modification of the J79-2 turbojet engine coupled with a power turbine, was scheduled for installation in the Maritime Administration's 80 ton hydrofoil craft by mid-1961. The craft was being built by Dynamic Developments, Inc., a subsidiary of the Grumman Aircraft Engineering Corporation. Subsequent models of General Electric's Model 240 will incorporate a modified version of the company's commercial CJ-805 gas generator.

COMMERCIAL ENGINE OPERATION

In May, 1960, the Convair 880, powered by four CJ-805-3 turbojets, entered regular airline service. On its maiden flight with Delta Air Lines, the 880 established a new transcontinental speed record by flying from San Diego to Miami in 3 hours, 31 minutes and 54 seconds.

The CJ-805-23 aft-fan engine flew for the first time in February, powering a company-leased RB-66. This was the first time an engine manufacturer had ever flight tested a turbofan engine as the primary powerplant of an aircraft.

The company then began an extensive flight test program of the engine, highlighted by a demonstration tour of the east and midwest. The CJ-805-23 engine is scheduled to enter service before mid-1961 on the Convair 990 Coronado.

General Electric announced that it had purchased a Caravelle from Sud Aviation in December, 1959. The airplane was delivered to the company in this country in July, 1960. The purpose of this move was to make a GE-powered version of the Caravelle available to the world market as soon as possible by demonstrating the improved performance of the aircraft with the company's aft-fan engines.

First flight of the GE Caravelle, powered by CJ-805-23 engines, occurred in December, 1960. A flight test program is planned, followed by extensive demonstration tours.

The company's turbojets were slated to power Convair 880's on order by AVENSA of Venezuela, Civil Air Transport, Delta Air Lines, Japan Air Lines, Northeast Airlines, Alaska Airlines and Trans World Airlines. CJ-805-23 engines will power the Convair 990, now on order from American Airlines, Swissair, Scandinavian Airlines System and REAL of Brazil.

AN/SPS-30 radar atop the mast of the USS Macon.

SMALL AIRCRAFT ENGINE DEPARTMENT

General Electric's Small Aircraft Engine Department (SAED) in 1960 made significant progress in development of gas turbine engines for commercial aircraft and industrial applications.

Following announcement of the 4,200-pound-thrust CF 700 turbofan engine in 1959, the department unveiled in March, 1960, a companion engine, the 2,700-pound-thrust CJ610 turbojet. The 355-pound engine was designed for medium-size business aircraft ranging in gross weight from 8,500 to 18,000 pounds.

In the industrial field, SAED announced addition of a 1,000-horsepower gas turbine based on its military T58 engine. Its high power-to-weight ratio, 3.1 to 1, suits it for a variety of stationary and mobile tasks. The Model 720 industrial gas turbine has been selected to power hyrofoil boats, emergency generator sets, oil field fracturing units, gas line pumping stations and military amphibious vehicles.

Contracts for military and commercial production engines represented the largest in history of the department. Orders totalling more than $90,000,000 were received for the J85 turbojet and the T58 turboshaft engines.

In other developments, the J85-7-powered GAM-72 decoy missile made its first free flight in March, 1960. In late June, the Strategic Air Command made the first successful multiple launch of the decoy missile. The J85-7 develops 2,450-pounds of thrust.

General Electric in July received from the

Air Force a bailed T-38 "Talon" trainer for its flight evaluation program. Twin afterburning J85-5's power the supersonic trainer. Both the -5 and -7 engines were fully qualified and entered production in 1960.

In the commercial engine line, the department's CF700 and CJ610 companion engines are continuing to undergo parallel development. The basic J85 gas generator is used in both of the new commercial engines.

Two unofficial 150-hour endurance runs were completed in 1960. Both engines are scheduled for certification in 1961.

The 1,250-horsepower T58-8 turboshaft engine passed its qualification test last year and has entered production. A growth version of the 1,050-horsepower T58-6 production engine, the -8 configuration was being used in the Navy's Kaman HU2K and Sikorsky HSS-2 programs.

Three other milestones were reached with the T58. It successfully completed a 2,000-hour endurance run, was granted a 1,000-hour allowable time between overhaul on the Sikorsky S-62 for non-scheduled operations and received FAA production facility certification.

Applications for the CT58-110, commercial version of the military T58-8, were announced for the DC-3 size Vertol 107 and Sikorsky S-61 turbocopters which will enter passenger service in 1961. This engine is rated at 1,250-horsepower and was FAA certificated in December 1960.

Sikorsky's S-62, a 10-passenger craft powered by the CT58-100, late in 1960 became the first turbine-powered helicopter to enter scheduled airline service. The turbocopter was placed in service by Los Angeles Airways.

Two new configurations were added in January 1960 to SAED's existing T64 turboshaft and turboprop models. A direct drive turboshaft version, designated T64-GE-6, and a turboprop model with the gearbox offset above the engine line, T64-GE-8, were unveiled. The T64-2/-6/-A turboshaft engines are rated at 2,650-horsepower and the -4/-8 turboprop engines are rated at 2,700-horsepower. Both basic configurations completed official 50-hour preliminary flight rating tests ahead of schedule in 1960.

The T64 turboprop was to be flight-tested late in the year on de Havilland's Caribou.

AIRCRAFT ACCESSORY TURBINE DEPARTMENT

In 1960, General Electric's Aircraft Accessory Turbine Department made significant contributions for marine and aircraft applications.

A portable power supply representing one of the first practical military applications of fuel cells—devices that convert chemical energy directly into electricity—was developed by the department. General Electric's program was the first aimed at building a fuel cell power source that can be mass-produced and made available to the military as an off-the-shelf item.

Producing 200-watts of 24-volt direct current for 14 hours, the 35-pound power pack can be carried easily by one man and will take the place of a 55-pound engine generator or 80 pounds of secondary batteries. If operated continuously over longer periods of time, it requires only additional increments of fuel.

A unique hydraulic power package was developed to provide power for the flight control system of the Navy's Polaris missile. The unit is an integrated package combining the characteristics of an existing direct current motor with a new variable displacement, pressure compensated, ball-piston pump. The new variable displacement pump takes no more space than a fixed-displacement pump.

A self-contained starter, normally used on aircraft engines, will be used to start a 600 horsepower gas turbine engine to drive shipboard generator sets slated for use by both the Navy's Bureau of Ships and the Federal Republic of Germany.

New turbodrives for oxidizer and fuel boost pumps to be incorporated in a unique, lightweight fuel system for an advanced space probe went into production.

More than 3,000 hours of successful flight testing of General Electric's hydraulic constant speed drives were logged on a leased Air Force RB-66 jet.

G-E turbo alternator drives achieved a record of 70,000 drive flight operating hours without an unscheduled removal during operations of B-52 "Stratofortress" bombers of the 99th Bombardment Wing at Westover Air Force Base.

Announcement was made of the successful development of sheet metal turbine buckets that cut costs and weight of small turbine wheels by more than 50 per cent.

AIRCRAFT NUCLEAR PROPULSION DEPARTMENT

During the year, General Electric's Aircraft Nuclear Propulsion Department (ANPD) began design of a high-performance nuclear turbojet system which will be available for flight in mid-1965. The new system is a developmental extension of the Heat Transfer Reactor Experiments (HTRE) which have produced a technology now applicable directly to flight systems, including those which will be supersonic.

The latest of these, the HTRE-3, involved the simultaneous powering by atomic energy of two modified General Electric J47's in the first such successful operation of its kind in the world.

This assembly, in which the reactor was placed in a horizontal configuration, operated for more than 120 hours on the ground. Of this total time, 65 hours were continuous. Both reactor and engines performed in accordance with all design specifications.

These historic experiments were carried out by ANPD at the Atomic Energy Commission's Idaho Falls test station. General Electric operates ANPD, with headquarters at Cincinnati, for the Air Force and the AEC.

ANPD was developing a direct-cycle nuclear propulsion system for aircraft that will have almost unlimited range. Such a nuclear powered plane will be adaptable as a strategic bomber, for reconnaissance, missile launching, and airborne alert. Earlier in its history, ANPD conducted the first successful operation of a jet engine on nuclear power at the Idaho Test Station, located at the AEC's National Reactor Testing Station.

Other ANP accomplishments included:

1. Completion of the first endurance run of the aircraft nuclear propulsion system turbomachinery.

2. Development of metals for fuel elements and moderators to meet initial power plant flight test requirements.

3. Establishment of the fundamental stability of nuclear power plant control systems.

4. Verification of the theoretical reactor physics and full-scale power plant feasibility.

5. Effective use of fuel and moderator in the reactor to produce optimum power distribution.

6. Establishment of nuclear principles on shielding work, with assurance that special shielding work in progress can be completed successfully.

7. Development of the first electronic components, for control of an atomic reactor, which operated successfully at 845 degrees fahrenheit and in high intensity radiation for more than 1,000 hours.

8. Development of reactor technology materials to the point where they benefited the Army package power plant program, the nuclear missile (project Pluto) and the nuclear rocket (project Rover) programs.

HEAVY MILITARY ELECTRONICS DEPARTMENT

Heavy Military Electronics Department products in 1960 ranged from mobile and shipborne electronic equipments to fixed radars weighing many thousands of tons, and included tiny encapsulated electronic components for marketing to other defense industry prime contractors.

In the field of electronic control and guidance, the department was engaged in design, development, and systems management work on the 412L Air Weapons Control System. This is an advanced air defense system designed to coordinate a wide variety of defensive weapons. It has been nicknamed "The Little SAGE" since it will be used outside of the Continental United States. The department also was designing and producing the AN/GPA-73 Data Processing and Display Subsystem, which is the heart of the overall 412L System. In the missile guidance field, the department was responsible for developing and producing the ground electronic equipment for the radio-command guidance system used by the Atlas ICBM, and the precision tracking subsystem for the new Missile Trajectory Measurement System (MISTRAM) being developed by General Electric for the Air Force.

For missile defense, the department was producing, installing, and placing in operation the world's largest radar for ballistic missile early warning at Thule, Greenland and Clear, Alaska. This giant surveillance radar will play a major role in the USAF's Ballistic Missile Early Warning System. Similarly, the department was developing and producing an advanced high power acquisition radar (HIPAR) for use with the Improved Nike-Hercules Weapon System.

This radar played a key role in the destruction of a Nike-Hercules by another Hercules missile in tests at the White Sands Proving Ground in Southern New Mexico. Highly specialized developments also were underway in the areas of counter-counter measures and space vehicle detection, location and cataloging.

Undersea warfare equipments being designed and produced by the Heavy Military Electronics Department included the AN/SQS-26 antisubmarine sonar, believed to be the world's largest for surface ships, and the AN/UQS-1 and other advanced mine detection and classification sonars. The department's sonar aboard the USS Nautilus and the USS Skate on their historic under-the-pole voyages enabled these nucleared-powered submarines to detect open areas in the ice-cap for surfacing.

For land warfare, the Heavy Military Elec-

MODEL of General Electric's Valley Forge Space Technology Center.

tronics Department was providing combat surveillance, weapons instrumentation and direction finding equipment. Typical field combat equipments included the AN/MPQ-4 Mortar Locator, T-7 Muzzle Velocity Chronograph, and TPQ-10 Close Support Equipment.

A wide variety of surface-based air defense radars also were produced by the department. These included the AN/FPS-6 Height Finder, AN/FPS-8 Search Radar, AN/SPS-8 Shipborne Height Finder Radar, AN/FPS-24 Frequency Diversity Search Radar, as well as combination search and height-finding radars such as the shipborne AN/SPS-2 and ground-based AN/FPS-7.

The department's development work in low-noise amplifiers resulted in record breaking reception of Pioneer IV signals at more than 407,000 miles through space, with the satellite transmitting signals of less than two-tenths of a watt. A specially developed solid state parametric amplifier made this feat possible. Other advanced developments in the electronic component area included *computer logic elements* in the form of encapsulated modular circuits of transistor logic forming building blocks for military tactical computers; *magnetic shift registers* in the form of high performance magnetic modules which provide temporary data storage for digital data processing equipment; *memory packs* in the form of a completely encapsulated ferrite core coincident current memory planes for application in military environments; *wire sonic delay lines* which provide long delays, with excellent temperature stability, in a small package; *electrically variable delay lines* providing infinite steps of delay variation by electrical control; as well as piezoelectric ceramics, barium titanate, lead metaniobate and microwave and high frequency ferrites.

The Heavy Military Electronics Department's Electronics Laboratory in Syracuse provided applied research and development in dielectric materials and devices, thermionics, energy sources, advance circuitry and displays, microwave, radar, communications, computers and data processing.

A Materials and Processes Laboatory provided investigation, test, consultation and evaluation of new materials and processes and special measuring equipment, and calibration and construction of instrument devices.

LIGHT MILITARY ELECTRONICS DEPARTMENT

GE's Light Military Electronics Department continued to expand its product line during 1960, growing from a base of two lines in 1953 to more than 30 by year-end.

These product lines centered around the Department's chief capabilities: airborne electronics used by the armed forces for search and detection, identification and reconnaissance, flight and missile control and guidance, navigation, data handling and display, weapon control, communication and electronic countermeasures.

Among the major products produced by the department during the year were radar equipment for airborne early warning systems, armament and flight control equipment for such aircraft as the Lockheed F-105, Republic F-105 and McDonnell F4H, guidance systems for the Navy's Sidewinder air-to-air missile, guidance equipment for Atlas, guidance electronics for the Fleet Ballistic Missile Polaris and undersea warfare equipment including the Sonobuoy.

The department was also selected to supply the ballistic missile computer for the GAM 87-A Skybolt guidance system.

Other products included GEVIC, a compact digital computer based on the new variable increment technique, and GEPAC, a programmable automatic comparator for electronic systems.

MISSILE PRODUCTION SECTION

General Electric's Missile Production Section of the Missile & Space Vehicle Department received additional contracts in 1960 for further work on the company's fast-firing M-61 Vulcan cannon and linkless ammunition feed system. The gun was being employed as armament on the Republic F-105 Thunderchief, the Lockheed F-104 fighter-interceptor and the Convair B-58 Hustler bomber.

In addition to the Vulcan weapon, the department was working on Army research and development contracts for helicopter armament systems designed to decrease the vulnerability of the aircraft to ground fire in battle areas. The Missile Production Section was also engaged in developing and producing safing, arming and fuzing subsystems for Army surface-to-air and surface-to-surface missiles: Nike-Hercules, Honest John, LaCrosse, and Little John.

MISSILE AND SPACE VEHICLE DEPARTMENT

The General Electric Missile and Space Vehicle Department continued its growth during 1960, both in facilities and personnel and in the number of space programs in which it is involved.

Probably the highlight of the year was the successful recovery from orbit of the department-designed Discoverer XIII recovery capsule. The recovery of this capsule, and the subsequent recovery of several others during the year, was an important step forward in solving the problems involved in future space flight. Work on the program continued in the department and it was expected that during 1961 Discoverer recovery vehicles housing a department-developed life support system would carry a primate into orbit and return.

The recovered Discoverer XIII capsule was presented to the Smithsonian Institution, joining other department-developed items already on permanent display there, including the data capsule which was the first object ever recovered from outer space, a Mark 2 re-entry vehicle, and the RVX-1, the first ablative nose cone to travel intercontinental distance and re-enter.

Research, development, and production of nose cones for ballistic missiles continued to be a major function of the department during 1960.

Production of the first of the operational nose cones, the Mark 2 heat-sink type re-entry vehicle, was completed by MSVD early in the year, and the last test flight of this nose cone was made at Cape Canaveral on February 29. Mark 2's were operational on the Thor intermediate range missiles stationed in England, and on the Atlas intercontinental range missile in the U.S.

Development and production of the Mark 3 ablative-type nose cone, the so-called "second generation" re-entry vehicle, was continued by the department during the year. The Mark 3 is intended for operational use on the Air Force's Atlas missile. Among the many flight tests conducted on this vehicle during the year, two were for distances exceeding 9,000 miles.

Work was begun on development of a re-entry vehicle for the Air Force's Titan II intercontinental range ballistic missile. This vehicle, designated the Mark 6, will be an ablative-type nose cone and will have an improved technical configuration.

Work continued on the department's fourth major re-entry vehicle program, the development of the nose cone for the Air Force's Skybolt air-launched ballistic missile. This work was being conducted under a contract awarded by the Douglas Aircraft Company.

Research and development of new ablative materials for advanced re-entry vehicles was another important aspect of the department's efforts during the year, and out of this work evolved materials designated the "G-E Century Series." One of the highlights of the materials development program was the launching in October of the RVX-2-A materials research re-entry vehicle aboard an Atlas missile from Cape Canaveral.

The RVX-2-A was the largest re-entry vehicle yet flown in the free world and was also the largest vehicle to be recovered after a ballistic flight. Within a few hours after its sucessful flight and impact 5,000 miles down the Atlantic Missile Range near Ascension Island it was aboard a recovery ship and on its way back to department headquarters for analysis of the effects of re-entry on the "Century Series" materials.

An additional feature of the RVX-2-A flight was that it carried a great variety of scientific experiments in addition to its main materials research purpose. Included in the experiments were three mice in a life support cell, two space power devices, and several experimental packages designed to measure flux and distribution of radiation particles in space. Also included was a 70-millimeter camera which took the first color pictures of Earth from outer space.

Work in the area of manned space vehicle development was accelerated by MSVD during the year, with department engineers and scientists studying the electrical, electronic, structural, physical, medical, and other problems of manned space flight. Design concepts of various types of manned vehicles were developed, and a study contract for the Apollo manned space vehicle was received from the National Aeronautics and Space Administration.

In fields allied to man-in-space, the department during 1960 conducted several funded studies concerned with life support in space. Among these are Project Frost, designed to learn more about the preservation of food on long space flights; design of a device for recovering potable water from biological wastes; and the design of space suits and equipment for use outside space vehicles while in outer space.

Much effort was also devoted during the year in the calculation of trajectories for space vehicles to follow in trips to the moon, Mars, Venus, and other planets.

Development of units to provide electrical power in space was also given great emphasis in the department during 1960. This work, under several contracts from the military services and NASA, included design of thermionic converters using the sun's energy to produce electrical energy: solar cell development; the design of fuel cells in which chemical energy is converted directly into electricity; and the use of magnetohydrodynamic power generation.

In the field of satellite development, MSVD conducted work under a contract from the Air Force Ballistic Missile Center to design and produce the space vehicle for the Advent communication satellite. The Advent satellite will be an active repeater system which will receive and repeat a radio signal back to earth. The satellite will be placed in orbit around the equator travelling at speeds equal to the earth's rotation at an altitude of approximately 20,000 nautical miles, and must be able to operate without maintenance in space for a full year.

The department also carried out design work on the control and stabilization system for the National Aeronautics and Space Administration's Nimbus meteorological satellite system.

The department was also extensively involved in the design and production of various components for such missiles as the Army's Honest John, Little John, and Lacrosse missiles. These components included arming and fuzing systems, nose cones, and other subsystems.

Late in the year, MSVD announced receipt of a $1.6 million contract from the Army for fabrication and test of airframes for the Army's surface-launched free flight rockets and Automet test vehicles.

The signing of a license agreement between the department and Nord Aviation of France covering the American production of the SS-10 and SS-11 wire-guided anti-tank missiles was also announced during the year.

Vulcan, the six-barrelled cannon developed by General Electric, was maintained in production by the department for use in both American and European aircraft, and studies on the development of helicopter armament systems were continued.

Employment in the department continued to climb at a rapid pace and at year's end had increased over 60% over January. Facilities were also increased, and early in the year ground was broken for the Department's new Space Technology Center near Valley Forge, Pennsylvania. This facility will be one of the largest pirvately financed space research centers in the country. Department personnel will begin occupying the center late this year.

Plans were also announced to construct a new solar test facility near Phoenix, Arizona to be used in the development of solar powered electrical generating systems for space vehicles. This facility was expected to be in operation early in 1961.

ORDNANCE DEPARTMENT

The Ordnance Department's activity in 1960 centered around the Polaris fleet ballistic missile and the ASROC anti-submarine warfare weapons systems.

In January, Polaris made its first fully-guided flight using the inertial guidance system produced by the Ordnance Department. Throughout the year there were a number of subsequent flights, none aborted because of guidance malfunction.

Ordnance Department also supplied the fire control system for Polaris-carrying nuclear powered subs. On July 20, Polaris was launched from the submarine *George Washington* while submerged off Cape Canaveral, the fire control system functioning perfectly. A number of successful launchings from the *George Washington* and the *Patrick Henry* followed later in the year.

The GE fully-transistorized fire control system contains more than 17,000 transistors, 1054 digital boards, 40,000 circuits and 250,000 terminations. Designed to operate under all conditions of sea and weather, it provides accurate information to the missile guidance system despite sea conditions which induce roll, pitch, yaw and other motions to the submarine.

In June, the Navy demonstrated the ASROC ASW weapon using Ordnance Department's MK 44 acoustic homing torpedo as its payload.

In September, the Navy's first guided missile destroyer to be equipped with the Tartar missile was commissioned. The *USS C.F. Adams* was also the first to be equipped with GE's Ordnance Department's MK 73 Director.

During the year, Ordnance Department announced development of a cryogenic gyroscope. Under contract with the Army, Ordnance Department was sponsoring the work, which was being conducted at GE's General Engineering Laboratory in Schenectady, N.Y. The cryogenic gyro promises accuracies many times greater than existing gyros and offers utility in future submarine navigation and missile and space inertial guidance systems where extreme accuracies are required.

GOODYEAR AIRCRAFT CORPORATION

GOODYEAR Aircraft Corporation in 1960 began reorienting its diverse interests by regrouping its capabilities in order to focus attention on specific fields of effort.

The prime areas, reflecting what the company feels are its strongest capabilities in terms of interest, experience, proprietary technology and facilities, include Undersea Warfare, Electronics, Astronautics, Radar and Communications Structures and Fabric Structures.

Long known for its activity in the lighter-than-air field, the company in recent years has applied its extensive experience with fabrics to development of inflatable vehicles such as the rubberized Inflatoplane and retardation devices for slowing re-entry of missiles and space craft. Foreseeing a need for expanded structures, the company in 1960 was devoting considerable research to the use of inflatable structures for manned space stations.

From its early experience in design and construction of computer installations, GAC developed its electronic capabilities to the extent that in 1960 it was one of the Navy's prime contractors for development and production of flight simulation equipment. The company also served the Air Force as prime contractor for the ATRAN map-matching guidance system used in the TM 61B Matador and in the TM 76A Mace missile, the latter deployed on operational status with the Tactical Air Command in Europe.

As prime contractor for the Subroc system to the Bureau of Naval Weapons, GAC was working closely with the Naval Ordnance Laboratory and making rapid strides in the missile's development. The Subroc system can detect submarines at considerable distances, automatically compute speed, range, and bearing of the target, then launch the weapon through torpedo tubes by conventional launching methods.

Programmed to exit from the water and to fly as a ballistic-type missile, a rocket motor is ignited as soon as the weapon is a safe distance from the submarine. At a predetermined point in the trajectory, the motor is separated from the warhead, which continues to the target guided by an inertial system. After water impact, the warhead sinks to the required depth and detonates.

Because of the ever-growing importance of underseas warfare to the defense of the country, the USW group in the Weapon Systems and Forward Planning department was being expanded. A number of scientists and engineers with wide experience in this type work were engaged in studies of what may become military requirements in the years ahead.

In July, the company delivered to the Navy the last of four ZPG-3W AEW airships. The largest non-rigid airships ever built, the huge craft are 403-feet long and have an envelope capacity of 1,500,000 cubic feet non-inflammable helium gas. The largest airborne radar antennas ever built—40 feet long—are mounted inside the bags and can detect aircraft at great distances.

A proposal to the Department of Defense to use blimps of even larger sizes to transport missile rocket motor sections from factory to any point in the world was presented in April for study by the services.

Many studies were conducted, with company funds and under contract, in the applicability of fabrics to structures previously considered requiring metals. This was particularly true in space vehicles where great tensile strength is not usually required. Preliminary plans were drawn for huge orbiting platforms, housing space scientists.

Operating engineering models of several fabric devices were tested in laboratories or in the field. One such device holding great promise is a solar collector with aluminized bowl to concentrate the sun's rays for power stations in space. A method developed at GAC makes the interior of such a collector smooth and wrinkle-free so no rays are lost.

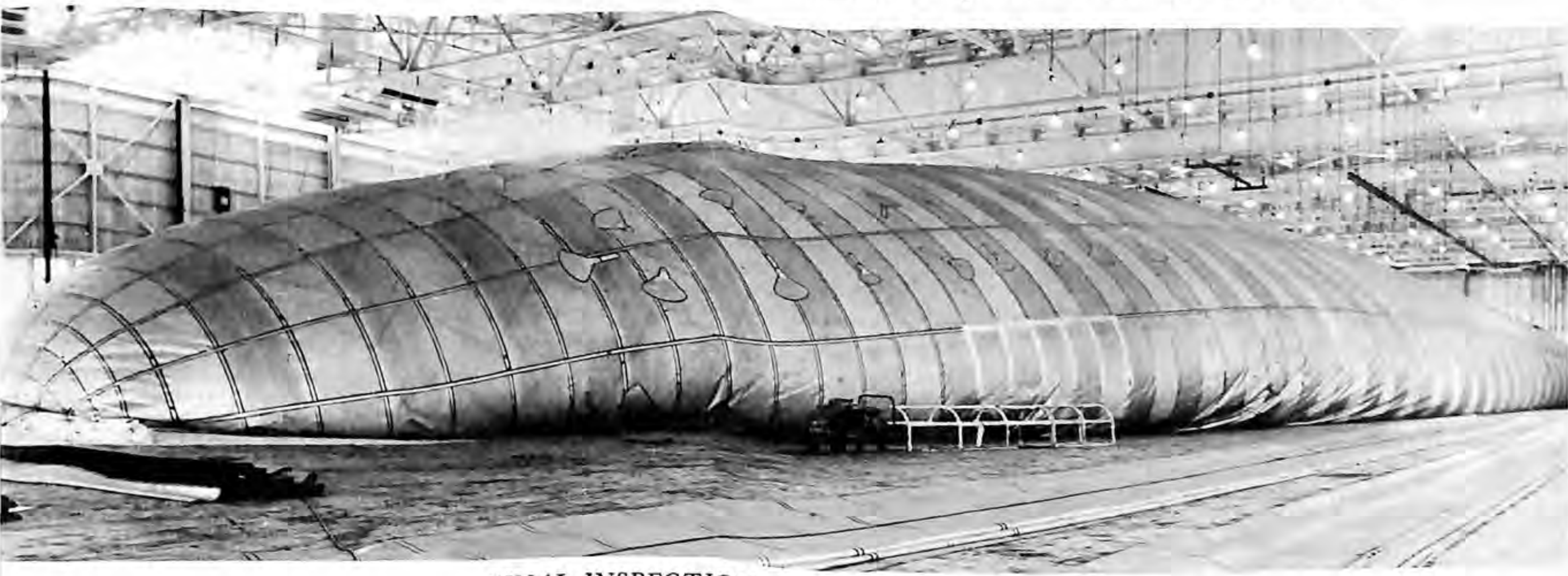
A high altitude recovery system, called Ballute, using a fabric balloon to slow down research missiles for recovery, was successfully tested at the Eglin Gulf Test Range in September.

A protective restraining system of inflatable bladders, netting and straps that will draw a pilot tight in his escape capsule to prevent injurious movements during high altitude ejection from a troubled aircraft was announced during the year.

After a pilot pushes the emergency escape button, he is merely along for the ride. Straps on his shoes draw his feet inside the escape capsule, bladders around his legs, arms, body and head inflate and netting becomes taut. The capsule doors close and the escape unit is pressurized, air-conditioned and ejected, all in the period of ten seconds.

Developed for the Wright Air Development Division of the Air Force's Air Research and Development Command, the new gear can be adapted for any of several advanced flight vehicles, such as Dyna Soar, the B-70 and other orbital and re-entry aircraft.

Electronic trainers for two advanced aircraft under development were started in an expanded simulator department. The aircraft are the A2F and the W2F, both of which will see service with the Navy.



FINAL INSPECTION of Navy blimp envelope.

Production continued on the ATRAN guidance system and a modification program began on units already delivered and needing updating. In addition to the guidance system, GAC also furnished much of the ground support equipment for the Mace system, equipment originally conceived and designed for this specific application. The Mace is operational overseas.

A universal checkout console was announced in mid-year. The unit contains all the necessary permanent modules for evaluation of almost any electronic device ranging from a missile system to a TV set. Only the article to be tested and a specific stimulus need be plugged into the assembly. The console is called a Central Programmer and Evaluator, or CPE.

Production continued in a GAC specialty—radar antennas. In addition to big ones for BMEWS and small helical ones for aircraft, a production line was established for the fabrication of taxi radar antennas to be used to control traffic at airports, and big horns for transmission of microwave signals and television.

Goodyear Aircraft was contributing important portions of two other defense systems—the Air Force's BMEWS (Ballistic Missile Early Warning System) and the Army's Nike Zeus anti-missile missile weapon system.

Fabrication was started on radomes and tracking antennas for BMEWS installations at Thule, Greenland, and Fylingdale Moors, England. Built entirely of plastic faces and paper honeycomb core, except for the metal bolts holding the 1600 hexagonal and pentagonal panels together, the huge radomes are the world's largest. There is no framework or support other than that provided by the panels themselves. The radomes will withstand winds to 130 mph and can be modified to withstand 180 mph gales.

The GAC-built tracking antennas, which will be protected by these radomes, are 84-foot diameter concave dishes that can lock onto a missile as soon as it appears over the horizon several thousands of miles away, track the weapon and feed data on speed, range, and bearing to computers that calculate the impact point and give warning.

During the year, one of the antennas underwent a mechanical "torture test" in the big GAC airdock at Akron. It operated continuously for nine months with only brief programmed shutdowns for inspection.

For the Nike Zeus program, Goodyear Aircraft was building the radomes to cover receiving antennas for the anti-missile missile system. These enclosures are only slightly smaller than those for BMEWS—140 feet in diameter for BMEWS, 110 feet for Nike Zeus—but are built of plastic panels mounted on metal random-pattern space frames.

The receiving antenna for Nike Zeus is a Luneberg lens fabricated by GAC and consisting of thousands of foam plastic blocks impregnated with slivers of aluminum to focus incoming radar beams. For the transmitter, Goodyear Aircraft was making polarized windows that are among the largest of its type ever built.

Plastic products development and fabrication were important in the over-all picture for 1960. Two old standbys—fiberglass fertilizer hoppers and food bins—continued to be made in quantity, while plastic radomes and windows for military and commercial aircraft were fabricated.

A development in the honeycomb type of construction materials was announced and given the name of Bondolite Z panels. These panels are in the three most popular gages of sheet metal, but weigh only about half as much and practically nothing in rigidity or strength is lost when Z panels replace sheet metal. Many applications for aircraft and missiles are envisioned.

Manufacture of airplane wheels and brakes for The Goodyear Tire & Rubber Company continued to be a source of substantial income at the Akron plant.

ARIZONA DIVISION

Avionics, ground support equipment and plastic components took on added importance at Goodyear Aircraft Corporation's Arizona Division at Litchfield Park during 1960.

Transition from mass production of airframe components for manned aircraft to similar activity embracing the field of missiles has been a continuing factor at the Arizona Division.

Nonetheless, airframe work continued on wing center sections for the Boeing B-52 Stratofortress, with change-over from the "G" to the "H" model of the jet-powered, high-speed, long-range Strategic Air Command bomber.

In the Division's Aerophysics department major advances were made during the year in the development of high-resolution radar, radar data processors, electronic test equipment and high-speed electronic communicators.

Of special interest was the award of a contract for the development of an electronic computer and radar display system to eliminate human error in ship navigation to prevent collision at sea. An outgrowth of knowledge gained in research and development of missile guidance system, the radar data computer will be applied to ship navigation. The device is capable of indicating course, speed, bearing and range of up to ten vessels in either true or relative position.

According to the Maritime Administration, which awarded the Arizona Division a research and development contract in October, of particular importance to safety at sea will be the automatic determination of an appropriate avoidance maneuver in the event a possible collision is indicated. Electronic computation will not only include avoidance of a single vessel but others in the area as well.

Further advancements were made during the year in development of three dimensional and color radar displays. Flight testing as well as laboratory work on a number of research and development programs continued during 1960.

The Division's environmental test laboratory, which contains one of the largest acoustic test chambers in the country, was in full operation early in the year. Here studies were being conducted on the effects of noise, vibration, shock, climate and altitude on electronic and other equipment destined for use in supersonic flight.

Production of laminated fiberglass radomes, radar reflectors and antenna covers, as well as clear Plexiglas pilot enclosures, windshields and windows, continued for a wide variety of aircraft, both military and commercial.

In addition to the building of components for the B-52 Stratofortress, ground support equipment for airplanes and production of huge transport trailers, erection boom and erection mechanism for the Atlas missile featured metalcraft activities at the company.

Several new projects were initiated in 1960 in rubberized fabric work. In addition to airship envelopes, the Arizona Division produced protective covers for use in constructing Nike-Zeus radomes; covers for missiles in transit; components for shock-absorbing equipment for missile trailers and transport cases and specialized equipment for use in space projects.

Among the military programs in which the Division participated during the year were: Convair-Astronautics Atlas ICBM; Western Electric Nike-Hercules radar reflectors; Northrop Freedom Fighter (N-156F) and T-38 Talon supersonic trainer; Polaris, MACE and SUBROC missile programs and the Boeing K-135 and B-52 aircraft.

GRUMMAN AIRCRAFT ENGINEERING CORPORATION

NINE AIRCRAFT were in the production phase, one missile neared development completion, and development work on the company's first space craft was begun at Grumman Aircraft Engineering Corporation as 1960 came to a close. Military customers accepted four different weapons systems—the A2F-1 Intruder, W2F-1 Hawkeye, AO1 Mohawk, and the S2F-3 Tracker—an achievement which set a record for Grumman.

Grumman's newest project, the result of many years of intensified research work, was the OAO (Orbiting Astronomical Observatory), a highly complex "eye in the sky" which will monitor cosmic data and provide mankind with information about the universe never before available to him. The 1½ ton space craft marked the company's entrance into the satellite field. The OAO was under development for the National Aeronautics and Space Administration and will be launched from an Agena B missile in 1963.

GRUMMAN's OAO "eye in the sky" model.

Four military aircraft emerged into the production stage as the result of an accelerated development program at Grumman. The record is even more noteworthy when the true nature of these aircraft—carrying the newest and most advanced electronic systems—is considered. They are:

...The W2F-1 Hawkeye, a veritable flying brain design to perform early warning of attack and intercept control missions for fleet units, was accepted by the Navy.

...The A2F-1 Intruder, a 2-place, carrier-based, low level attack aircraft, employed the first fruit of ANIP (Army-Navy Instrument Program) in its utilization of equipment which enables the Intruder's pilot and radar operator to "see" by means of viewing screens in the cockpit enemy targets and ground terrain, despite inclement weather conditions or the darkness of night. INTRUDER is a Navy aircraft.

...The S2F-3 TRACKER, which carries the most modern and advanced anti-submarine detection and destruction devices, was delivered and assigned to Navy fleet units.

...The AO-1 MOHAWK, the Army's first medium weight observation aircraft with STOL (short take-off and landing) characteristics, was evaluated and delivered to the Army.

propelled into space to transmit to earth precise measurements of cosmic rays and the limits and nature of the Van Allen belt.

2. Military uses: A simple, rugged device supplying field troops with instant information on radioactivity in their area.

3. Nuclear power control: Instrumentation which will provide rapid response to changes and accurate measurement of radiation level in nuclear reactors.

4. Cancer treatment: Measurement and control of radiation therapy in the destruction of malignant tissue together with other medical uses.

5. Industrial process control: Flow measurement, thickness gauging, liquid level measurement, oil well logging—all with greater accuracy, greater speed, less hazard and with reduced use of radioactive material.

6. Basic physical research: Determination of location, time and energy of nuclear particles in laboratory experiments.

In March the world's "brainiest" airplane, an Air Force F-106 Delta Dart all-weather interceptor, flew itself across the country from California to Florida in three hours and 17 minutes for the aircraft and five minutes for the pilot.

Key to the fully automatic flight was the aircraft's MA-1 naviagation and fire control system built by HAC. The system is designed to fly the interceptor throughout all phases of an intercept mission from shortly after takeoff to landing.

Before the F-106 took off its entire flight was pre-programmed into the MA-1 system's "Digitair" airborne digital computer. It included such information as route, altitude and fuel available. With this data and continuous range and bearing information flashed to the aircraft by TACAN stations across the country, the Hughes system automatically compared the jet's position to the prescribed route and supplied signals to the airborne flight control system. It automatically corrected heading and altitude.

The first mobile electronic air defense missile fire detection system, announced last year by Hughes, was deployed to operational sites with the Army in Europe in the spring of 1960.

RUBY CRYSTAL, the heart of a new scientific breakthrough device called a laser.

This completed deployment of the first Missile Monitor begun almost two years ago with the AN/MSQ-18 battalion level elements of the system and provided initial operational test information concerning on-site capabilities of the system.

Designed to operate on a 24-hour alert, the Missile Monitor system employs digital computer techniques for rapid and accurate information handling.

The Army and Hughes Aircraft Company broke the news of a new "electronic ear" described as pound-for-pound the most sensitive listening device in the history of science and keen enough to pick up the faint signals from interplanetary rockets millions of miles in outer space.

The super-detector is a 25 pound "ruby maser" amplifier, the smallest and easiest to operate device of its kind and could extend by tenfold the range of many Army electronic systems and could also provide the sensitivity needed to detect radio beeps from space vehicles million of miles away; enable U.S. military defense systems to detct ICBMs earlier than they can now; pick up signals from distant stars and eventually facilitate communications between space vehicles.

The Marine Corps purchased the first two complete "Airtrac" helihut-installed units developed by Hughes Aircraft Company's ground systems group to give tactical support to Marine ground troops and became the first branch of the armed services to have a helicopter-carried electronic air defense system.

The system electronically coordinates split-second firing of Terrier and Hawk guided missile batteries, promising nearly instant destruction of hostile supersonic aircraft.

Production of Falcon missiles continued at the Hughes plant and by September 30,000 of the guided missiles had been delivered to the Air Force's Air Defense Command. An earlier announcement by the company bared the existence of the first air-to-air guided missile with a nuclear capability—the "Nuclear Falcon."

Two other versions of the Super Falcon with advanced guidance systems, new rocket motors, Mach 2 launch speed, deadly accuracy and ability to ignore enemy decoys were announced as being in quantity production for use with F-106A jet interceptors.

Scientists at HAC announced that for the first time man had created a source of "coherent" light—an atomic radio-light brighter than the center of the sun.

The "laser" (Light Amplification by Stimulated Emission of Radiation) is a new solid-state electronic device, smaller than a water tumbler and containing a synthetic ruby as its "heart."

As a scientific advance the laser projects the radio spectrum into a range 10,000 times higher. The radio spectrum is the range of electromagnetic frequencies starting with commercial radio at one million cycles per second and extending into upper microwave region of 50,000 million cycles. The laser jumps the gap from 50,000 million cycles to 500,000 billion cycles, opening the way for a host of important applications.

Some of these applications are: true amplification of light for the first time in scientific history; a new scientific tool for investigating properties of matter and performing basic experiments of physics; focusing of light into high-intensity beams for space communications; vast increases in the number of available communications channels and utilization of high light concentration for industrial, chemical and medical purposes.

In the educational field Hughes continued to grant fellowships for masters degrees. In 1960, some 52 college graduates from 21 states were awarded Master of Science fellowship grants.

The fellowships permit outstanding young graduates in engineering and physics to do graduate work while holding related jobs with Hughes. Since the program was instituted in 1952, 585 students have received masters of science degrees.

Throughout the year Hughes continued to expand through new divisions and the erection of laboratories.

In Tucson, Arizona, ground was broken for two new buildings to comprise the Tucson Engineering Laboratories of Hughes Aircraft Company. The buildings are to be used in further development of the Falcon missile.

Two new divisions of HAC were established for the development, production and marketing of commercial vacuum tube devices in Los Angeles. They were named the Microwave Tube division and the Vacuum Tube division.

In Fullerton, California, the HAC ground systems group established a computer laboratory with a staff of 600 employees. The ground systems group also began operations of its advanced radar test center in Carbon Canyon.

One name change took place during the year when the Airborne Systems Group became the Aerospace Group. During the year HAC purchased the MevA Corporation, Santa Monica, California, the nation's only commercial manufacturer of cyclotrons, high-energy machines popularly known as "atom smashers."

KAMAN AIRCRAFT CORPORATION

VOLUME DELIVERIES of the H-43B HUSKIE to the Air Force, a shift from prototype to initial production deliveries of the HU2K SEASPRITE to the Navy and its first space contract marked 1960 for Kaman Aircraft Corporation.

During the year the H-43B local base rescue helicopter entered operational status at Air Force bases around the country. In its first six months of active use the HUSKIE performed a number of life saving missions. Operational areas ranged from the turbulent winds at the bottom of the Grand Canyon to the high altitudes over the rugged terrain of the Donner Pass.

In October the H-43A, piston-powered predecessor of the HUSKIE put out a potentially dangerous fire and saved the lives of 11 KC-97 crewmen following a crash landing near Randolph Air Force Base. By the end of the year about half of the Air Force production order had been filled and the Air Force had begun a study of the HUSKIE's possible use in new requirements.

Late in 1960 the Navy awarded Kaman Aircraft a contract for production deliveries of the HU2K SEASPRITE utility helicopter. The order for operational models of the versatile, high speed SEASPRITE came just 14 months after first flight and less than four years after the initial development contract was awarded. When it becomes operational with the fleet in 1962, the SEASPRITE will provide the Navy with an all-weather helicopter capable of flying faster and farther than anything now in service. In addition to its electronic stabilization and navigation equipment, the SEASPRITE also has the capability of carrying additional electronic equipment for the performance of a wide range of support and combat missions. These features, plus the SEASPRITE's compact size, enable it to operate from the fleet's

ARTIST'S CONCEPT depicts one of future applications of the Rotochute.

smaller ships, further enhancing its versatility.

Just after mid-year Kaman Aircraft won an Air Force contract to test guided ROTOCHUTES, a rotary-wing recovery device which operates much like a maple seed spinning to Earth. In two phases, the contract calls for the test of small ROTOCHUTES with guidance for pin-point landings and for the study of possible applications of the device to the recovery of rocket boosters, nose cones and manned space capsules.

The company continued to follow the development of the Westland Rotodyne, the world's first vertical take-off airliner which Kaman Aircraft is licensed to manufacture, sell and service in the United States.

Kaman Nuclear, located at Colorado Springs, Colorado, continued to grow. Sales of the PULSATRON, Kaman's proprietary neutron generator, increased again during the first six months of the year.

Employment and plant space expanded at a rapid rate during the first half of 1960. In 1960 Kaman Aircraft's employment had reached 4,000, a rise of 1,000 from January 1, and its plant space, both owned and leased, had increased by 40 per cent over the same period for 1959.

Sales volume for the first six months of 1960 exceeded volume for the same period in 1959; $23,446,824 compared to $14,196,398. Net earnings for the same period declined from $324,859 in 1959 to $290,358 in 1960.

LOCKHEED AIRCRAFT CORPORATION

TECHNICAL ACHIEVEMENTS across a broad range of the physical sciences characterized Lockheed's operations during 1960—a period that saw sales push past the $1 billion mark for the second consecutive year. Ranked by sales, the company advanced from 37th to 28th largest U.S. industrial enterprise. Its three divisions, eight subsidiaries, and five affiliates spanned the free world from the Orient to Europe, from Alaska to the Argentine.

While remaining alert to promising diversification opportunities, Lockheed began the new decade by solidifying acquisitions of the late 1950's and strengthening its over-all competence.

In 1960 Lockheed maintained its position as a leading aircraft manufacturer with 16 different military and commercial models in production. The company also scored outstanding successes in the fields of missiles, satellites, and space programs. More than half its total sales were in missile-satellite work. It showed steady growth in military and industrial electronics. It expanded its new activities in shipbuilding and repair, antisubmarine and undersea warfare and oceanographic research, infrared, and propulsion. And it was probing opportunities in non-military goods including plastics and architectural products.

During the year's first half Lockheed reached important financial decisions. Large write-offs of excess costs in its transport aircraft programs brought a $55 million net loss. But by placing these costs and losses behind it, Lockheed returned to profitable operations in the second six months, even though it reported a net loss for the year.

Significant Lockheed firsts during the year included:

1. Firing of 1200-mile Navy Polaris test missiles from nuclear submarines below the surface of the Atlantic with what President Eisenhower described as "rifle-shot accuracy at great range." Two submarines were due to be armed with 16 Polaris missiles each by year-end.

2. Air Force recovery in mid-air of an instrumented capsule, first man-made object ever brought back from orbit in space. The capsule was part of a Discoverer satellite, a program on which Lockheed is prime contractor, and President Eisenhower hailed the feat as "another incident in a remarkable series of acomplishments that show how rapidly America has forged far ahead into worthwhile exploration of space."

3. First flights of five new aircraft—the production-line, four-engine JetStar for military and corporate executive use; a boundary layer control C-130 Hercules combat transport with very short takeoff capability; and three export versions of the 1500-mph F-104 Starfighter—Canada's CF-104 and West Germany's F-104F two-place trainer and F-104G advanced all-weather multi-mission fighter.

Prime contractor on the Polaris missile and Discoverer satellite, Lockheed's Missiles and Space Division also has prime responsibility for two other top-priority programs—Midas, which uses infrared devices to detect enemy missile launchings, and Samos, the surveillance satellite system. All three—Discoverer, Midas, and Samos—employ the Lockheed-designed and manufactured Agena space vehicle, which the National Aeronautics and Space Administration also will use in a series of deep space and lunar probes. During 1960 the Missiles and Space Division began developing longer ranged versions of Polaris, received an Air Force contract to establish and operate a world-wide communications-control network for various satellites, and began a study of requirements for a nuclear rocket flight test program.

Lockheed's participation in missile-satellite-space work was not restricted to one division only. Its California Division, diversifying into many areas unrelated to the conventional manned aircraft with which it has long been identified, accelerated efforts of its missile and spacecraft department. Among California Division space studies: high-speed re-entry vehicles; a recoverable booster; an orbital airplane; problems of landing manned vehicles after hypersonic glide or orbit around the earth. Lockheed's Georgia Division, active in space environment tests and nuclear rocket studies, is manufacturing components for NASA's Saturn space vehicle. Lockheed Aircraft Service designed and developed the direction finder that was a key link in the Air Force's successful recovery of a Discoverer capsule. Lockheed Electronics Company, a newly established subsidiary, has broad experience and skills in design and manufacture of missile training devices and check-out equipment, guidance systems, telemetering, data recording, test instrumentation, and tracking antennas. And early in 1960 Lockheed arranged to acquire a 50% interest in Grand Central Rocket Co. of Redlands, California, a producer of rocket motors and solid fuels.

In the military aircraft field, Lockheed's program to license manufacture of F-104 Starfighters abroad developed into the biggest of its kind. Under a $2¼ billion manufacturing program six free world nations will build more than 1300 F-104s abroad. Foreign governments also ordered P2V-7 Neptune antisubmarine patrol aircraft and C-130 Hercules combat transports. During 1960 Lockheed delivered C-130s to the Air Force, Navy, Marine Corps, and Coast Guard. It continued production of P2V-7s and manufacture of P3V-1 antisubmarine versions of the commercial Lockheed Electra. Production built up to fill initial military orders for five JetStars for the Air Force's airways communications and control service. Lockheed entered its advanced Super Hercules cargo transport design in an Air Force competition for an optimum air freighter.

In addition to extensive electronics work on missiles and aircraft, Lockheed moved more directly into electronics by forming Lockheed Electronics Company. This subsidiary was built around Stavid Engineering, which Lockheed acquired in 1959 and which had gained an impressive position in defense electronics.

AIR FORCE Samos satellite tracking and data station at Vandenberg Air Force Base, California.

LEC has four operating systems—Military Systems-Stavid, Information Technology, Engineering Services, and Avionics and Industrial Products. Lockheed was expanding LEC's capabilities, aimed at increasing its sales in 1961 and developing systems to satisfy varied government requirements.

After a fatal accident in March 1960 that duplicated some aspects of an earlier crash, the Federal Aviation Agency imposed speed restrictions that assured safe operations for Lockheed Electras then in service. After exhaustive investigation, Lockheed undertook a program to modify and improve the aircraft's power package-nacelle and wing, and all Electras were scheduled to be modified by midyear 1961. By the end of 1960's first nine months Lockheed had delivered 142 Electras, with 26 others to be delivered and one on lease to the Navy for use in over-ocean tracking for its Pacific Missile Range.

At year-end Lockheed had more than 20 firm orders for its four-engine JetStar for use as corporate planes. The company's affiliates in Mexico, Italy, and Argentina are gearing to begin deliveries this year of the LASA 60, a versatile six-place utility plane being marketed in Latin and North America, Europe, and Asia.

Lockheed's growing capabilities in nucleonics were reflected late in 1960 when the Lockheed Nuclear Products branch won its fifth contract to design and manufacture a low-power reactor, this one to be used by NASA for critical experiments at its Plum Brook facility in Ohio. LNP had previously designed and built reactors for Ohio State University, the University of Texas, Pensacola (Fla.) Junior College, and the Atomic Energy Commission. The AEC reactor features the current "Atoms at Work" exhibit that began a year-long tour of South America in November 1960.

At year-end Puget Sound Bridge & Dry Dock Co. of Seattle, Wash., which Lockheed acquired in April 1959, was at work on a four-year Navy program to construct a guided-missile destroyer leader and three guided-missile destroyers. Puget Sound was also in joint ventures to construct a floating bridge and a Titan missile base, and is active in freeway and building construction.

Total Lockheed employment at year-end among all divisions was 58,000, about 1000 under the same 1959 period. Its backlog at year-end stood at approximately $1.2 billion, somewhat higher than a year earlier.

McDONNELL AIRCRAFT CORPORATION

McDONNELL AIRCRAFT during 1960 successfully diversified into astronautics and automation from its strong position during its first 20 years in aeronautics.

The progressive solution of scientific problems continually arising in the probing of the frontiers of space and hypersonic flight greatly strengthened the company's capabilities in its government work, and will provide vital research support to the company's diversification in the fields of aeronautics, astronautics and automation.

The principal areas of research activities during 1960 were:

• Plasma Physics Research, directed at the generation of high enthalpy air plasma for simulating vehicle re-entry environments in the study of ablation, heat transfer, and chemical reaction characteristics of materials and configurations. To date, the plasma jet has attained a maximum temperature calculated to be 25,000° F.

• Heat Transfer Research, to investigate temperature characteristics of bodies at supersonic and hypersonic velocities. Emphasis was placed on nose cones and bodies inclined to the direction of flight, to provide scientific information important to boost-glide missiles and space systems.

• Astronomy and Astrophysics, concerning solar and stellar radiations, planetary atmospheres, and lunar atmosphere, as well as dynamical astronomy applicable to orbit and trajectory analysis. On 2 October 1959, the company, under joint sponsorship with the USAF Air Research and Development Command, made observations of the polarization of the solar corona during the total eclipse of the sun from a McDonnell F-101 airplane at 45,000 feet.

• Solid State Physics, to study fundamentals of energy conversion and amplification by solid state techniques. Part of the necessary laboratory equipment was in hand and preliminary research was initiated on arsenic telluride and silicon crystals.

• Anti-Submarine Warfare, to investigate methods for search, detection, classification, localization and attack as elements of integrated anti-submarine warfare systems. The company submitted two proposals to the government as an outgrowth of this effort.

In the field of fighter airplanes, means of further increasing the military capabilities of the Phantom II were vigorously sought. A new technique, known as "pre-compressor cooling," which greatly augments engine thrust at extreme speeds and thus improves both the speed and altitude performance, was proposed for test during the year. A boundary layer control system over the leading and trailing edge flaps to reduce approach and landing speeds was successfully developed for production airplanes. This permits the Phantom II to land aboard aircraft carriers 12 knots slower than had been possible previously and will greatly reduce landing hazards aboard carriers, particularly under adverse conditions of wind and sea.

In the missile field two missiles reached more advanced stages of development during the year. New applications for the flight-proven aeroballistic missile were found as continued studies demonstrated the missile's versatility.

The Army awarded the company two research contracts for further devolopment of a new anti-tank rocket which combines operational simplicity with extreme accuracy.

The Air Force also awarded the company contracts for study in the field of hypersonic flight, including a contract for the design of a boost glide flight test vehicle.

Research and development work was continued vigorously throughout the year on STOL (short takeoff and landing) aircraft.

A grueling flight test program conducted by both company and Navy personnel effectively proved the high performance capability of the Phantom II. Combining great speed (Mach 2+), range and high altitude capabilities with devastating fire power and the superior reliability of twin-engines, the Phantom II markedly enhances the Navy's deterrent and striking power.

Three world records were set by the Phantom II within a nine-month period. A dramatic recapturing of the world's altitude record from the Russians was accomplished in December, 1959 when Navy Commander Lawrence E. Flint, Jr. flew the Phantom II to 98,557 feet and attained speeds in excess of 1500 miles per hour in achieving the new mark.

On September 5, 1960 a Phantom II piloted by Marine Lt. Col. Thomas H. Miller set a new world 500-kilometer closed course record of 1216.78 miles per hour. Three weeks later on Sept. 25, 1960, Commander John F. Davis averaged 1390.21 miles per hour in a Phantom II to set a new 100-kilometer closed course record, thus bettering a Russian claim of 1298.7 miles per hour set May 28, 1960.

In another phase of the flight test program, the Phantom II successfully completed its carrier suitability trials with a total of 126 catapults and landings during the day and at night aboard the U.S.S. Independence, the U.S.S. Intrepid, the U.S.S. Saratoga and the U.S.S. Forrestal. Despite the great speed developed with the two J79 engines, the Phantom II in these trials conclusively demonstrated that it could land aboard carriers at speeds about equal to those of other current supersonic, carrier-based jet fighters.

The adaptability of the Phantom II to attack and other missions, and its ability to operate from limited runways, give it a world-wide operational potential for both the United States and its allies.

Deliveries of the Phantom II to the Navy for final Board of Inspection and Survey tests were made in July 1960.

An order from the Navy of $108,956,520 for additional Phantom II airplanes provided for continued deliveries of the carrier-based fighter through December, 1962.

The F-101B supersonic two-place, twin-jet interceptor for the Air Defense Command went into operation with nine more Air Force squadrons during the year. With its long range and its ability to deliver both Genie MB-1 nuclear rockets and Falcon missiles, the F-101B became primary air defense weapon at 16 U.S. Air Force bases.

After eight years of design, development and manufacture of the F-101, production was completed at year's end. Completion of this contract, except for a substantial business in spare parts, brought to an end a series of contracts for this airplane which have totalled more than $1,000,000,000.

Since the first flight of the F-101 Voodoo on 29 September 1954, the company delivered more than 800 airplanes in three versions . . . the F-101 fighter-bomber, the RF-101 photo reconnaissance airplane, and the F-101B interceptor.

The Voodoos, which hold several official world speed marks, as well as a number of trans-oceanic records, reached a total operational flight time of more than 220,000 flight hours in carrying out their missions with 29 Air Force squadrons throughout the free world.

Production of airframes and integrated ram-jet engines of the Navy's Talos surface-to-air missile continued through the year. The supersonic missile has a range of more than 65 miles and is designed to destroy enemy aircraft at ex-

tremely high altitudes with conventional or nuclear warheads. Talos is operational aboard the cruiser U.S.S. Galveston. Six additional cruisers, one of which will be nuclear powered, were undergoing construction or conversion, and will have Talos capability.

An an outgrowth of the Talos program, the company, under Navy contract, carried out design and development work on a new long-range Typhon missile. Delivery for flight test of the first airframe and integral ramjet was made on 3 May 1960.

Total contracts for the two missiles have aggregated $60 million.

The Quail is a diversionary missile designed to penetrate and confuse enemy air defenses. When launched from a Strategic Air Command bomber, the Quail appears to the enemy defense to be another bomber. Powered by a J-85 jet engine, the Quail flies at the same speed as the bomber, more than 650 miles per hour.

Air Force evaluation and pre-operational testing of the Quail missile was successfully concluded after an exacting flight test program conducted by personnel of the company, the Air Proving Ground Command at Eglin Air Force Base in Florida, and the Strategic Air Command. The highlight of the flight test program was the successful launching of three missiles into free flight from a B-52G bomber on 22 June.

The importance of the Quail program to the nation's defense is demonstrated by the fact that each B-52G bomber will carry several of the McDonnell missiles, thus adding greatly to penetration capability of the vital bombers of the Strategic Air Command.

McDonnell Aircraft was responsible for the complete Quail weapon system including, not only the design, development and production of the missile itself, but also the complex electronic checkout system, other ground support equipment, and the launch system in the bombers. A $24,157,484 contract with the Air Force for additional Quail missiles was announced in October, 1959, and this provided for additional deliveries through June, 1962.

Major effort was directed both toward meeting specific immediate requirements of the government and toward creating new capabilities for meeting future requirements. Among areas of activity pursued during the year were: a proposal for an orbiting astronomical ob-

PRELAUNCH preparations at Cape Canaveral for flight testing of Project Mercury.

servatory: a study contract for a multi-crew space laboratory; studies related to orbiting a man around the moon, and further uses for company-designed orbital space vehicles. McDonnell was one of four firms selected by the Jet Propulsion Laboratory of the National Aeronautics and Space Administration to work on a design study leading to a program to soft-land an instrumented spacecraft on the moon.

Another space project, under contract with the Air Force, called for the design, fabrication, and testing of structural re-entry components for spacecraft, utilizing refractory metals with working temperatures up to 2500°F. A typical structural assembly of special columbium alloy was designed and fabricating techniques for this component were developed during the year.

The above programs were necessary early steps. They provide the broad technical base needed for development of larger, more sophisticated spacecraft which will soon be feasible.

The design and construction of a manned orbital space vehicle by this company in close coordination with the National Aeronautics and Space Administration (NASA) represents one of the great engineering team undertakings in the history of the aerospace industry. Man's ageless dream to explore space is becoming a reality as a result of funneling into the Mercury Project the practical application of accumulated scientific theory, knowledge, and skills. The satellite is designed to carry an astronaut more than 100 miles above the earth, travel at a speed of 17,400 miles per hour, withstand re-entry heating, and land safely in a predetermined area in the Atlantic Ocean after three 90-minute orbits around the earth.

Complex, miniaturized systems provide automatic, manual, and ground control; two-way communications; a system to provide the astronaut with environmental cockpit conditions comparable to those in military aircraft flying within the atmosphere; and a system for locating the spacecraft during landing. Alternate systems are incorporated wherever they further insure the pilot's safety.

Construction of such a space vehicle has required aggressive, pioneering innovations to assure maximum reliability. New production and assembly procedures were introduced with the establishment of "white rooms" to provide precise control of temperature and humidity and to eliminate airborne contamination. New methods were devised to test the structural and functional elements and the environmental, control, and communication systems at various stages before, during, and after component installation.

Since the signing of the contract for the Mercury capsule and supporting equipment, a number of the 20 capsules and all of the check-out and telemetry mobile trailers and ground control block-house equipment were delivered. The first of the delivered capsules successfully tested the pilot escape system, which carries the capsule away from the booster for a parachute landing in case of a malfunction prior to launch or during the early stages of flight. Several capsules were being readied for tests to fully qualify the vehicle under anticipated orbital flight conditions before launching the manned space flight.

To familiarize the astronauts with the satellite systems and procedures which they will operate in actual flight, two M.A.C.-developed electronic mission simulators and an egress trainer were delivered to NASA.

An engineering task group from the company was established at Cape Canaveral, Florida, for the complete, final preparation of the satellite vehicle, and for the support of the NASA team during the countdown and launch procedures for the uninhabited, primate, and manned ballistic and orbital flights.

In the process of designing and producing aircraft and spacecraft, the company developed an unusual competence in the production and utilization of automatic equipment. This is illustrated by (1) an electronic equipment business which for fiscal 1960 totaled over $45,000,000 in completed work and year end backlog, and (2) the use of more than $7,000,000 worth of electronic data processing equipment.

On March 21, 1960, the company announced its first formal diversification in the commercial field of automation with the establishment of the McDonnell Automation Center to provide complete electronic data processing services both for scientific work as well as in administrative fields such as inventory control, marketing analyses, production control and accounting.

McDonnell had more than 300 specialists in data processing and systems work and its facilities are the largest in Mid-America. Processing capacity was being increased over 500% by the addition of two huge electronic computers: the IBM 7090 and the country's first commercial 7080 in September 1961.

The efficiency and savings provided by this service have stimulated interest by many types and sizes of businesses.

The design, development, and production of electronic equipment expanded materially at McDonnell Aircraft during the year, and the $24,900,000 of work was an increase of 98.4% over 1959.

While much of this effort was directed at developing subsystems and ground support equipment related to McDonnell airplane, missile and spacecraft systems, some of these electronic products were purchased by the government and other contractors for use in a variety of weapon systems and some had potential for commercial sales. Typical of these products were: McDonnell Simulator Rocket which permits economical training of interceptor crews by simulated rocket launchings instead of actual launchings of Genie rockets; an improved pitot-static test set developed for use at Navy air bases which provides a safe and rapid means of performing maintenance checks and calibration of the sensitive altitude and airspeed instruments; and the first development model of a message computer for data link equipped Phantom II airplanes which provides decoding for visual display of intercept instructions to the air crew, and in turn encodes speed, altitude, fuel and other aircraft information for reply to control center.

The construction of the $1,000,000 Hypervelocity Impulse Tunnel during the year completed the second of two 5-year facility programs originally begun 1 July 1950. This 10-year reinvestment in up-to-date facilities and equipment amounted to $57,709,654, and included the construction of an Engineering Campus, Engineering Laboratory, Low Speed and Polysonic Wind Tunnels, Thermodynamics and Propulsion Laboratories, Missile Assembly building, and two Manufacturing and Flight Test hangars.

These technically advanced facilities comprise a vital part of the fully integrated plant at Lambert-St. Louis Municipal Airport consisting of 3,425,911 gross square feet of the total 3,898,890 square feet occupied by the company at all locations on 30 June 1960. Of this total, only 19.7% was leased from the Government.

The new Hypervelocity Impulse Tunnel which was put into operation in May 1960, only 9 months after construction was begun, is designed to simulate speeds up to 27 times the speed of sound, temperatures hotter than the surface of the sun, and altitudes from 20 to about 60 miles. The new research facility is designed to test spacecraft and missiles under conditions similar to those encountered during re-entry from space.

The tunnel derives its energy from a bank of 2,320 capacitors which discharge 3,600,000 amperes at 12,000 volts in three milliseconds. In this fraction of a second the tunnel draws more current than the nation's five largest cities combined. The three-millisecond discharge of 3,200,000 kilowatts of electrical power represents an output greater than the impulse power of Grand Coulee Dam.

Expenditures for facilities for fiscal year 1960 amounted to $2,726,503, as compared to the cash return from depreciation of $5,678,313. According to plans, expenditures for facilities in fiscal 1961 will be lower than any year in the past decade.

THE MARQUARDT CORPORATION

DURING 1960, the Bomarc IM99A and B interceptor missiles became operational, and the development program for the Marquardt ramjet engine which powers these missiles reached a gratifying conclusion. The ramjet engine development program was initiated in 1956 to produce an engine with improved performance and resulted in three RJ43 engines, the -7, -9, and the -11. The -11 and its predecessor the -3 are the only two ramjets ever to have passed the Air Force Military Qualification tests. These engines were used to power the Bomarc missile on many successful flights, and their development paved the way for the hyperjet and a liquid-air-cycle engine as well as opening a development study for a hypersonic engine.

To compensate for the phaseout of the Bomarc engine development program at Van Nuys in 1960 and of Bomarc engine production at Ogden in 1962, Marquardt was expanding its activities in diversified areas. As part of a long-range plan to expand the company's product base, an Independent Research and Development Program was initiated last year.

Contributions to the development of a nuclear ramjet (Project Pluto) were made by Marquardt's Nuclear Systems Division in conjunction with a contract to support the Lawrence Radiation Laboratory's development of a non-flyable nuclear test reactor, the Tory II. Marquardt's primary effort was in the development of non-nuclear components for the reactor and in support studies.

The newly organized Facilities Engineering Division had a part in Project Pluto, designing the airflow system and furnishing preliminary designs for other phases of the test facility at the AEC site at Jackass Flats, Nevada. The new division designed and was building the static test facility for the Air Force Directorate of Rocket Propulsion and Missiles at Edwards Air Force Base. The facility will be capable of simulating altitude environment of a rocket engine through its full operational cycle. Control rocket systems can be tested in excess of 100,000 feet.

The installation of tape-controlled machine tools, such as the Milwaukee-matic, and research in spin forging and explosive forming at Ogden expanded that division's capabilities, and sales efforts were accelerated in the general area of metal fabrication and precision machine work.

The corporation's Aero Space Technology Research Organization (ASTRO) moved into a new building which includes a new space laboratory. ASTRO's services were available to the other operations of the corporation. An example was ASTRO's research on the Marquardt-Pomona Multi Channel Memory system of data storage, which utilizes the high-density storage of color film as a means of reducing physical properties necessary for data storage and read-out hardware. Nuclear space power systems were being investigated by ASTRO, and considerable work was completed with the plasma diode space power system and with a direct cycle diphenyl reactor.

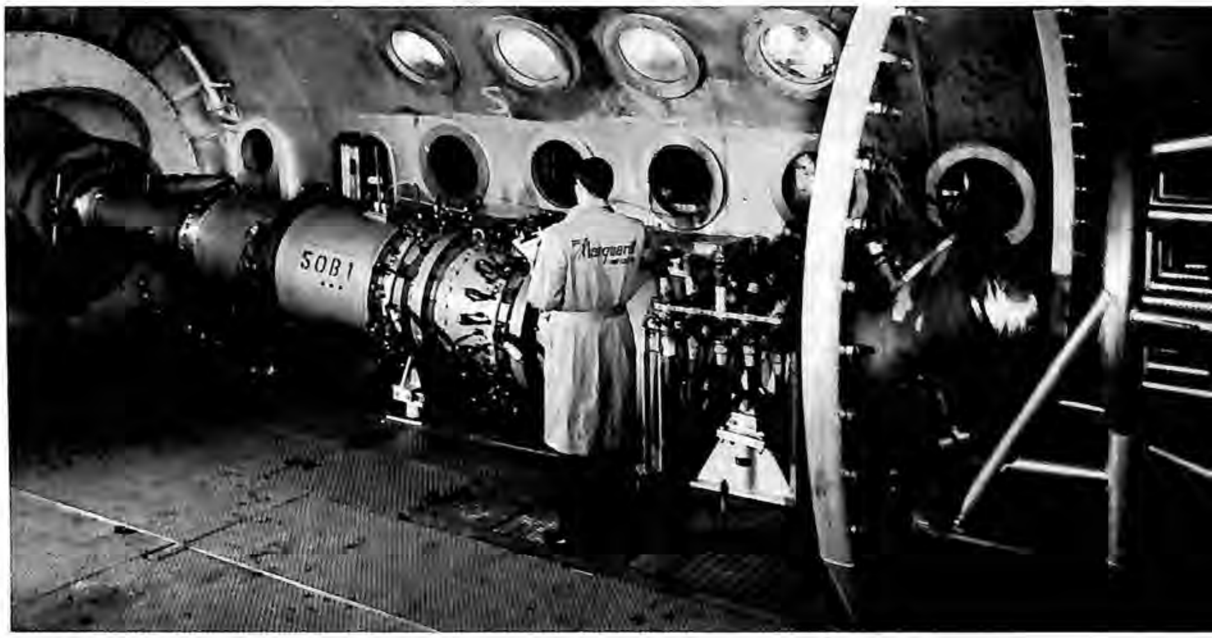
A blood heating and cooling device for use during surgery was developed and donated to the medical department of the University of California at Los Angles (UCLA).

During 1960, a large rocket engine burning high-energy boron fuel and using a storable oxidizer demonstrated the highest performance ever attained with storable liquid propellants. Developed by Marquardt, the rocket engine operated at a thrust level of approximately 100,000 pounds in facilities of the Air Force's Directorate of Rocket Propulsion and Missiles at Edwards Air Force Base.

Pursuing an independent research program, Marquardt designed a pneumatic servo actuator, to function in extreme temperature and radiation environments, which underwent testing for 42 consecutive hours at temperatures ranging up to 1600°F.

Marquardt also developed the Position, Altitude, Trajectory Control system (PAT-C) which will keep a satellite's flight operation under control. PAT-C is a constellation of small-nozzle rockets with its own sensors, electronic controls, and computer circuitry.

The Marquardt-Pomona AN/GPS-T4 radar signal simulator was accepted by the Air Force. This experience has been expanded into the field of launch training devices, and a contract was awarded for development of launch trainers for the Green Quail and Hound Dog missiles. An improved version of the Digitron was developed and is being marketed under the new name of Marquatron.



AIR FORCE—Marquardt Jet Laboratory testing facilities of Cell 8.

In the propulsion field, Marquardt was awarded a sub-contract by North American Aviation, Inc., for the design and fabrication of a ramjet-powered system designed to operate the Army's new high- and low-level target missiles, the Redhead and the Roadrunner.

In addition to the new facilities to house ASTRO, a company-financed radiation effects laboratory to support the company's nuclear systems activity was completed. The $200,000 facility is capable of nuclear environmental testing and handling of radioactive components. Located at the Van Nuys plant, the laboratory also offers its services to industrial users.

A Special Projects Laboratory for the purpose of developing security devices and systems for government and commercial applications was established in the Congressional Plaza area at Rockville, Maryland. The 4,000 square-foot laboratory is designed for engineering development and model-shop fabrication of small-scale electronic and electromechanical security equipment.

The Cooper Division was moved to Van Nuys, location of the Power Systems Group, where Cooper now has immediate access to the technical and facility resources of the new environment. Cooper had been located at Monrovia, California, and was acquired by Marquardt in 1958. Among Cooper's major efforts is a recent contract from the Army Signal Supply Agency, Fort Monmouth, New Jersey, for 600 meteorological rockets received late in 1960. Other contract work is being done by this division in the area of launch recovery systems.

A program of realignment commensurate with increased sales activity brought the marketing and engineering functions of the Power Systems Group together to establish centralized engineering-sales teams in support of specific projects of the Group.

Marketing activities were further accelerated with the election of a marketing vice president, Stuart E. Weaver, formerly of Northrop. Harry B. Horne, former director of corporate planning, was elected to the vice presidency of that function.

In the early part of 1960, Marquardt was listed on the New York Stock Exchange with the designation "MRQ." At the end of October, current sales for the preceding 40-week period approximated those for the same period the previous year, and sales for the entire year were estimated to be about the same as 1959, when sales amounted to $69,011,225.

THE MARTIN COMPANY

DURING 1960, The Martin Company's activities included missiles and support equipment, electronics, space age projects, nucleonics and research. The company was operating six divisions: Baltimore (Maryland), Orlando (Florida), Cocoa (Florida-near Cape Canaveral), Denver (Colorado), Nuclear (Maryland), and RIAS—Research Institute for Advanced Studies (Maryland).

In 1960 Martin continued to show gains in sales and earnings, with a steady favorable relationship to costs and expenses. This was the firm's 10th consecutive year of increasing sales volume. Indicative of this rise in business was an increase in the company's approximate total employment from 34,300 to 40,700 during the past year.

Two new vice presidents were added to the corporate executive staff: Dr. William L. Whitson (Denver Division) and Douglas V. Dorman (Industrial Relations). George M. Bunker, board chairman, and William B. Bergen, president, directed Martin's six divisions and other corporate activities.

Martin acquired stock in two smaller companies, General Precision Equipment Corporation and Nuclear Corporation of America, and in October three Martin executives were elected to the board of the latter.

In education, Martin established an annual $5000 VANGUARD doctorate fellowship at Johns Hopkins University (open to students of all nations that participated in the International Geophysical Year), and continued its Foundation Scholarship and cooperative engineering education programs.

A recently-formed group attached directly to the corporate organization, Advanced Programs, coordinates new business activities among the company's half-dozen geographically separate divisions. Its functions are to develop plans and strategies for acquiring new business, to direct specific efforts to this end and to identify and help solve problems that stand in the way of its goal.

Because of the company's expansion, a site near the Baltimore Friendship International Airport was purchased for the construction of new corporate offices. The executive move should be accomplished in 1961.

BALTIMORE DIVISION

Martin-Baltimore during 1960 developed important refinements to its Air Force MACE missile system, began manufacturing the booster of the new Air Force DYNA-SOAR manned space vehicle, produced a lightweight trainer modification of the Martin Navy-Air Force BULLPUP, designed a unique infrared seeker-tracker, established a special electronics division, and began a study for NASA on PROJECT APOLLO, in addition to diversified activities in other scientific and electronic areas.

The TM-76A MACE, in production since mid-1958 and operational a year later, was in full combat readiness status with the Air Force

ZERO POWER tests on PM-1 reactor core.

in the Far East and with NATO tactical units in Europe. Its successor, the B MACE, emerged from its design stages, underwent a series of successful hard site tests from Cape Canaveral including several in which it was launched by an all-military crew.

While the A MACE uses a self-contained ATRAN tracking system, the B weapon utilizes an inertial guidance system. ATRAN, subcontracted to Goodyear Aircraft Corporation, scans the terrain by means of radar and correlates with a previously prepared film strip in the missile. The inertial system, made by the AC Spark Plug Division of General Motors, operates by means of a series of built-in gyroscopes, computers and reference platforms in a form of memory navigation. The system emits no radiation of any type, and it is invulnerable to enemy jamming. It not only eliminates the need for ground control facilities, but makes terrain check points unnecessary. The inertial system also compensates for changes in wind, temperature and barometric pressures, while remaining impervious to foul weather or unusual climatic conditions.

The new surface-to-surface MACE B missile can cruise at altitudes from under 1000 feet to over 40,000 feet, and can attain ranges beyond 1200 miles.

Basically, DYNA-SOAR is a program to send a manned vehicle into space and back to Earth again in controlled flight. The system will combine the high speed of a ballistic missile with the control advantages of atmospheric flight. The DYNA-SOAR program rests with the Air Force, acting with the advice and assistance of NASA.

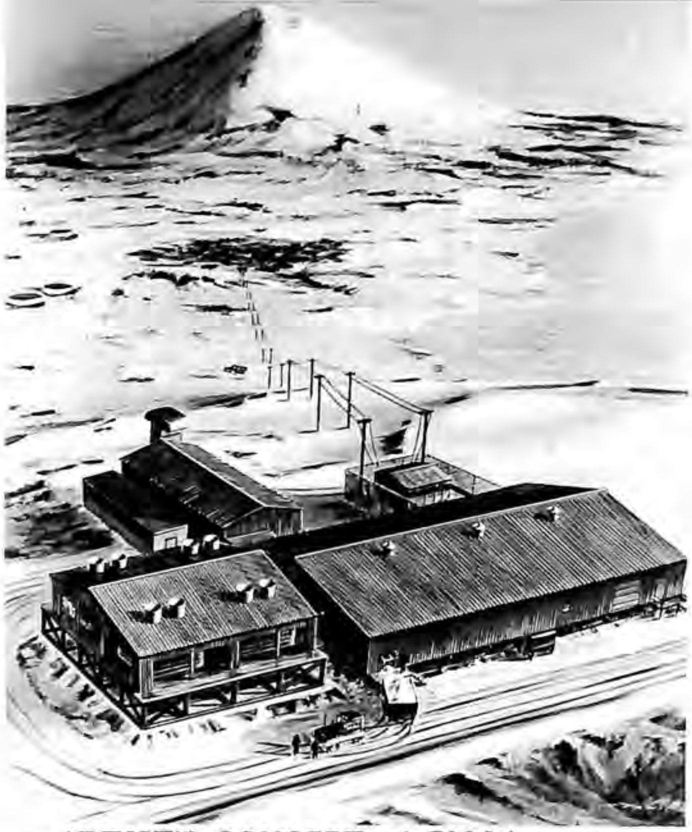
In late 1959 the Air Force awarded Martin the contract to build the DYNA-SOAR booster and Boeing received the glider contract. The booster—slated for production at the Baltimore plant—will be a modified version of the Martin-USAF TITAN.

The first unmanned launch of DYNA-SOAR is tentatively scheduled for mid-1963, with the first manned launch expected in early 1964. The system will give its human passenger control of his vehicle.

With surplus World War II rocket motors Martin-Baltimore produced a trainer modification of the BULLPUP missile manufactured by Martin-Orlando. While still possessing the same aerodynamic characteristics as the parent missile as far as training operations require, the T-GAM weighs only a fifth of the original and represents a substantial cost saving.

In the electronics field, Martin-Baltimore developed an infrared scanner adaptable for anti-ICBM missile guidance, and extended the facilities of its anti-submarine warfare laboratory. The important feature of the scanner is that the entire system—detectors, mirrors, amplifiers and coolant—rotates as a unit. Infrared detection has been concentrated until recently on sensing objects of relatively high temperatures. The new Martin seeker-tracker permits detection and distinction of objects having very low temperatures (e.g., an orbiting satellite's outer skin surface or a low magnitude star).

To further the effectiveness of its sonar research, the company has launched a special testing platform in a waterway adjacent to the Baltimore plant. Transducers mounted on the barge's electrically-controlled measurement shafts enable ASW engineers to establish limits and measurements for improving the acoustic detection of submarines.



ARTIST'S CONCEPT of PM-3A reactor.

In order to strengthen Martin-Baltimore's overall position in the space age electronics field, a new electronics division was formed which will integrate many of the company's widespread electronic engineering and production facilities.

In mid-November Martin was awarded a study contract by the National Aeronautics and Space Administration for PROJECT APOLLO, the first manned circumlunar space ship. The company will originate preliminary designs and plans with the following four objectives: (1) Definition of a manned space craft system. (2) Planning of the program from design to flight test. (3) Identification of technical areas that might take particularly long to complete. (4) Assessment of the program cost and funding schedule.

In education, Martin-Baltimore contributed an initial endowment to George Washington University to establish a school of metrology. Metrology—the science of measurement—has been up to this time a gravely neglected field in the United States, and at present the Soviet Union is believed well ahead of the free world in its ability to calibrate accurately. (The U.S. Bureau of Standards, for example, can provide reasonably accurate temperature calibrations up to 4200 degrees centrigrade, whereas the Soviets claim competence in measuring 12,000 degrees.) The Soviet advances in metrology have contributed greatly to their missile and space achievements. With the new George Washington Institute of Measurement Science, Martin-Baltimore hopes to see the gradual easement of the nation's dangerous "measurement pinch."

In addition to manufacturing the MACE and the DYNA-SOAR booster, Martin-Baltimore produces a wide variety of ground and special equipment for the weapons systems assembled at other company division plants. Among these are instrumentation systems for the giant Air Force TITAN ICBM, and support equipments for the Army LACROSSE and PERSHING missiles and the Navy-Air Force BULLPUP.

Production continued throughout the year on the final Navy P5M-2 MARLIN anti-submarine warfare patrol seaplanes.

ORLANDO DIVISION

The Martin Company's Orlando Division, now Florida's largest industrial employer with 8,800 employes, continued to expand and increase its scope of activity in five major national defense systems. Production continued on the Army LACROSSE, the Army MISSILE MASTER, Navy BULLPUP and Air Force GAM-83. The Army PERSHING ballistic missile system continued on schedule in research and development.

A total of eight LACROSSE battalions were activated in 1960, and several battalions were deployed overseas. Significant improvements were made in the system's reliability and an improved guidance package was developed which will significantly enhance the potential of the LACROSSE weapon system. This development was being considered at year-end by the Army for possible adoption.

The Navy BULLPUP, operational with the fleet since 1959, was on front line duty with about 20 Navy and Marine squadrons by January, 1961. The highly reliable and accurate ASM-N-7 and ASM-N-7A were in production and the first of the larger and more powerful BULLPUP "B" began rolling off the lines for advanced testing.

The first Air Force squadron to be equipped with the GAM-83A BULLPUP gained operational status in November, with three other squadrons of F-100 jets scheduled to follow them closely. The Air Force announced that the F-105 THUNDERCHIEF would get the missile in the future—both in the conventional warhead GAM-83A and nuclear GAM-83B, which is scheduled for early 1962.

The installation in 1960 of MISSILE MASTER electronic control defense systems to coordinate NIKE-AJAX and NIKE-HERCU-

LES batteries was called "a significant step toward perfecting the defenses of the American continent." By year-end ten scheduled MISSILE MASTER installations were activated and were coordinating NIKE batteries at Ft. Meade, Md. (Washington-Baltimore defense); Ft. Lawton, Wash. (Seattle-Tacoma); Ft. Heath, Mass. (Boston-Providence); Highlands Air Force Station, N.J. (New York metropolitan area); Lockport Air Force Station, N.Y. (Buffalo-Niagara) and Selfridge Air Force Base (Detroit). Installations were completed and scheduled for operational status by the end of 1960 at Pittsburgh, Philadelphia, Chicago and Los Angeles.

Initiation of the PERSHING flight test program at Cape Canaveral began in early 1960. The first six attempts (first stage only with dummy second stage) were successful, establishing a new reliability record at the Atlantic Missile Range. By the end of the year PERSHING was well into its two-stage flight test program.

The Pershing weapon system was demonstrated before President Eisenhower and top Pentagon leaders at the Army's Project MAN; it was also flown to Europe and demonstrated before ranking U.S. and NATO commanders and staff.

In support of the Orlando Division's accelerated research program, a new technical and research staff (TARS) was organized in mid-1960. This group was concentrating on the application of technical competence to existing weapon system projects.

In addition, this high level research and development team was providing technical support to the Division's Advanced Systems group, assuring the superiority of future projects.

Two of the more promising developments to come out of this group are the Cesium vapor cell and thin film circuits.

It was discovered that a simplified frequency standard can be developed by ground state hyperfine splitting of the Cesium atom. Light from a ten watt Cesium lamp is polarized by being passed through suitable filters to excite a Cesium vapor cell mounted in a cylindrical cavity.

The accuracy and stability of this frequency standard makes possible the development of an atomic clock which will vary not more than one second in 300,000 years. This timing device has further application as a precise tool for checking Einstein's Theory of Relativity.

In the area of thin film previously unused electrical properties of matter find application in thin film circuits. A single thin film, 18 millimeters square by one millimeter thick, represents a complete flip-flop circuit, many hundreds of which are used in digital computers. In addition to the extraordinary space and weight savings, simplicity and fewer solder connections lead to the greater reliability demanded of space and missile systems.

COCOA DIVISION

In the first 11 months of 1960, Martin-Cocoa launched 19 Denver-built TITAN intercontinental ballistic missiles for the Air Force, eight selective-range PERSHING missiles for the Army and ten MACE tactical missiles for the Air Force, a total of 37 missiles, or a launch rate of better than three per month.

The year saw the first two-stage TITAN flight on February 2 and the first complete systems, full-ICBM-range flight on February 24. The test program for this largest of U.S. missiles progressed so rapidly during 1960 that the first successful operational prototype was launched August 10 and five more of these missiles had been flown, including one at 6100 miles, by the end of October. Of the 19 TITANS launched in that period, 14 TITANS accomplished all major objectives.

February also marked beginning of the flight test program for the Army's two-stage, solid propellant PERSHING, built in Orlando. This selective combat range artillery missile, which established a launch record at Cape Canaveral with six successes on its first six launches, was well into an advanced phase of testing by year's end.

A third missile test program conducted at the Cape during 1960 by Martin-Cocoa was the Air Force's TM-76B, an inertially-guided, longer-range version of the operational TM-76A MACE. Ten of these Baltimore-built, swept-wing, tactical missiles were launched, including five from a simulated battlefield launcher—a concrete shelter which would conceal and protect the MACE from enemy action. The first launch from the hardsite occurred July 11 and Air Force troops successfully launched a MACE from the shelter for the first time on October 7.

Martin-Cocoa's administrative staff, numbering less than one-tenth of the total Martin employment at the Cape, moved into a modern, one-story office building south of Canaveral early in 1960.

The Cocoa Division was established in 1957 to conduct all missile flight testing for Martin's other divisions at the Atlantic Missile Range. At the end of 1960, facilities assigned to and operated by Martin-Cocoa included three hangars and four launch complexes for the TITAN, an assembly building and complex with hard and soft launch sites for MACE and a complex with two launch pads for PERSHING.

DENVER DIVISION

In October 1960, the Air Force TITAN ICBM (SM-68) began full intercontinental range tests over the Atlantic Missile Range. A missile launched from Cape Canaveral, Fla., on Oct. 24, delivered its nose cone 6100 miles to a point near St. Helena Island in the South Atlantic. Late in 1960, TITAN was scheduled for its first fully operational flight test from training facilities at Vandenberg Air Force Base, California.

In its first complete systems test on February 24, 1960, TITAN was launched 5000 miles from Cape Canaveral. Both stages functioned properly, the nose cone separated and dropped in the target area near Ascension Island. A data capsule, carried in the nose cone, was recovered, beginning the collection of valuable re-entry data which cannot be achieved by telemetry. In all there have been 25 flights, since the first on February 6, 1959, 19 in the first 11 months of 1960.

On June 20, 1960, The Martin Company was awarded an Air Force contract for development and production of TITAN II, a bigger and more powerful version of TITAN. Designated SM-68B, TITAN II will be longer (TITAN I is 98 feet) and larger (10-foot-diameter second stage compared with eight feet in TITAN I). TITAN II engines are substantially uprated, utilizing storable fuels. (TITAN I first stage engine delivers 300,000 pounds of thrust; second stage 80,000 pounds.) The storable fuels (nitrogen tetroxide and a 50-50 mix of anhydrous hydrazine and unsymmetric dimethyl hydrazine) give TITAN II a virtually instantaneous reaction time. TITAN II will be launched from the bottom of its underground silo, whereas TITAN I must be lifted on an elevator to the surface before launch. TITAN II will incorporate a complete inertial guidance system; TITAN I depends upon ground radio guidance.

Bases were announced in 1960 for the 14 squadrons (TITAN I and TITAN II combined) so far authorized by the Air Force. Each squadron will contain nine missiles in silo, plus a spare maintained nearby, accounting for the current production total of 140 TITAN ICBM's.

The first squadron of TITAN I was to become operational during 1961. It will be located at Lowry Air Force Base where basic construction was nearly complete and installation and checkout of electronic and other ground based equipment had started by late 1960. Two squadrons will be located at Lowry. Construction was underway at four other TITAN I bases (one squadron each) at Ellsworth AFB, Rapid City, S.D.; Mountain Home AFB, Mountain Home, Idaho; Larson AFB, Moses Lake, Wash., and Beale AFB, Marysville, Calif.

Four TITAN II bases announced by the Air Force will be located at Davis-Monthan AFB, Tucson, Ariz., McConnell AFB, Wichita, Kansas, Little Rock AFB, Little Rock, Ark., and Griffiss AFB, Rome, New York. These bases will contain two squadrons each.

In the TITAN I base, missiles will be grouped in complexes of three TITANS each, with a central control and guidance center for each complex. TITAN II will be dispersed in individual silos capable of launching an entire squadron or more in salvo. All installations are of concrete and steel and placed deep underground to withstand the blast of an enemy nuclear attack.

NUCLEAR DIVISION

During 1960 Martin began work on its second air-transportable nuclear reactor for the Atomic Energy Commission and started electrical tests on a new "isotopic power" generator in the SNAP series. The company was also awarded a study contract by the National Aeronautics and Space Administration to develop plans for the first flight test of a nuclear rocket engine.

Work on the company's first portable reactor system, the PM-1, reached the hardware stage. Zero power tests began in March on the PM-1 core—an assembly of tubular fuel elements the size of a single oil drum which will produce heat and electrical power equal to that supplied by millions of gallons of high grade diesel fuel.

Preparation of the PM-1 site at Sundance Air Force Station, Wyoming, was completed and a flight test demonstrated air transport ability.

The new power plant for which Martin received an AEC contract during 1960 was PM-3A, a reactor system which will service the Naval Air Facility at McMurdo Sound, Antarctica—headquarters for all American scientific activities on the polar continent. The electrical output of PM-3A will be 1500 electrical kilowatts (50 per cent higher than PM-1), and the plant is scheduled for delivery in November, 1961.

A full year after it began operation, the tiny SNAP-3 generator built by Martin was still producing continuous electrical power, and further environmental tests indicated that "Systems for Nuclear Auxiliary Power" of this type could be used safely in satellites and space probes. Meanwhile, electrical tests began on a larger unit, the 125-watt SNAP 1-A, which is designed to operate at full power for a year.

In these isotopic power units pioneered by Martin, heat produced by the spontaneous decay of radioactive material is converted directly into electricity by thermoelectric elements. The operating life and the power density depend on the specific radioisotope used.

A new, highly-automated laboratory built by Martin during 1960 will help to multiply the supply of one radioisotope which is particularly valuable for such applications, Curium-242. Almost simultaneously, the company leased additional laboratory facilities at Quehanna, Pennsylvania, where final steps in the Curium production process can be carried out and where future isotopic power units will be fueled and tested.

The NASA contract in the nuclear rocket flight test program calls for preliminary design of the system, evaluation of safety factors, planning of test and tracking facilities, and development programming and scheduling. The study will consider three basic approaches to the first flight test: (1) start-up of the nuclear engine on the ground in a "booster" stage; (2) use of the nuclear engine in the second stage; or (3) start-up after being placed in orbit by a Saturn vehicle.

Independent of the NASA study (in which the Denver and Nuclear Divisions are cooperating) Martin continued its intensive investigations of suitable fuel element materials for nuclear rocket reactors. The extreme temperatures which will be experienced in such a working system pose a severe materials problem which must be solved in order to make possible the increased endurance and specific impulse offered by nuclear rocketry.

Research and development in the field of direct energy conversion was also expanded during the year by the establishment of a new laboratory and the creation of a new group to investigate advanced thermoelectric, thermionic and magnetohydrodynamic systems.

RIAS

RIAS intensified its program of basic research in 1960. Scientific advances were accompanied by a growing measure of support from government agencies, mindful of the need for a deeper understanding of fundamental scientific principles. Basic studies in mathematics, the biosciences, physics, chemistry and metallurgy were conducted by the staff, aided by contracts and grants from the Air Force, the Army, the Navy, the Atomic Energy Commission, the National Science Foundation and the National Institutes of Health.

In the RIAS metallurgical laboratories, notable results were achieved in studies of dispersion-hardened alloys. Experiments with a matrix of silver in which had been incorporated an aggregate of aluminum oxide proved that this alloy retained mechanical strength at temperatures higher than the melting point of silver.

Studies were conducted on the effects of surface treatment on the mechanical properties of metals and on the influence of plane defects on the strength of fabricated metal.

Among the photosynthesis investigations performed by the Biosciences Group were studies of carbon monoxide uptake in green plants; the analysis of the lipid constituents of the chloroplasts and lipid metabolism in plants; the significance of the laminar structures in which radiant energy is converted into chemical energy, and the mode of pigment interaction in the photochemical conversions.

In the Physics Group experimental and theoretical studies were conducted in solid state physics, cosmic radiation and the modern theories of fields. The solid-state program was concerned with the properties associated with the transport of electrons and photons through solids.

The cosmic ray studies were being performed by sending ionization chambers aloft in satellites, rockets and balloons. Analysis continued of data obtained in the experiment with the Explorer VII satellite. This research was devoted to an investigation of the heavy component of the primary cosmic radiation and of the secondary neutrons emergent from the atmosphere.

A major theoretical program involved the study of the combined theories of electromagnetism and gravitation as expressed by the general theory of relativity and the covariant form of Maxwell's equations.

In theoretical chemistry, studies were begun, seeking the cause of interfacial instability in systems where diffusion of a solute is occurring. The newly-expanded quantum chemistry group was working to set up methods to predict molecular properties based on molecular orbital calculations for compounds containing heteroatoms, such as boron and nitrogen, in addition to simple carbon and hydrogen atoms.

Members of the Mathematics Group concentrated most of their work in the field of non-linear differential equations, which can be used to describe highly dynamic systems, such as those used for missile and rocket controls. Four RIAS mathematicians presented papers at the International Federated Automatic Control Congress in Moscow during the spring of 1960.

The growing productiveness of the RIAS research program was reflected in the sizeable increase in the number of papers published in scientific journals. More than 60 technical reports and monographs were published in 1960, an increase of 50 per cent over the best previous year. Staff members conducted numerous seminars and conferences and delivered many lectures to disseminate the results of their research.

NORTH AMERICAN AVIATION, INC.

NEW WORLD RECORDS for speed and altitude in a manned aircraft were set by North American's X-15 rocket plane when the ship went 2,196 miles an hour and up to 136,500 feet with two XLR-11 engines totaling 16,000 pounds thrust. First tests were made with the single 57,000-lb. thrust XLR-99 engine in the aircraft.

Development work went ahead on the B-70 Valkyrie, strategic bomber which will fly at 2,000 miles an hour and above 70,000 feet.

The T-39 Sabreliner twin-jet trainer bettered its design speed and range in first flight tests of production models. Quantity production started with 94 aircraft on order from the Air Force.

The A3J Vigilante attack weapon system completed carrier suitability trials and the T2J Buckeye jet trainer graduated its first class of Navy fliers.

Rocketdyne's Atlas engines were employed in the first generation of operational ICBM's, the first full cluster of Saturn engines was test-fired and work went ahead on the F-1 engine, 1,500,000 lbs. of thrust in one chamber. Thor, Atlas, and other Rocketdyne engines continued to put up the great majority of the nation's satellites and space probes. Production was begun on the J-2, a liquid hydrogen engine of 200,000 lbs. thrust, for later versions of Saturn. Other production during the year included Redstone and Jupiter engines and solid propellant boosters.

The company was in production on the Air Force GAM-77 Hound Dog air-to-surface missile and was developing the Redhead-Roadrunner target missile for the Army.

Development and production of the guidance and control system for Minuteman and for the Hound Dog, inertial navigation systems for nuclear submarines, flight control for the A3J and armament control for the F-105, F-104, A3J and T-39 continued. The company also increased its activity in computers and data processing equipment.

Fabrication was started on the 600-ft. radio telescope antenna for the Navy.

Construction of two nuclear power plants proceeded and the company continued a number of nuclear reactor experiments for the AEC, including development of systems for nuclear auxiliary power in space and a reactor for nuclear ramjet propulsion.

There was sharply increased effort in basic research and in research and development across a wide range of technology, but particularly in the area of space.

Agreement was completed with the French firm, Societe D'Etude De La Propulsion Par Reaction in the rocket field. North American and two other French firms organized Dynatom, a joint company to design, build and market nuclear reactors. A mutual licensing agreement in electronics was reached between North American and A. B. Atvidabergs Industrier of Sweden.

In 1960, North American received the Arnold Air Society's Hoyt S. Vandenberg Award for the company's contribution to aerospace power for national security.

Employment rose to 67,000 on September 30, the highest mark for any year but one since 1943.

North American's sales for the fiscal year ending September 30 totaled $964,162,496, compared with $1,044,899,580 for the previous year. Net income after all costs and provisions for federal income taxes was $23,394,548.

Back log of unfilled orders on September 30 was $873,000,000, not including orders that were negotiated but not yet funded. Activities of the various divisions were as follows:

LOS ANGELES DIVISION

Development of the Mach 3 B-70 bomber which will cruise between continents at 2000 miles an hour continued in 1960, passing significant design milestones. Both Mockup and Design Engineering Inspections have been completed and more than six million manhours have been accumulated.

Four flights in excess of Mach 3 were successfully completed by the X-15 research vehicle and unofficial world records set for both speed and altitude. NASA pilot Joe Walker flew an X-15 2196 mph on August 4 and Air Force Major Bob White flew to 136,500 feet on August 12.

The Air Force awarded follow-on contracts for production of the T-39 Sabreliner totaling 94 aircraft. Exceeding design specifications by a substantial margin the first production T-39 flew non-stop 1820 miles at an average speed of 540 mph.

Modifications to F-100 Super Sabres extending the useful service life of this front-line Air Force fighter-bomber were conducted at North American's Palmdale facility. Nearly 2300 F-100s were manufactured in a six year period and the versatile jet continued to serve as the backbone of the Tactical Air Command's strike force.

Nearing completion at Los Angeles was a $10,000,000 laboratory devoted to the study of space and its effects on the metals and fluids being used to conquer it.

ROCKETDYNE DIVISION

Rocketdyne propulsion systems boosted all American successful satellites and deep space probes, and more than 85 per cent of the successful high thrust ballistic missiles launched by liquid propellant engines in the United States in the 12-month period ending October, 1960. Included in the space launchings were Pioneer V, the sun orbiting satellite; Delta II, the Project Echo communications satellite; Tiros I, weather observation satellite; Transit 1B, navigational satellite; Explorer VII; and Courier 1-B.

Production of engines for the Atlas intercontinental ballistic missile, the Thor intermediate range ballistic missile, and the Saturn vehicle were continued during the year, and development work progressed on the 1,500,000 pound thrust single chamber F-1 engine for use in the heavy duty "space truck." Production was concluded during the year on the Jupiter intermediate range ballistic missile, and the Redstone tactical missile.

NORTH American's A3J Vigilante.

A contract for development of the J-2 liquid hydrogen/liquid oxygen engine was awarded Rocketdyne in October, 1960, and development work was immediately begun. The J-2 will provide a 200,000-pound thrust engine to be used as the second stage for the Saturn. Work also continued on ion and nuclear propulsion and engines that will use storable and high energy propellants.

Announced during the year was the development of the Flexadyne family of solid propellants, which offer superior physical and performance characteristics to castable solid propellants currently in use.

Development continued on Quickmix, an advanced method of continuous processing; a booster for the Army's Redhead-Roadrunner target missile system; and a new low-cost, weather sounding rocket.

Production included solid propellant gas generators for the Tartar and Terrier missiles; turbine starters for the Atlas and Saturn engines; 130,000-pound thrust M-34 boosters for launching the KD2U target drone; and miscellaneous jatos and igniters.

The division's solid propellant activities were centered in the McGregor, Texas, facility, while liquid propellant work was conducted at the Canoga Park, California, plant and at Neosho, Missouri; research and development facilities are centered at Canoga Park.

AUTONETICS DIVISION

Autonetics growth in 1960 was highlighted by an increase in employment from 13,500 to 22,000 to make it North American Aviation's largest division. To improve its efficiency and expanding markets for military and industrial electronic products, the organization was divided into four product divisions: Armament and Flight Control; Computers and Data Systems; Inertial Navigation and Industrial Products.

The Computers and Data Systems building was completed and occupied in Downey; construction of the first of three buildings was begun on 130 acres purchased in Anaheim; an International Operations office was established; a sales and service office for Industrial Products was opened in New York City and plans for construction of an advanced electronics research center in Anaheim were announced.

Autonetics inertial navigation systems participated in two history-making events. Its Ship's Inertial Navigation System (SINS) operated perfectly aboard the nuclear-powered submarine USS George Washington during the first two underwater firings of Polaris Fleet Ballistic Missiles. Its N6A all-inertial autonavigator helped guide the atomic submarine USS Sargo on a deep winter voyage under the Arctic icecap and to the North Pole.

In research and development of the USAF Minuteman ICBM, Autonetics' guidance system was successful in rocket sled testing at Holloman Air Force Base and the USAF accepted the first production-type inertial navigation system.

Verdan computers were delivered by Autonetics to USAF Strategic Air Command squadrons to do double duty by guiding the GAM-77 Hound Dog air-to-surface missiles as well as checking out the missile's inertial autonavigator on the ground. Development of the FADAC computer was furthered with additional U.S. Army contracts.

Production of Autonetics R14A Nasarr radar for the USAF F-105 Thunderchief fighter-bomber was in high gear. Nasarr also was ordered for Lockheed's F-104 for various Free World nations—West Germany, Belgium, Netherlands, Canada, and Japan.

A Navy contract was received to develop a lightweight, helicopter stability augmentation system. Another Air Force contract called for design, fabrication and flight testing an all-weather automatic landing system.

Autonetics Industrial Products achieved wider use of its RECOMP computer which was leased by several organizations for use on a variety of scientific and engineering problems. The year also brought successful completion of a reciprocal agreement between Autonetics and Facit Electronics (subsidiary of AB Atvidabergs Industrier) of Sweden and the introduction of a new wiring continuity tester called NIFTE (Neon Indicator Flashing Test Equipment).

COLUMBUS DIVISION

The carrier-based A3J Vigilante, produced by the Columbus Division for the Navy, successfully completed carrier suitability trials and is to be ready for fleet assignment early in 1961. Flying at twice the speed of sound, the A3J can deliver either nuclear or conventional weapons over long distances at either high or low altitudes, and in any weather. It ejects its stores from the tail through a tunnel-like linear bomb bay.

During 1960 the first Navy fliers graduated from training in North American's T2J Buckeye.

The Columbus Division was at work on the fabrication and flight testing of a new supersonic high or low level recoverable target missile, the Redhead-Roadrunner, for the Army. The low-cost missile is unique in that the same missile system is intended to be used for either high or low controlled missions, and has stubby delta wings which can be quickly attached for added maneuverability on high-level supersonic flights. The missile will be able to fly in the Mach 2 range and from near ground level to more than 50,000 feet.

Columbus was building the 600-foot reflector for the Navy's giant radio telescope at Sugar Grove, West Virginia and is at work on various other telescope, antenna and communications projects.

Many other programs were embraced by new laboratories including one finished late in the year which was testing the effects of sonic fatigue on men and materials.

MISSILE DIVISION

Strategic Air Command squadrons were being equipped with the GAM-77 Hound Dog air-to-surface missile, developed and produced by the company's Missile Division in Downey, California. The 43-ft. missiles can be launched from B-52 bombers to deliver nuclear warheads at supersonic speeds over a range of hundreds of miles.

The missile's turbo-jet engine, with a thrust of 7500 pounds, can be used to assist the mother bomber during takeoff, substantially reducing the length of take-off roll.

Simultaneous with the production of the GAM-77 the division was developing an advanced Hound Dog with several improved capabilities.

In addition to the Hound Dog program, the Missile Division had several study contracts with various government agencies. Through the division's Aero-Space Laboratories, research was being conducted in such areas as flight space mechanics, gas dynamics, and the geophysical, material and astronautical sciences.

ATOMICS INTERNATIONAL

This division was building compact power reactors for the Atomic Energy Commission's program to develop Systems for Nuclear Auxiliary Power (SNAP) for space vehicles. Studies also were being conducted for the AEC on the development of a power reactor for nuclear ramjet propulsion. The division continued design and production of reactors for research and the generation of commercial power both in this country and abroad.

NORTHROP CORPORATION

NORTHROP Corporation, headquartered in Beverly Hills, California, continued during 1960 to carry on its research and development, manufacturing and marketing activities through its four divisions: Norair, Nortronics, Radioplane, and Northrop International, and a wholly-owned subsidiary, Page Communications Engineers. The company had approximately 70 basic products and programs concentrated in weapon systems, subsystems and other developments related to the national defense effort.

Out of the company's plants and laboratories have come technologies which have put Northrop into new and expanding programs in electronics, missiles, aeronautics, space, and communications systems.

During the year Northrop moved deep into two top-priority ballistic missile programs—the Air Force's Skybolt and the Navy's Polaris. Skybolt, in an early stage of development, and the Polaris which was operational status, both represent the most advanced concepts in mobile missile-launching systems. The Skybolt will be launched from high altitude bombers; the Polaris is launched from submerged nuclear submarines. Both demand electronic systems of the highest reliability and precision.

For Skybolt, Northrop was developing the astronertial guidance system. Northrop's capability in this field grew out of more than ten years of leadership in the development of stellar-monitored inertial guidance systems, using electronics, mechanics, and optics to track the stars by day and by night.

For Polaris, Northrop was supplier of an electronic system known as Datico. Aboard the submarine, Datico monitors all of the 16 Polaris missiles, activates and checks the various phases of the missile launch-sequence, and finally gives a green light to the fire control officer. Developed at Northrop, Datico was installed in the first missile launching submarines and contributed to the success of the first Polaris flights.

The George Washington-type nuclear submarine also uses a stabilized periscope, precision gyroscopes, and a radiometric sextant, all produced by Northrop for the Navy, to make possible underwater stellar navigation.

In aeronautics, eleven years of Northrop research produced a major breakthrough in the field of Low-Drag Boundary Layer Control. This is a technique which, applied to large aircraft, will double their range without increasing the fuel requirement. Northrop will apply the technique to two test aircraft to be designed and built under an Air Force contract received during the 1960 fiscal year. The impact of Northrop's Low-Drag Boundary Layer Control on military and civilian air transport is expected to be profound.

The Northrop T-38 Talon, the country's only lightweight supersonic trainer aircraft, was being produced in increasing volume and continued the company's tradition of advanced aircraft design.

The technology used to decelerate and recover high-speed target missiles has placed the company in NASA's Project Mercury, the manned satellite program, for which Northrop will supply the astronaut recovery system. Drawing on the same technology, Northrop was designing the specialized components in the recovery system for Samos, the orbital reconnaissance satellite.

The company received an important contract which draws on Northrop's experience in equipping and activating missile bases. Northrop will manage the installation, equipping, and activation of the first launching site for the Titan missile at Ellsworth Air Force Base, South Dakota. The company's specialized competence in this area, developed in connection with the Snark missile base, should bring additional assignments in connection with the many bases which will be required for the Titan, Atlas, and Minuteman ballistic missiles.

During the fiscal year Northrop broadened the scope of its activities through four acquisitions. All of these acquisitions were profitable when they were acquired and have increased their profitability since. In February, the company acquired the Military Products Division of American Radiator and Standard Sanitary Corporation for cash. This unit, whose three plants near Boston produce precision gyroscope and electronic equipment for the Navy, was made the Precision Products Department of the company's Nortronics Division. With the aid of Nortronics' broad technical, marketing, and managerial assistance, the new department's production competence was improved and sales increased. The department's sales were expected to increase substantially and to contribute proportionately to the company's earnings.

During the year Northrop acquired for cash the Acme Metal Molding Company of Los Angeles, a leading manufacturer and distributor of aluminum architectural shapes used extensively in the building construction industry. This company operates in a field in which Northrop's engineering and manufacturing experience with metals can make an important contribution. Acme is being operated as a wholly-owned subsidiary under its founder management and is attached administratively to the company's Norair Division. It is making a satisfactory contribution to Northrop's sales and earnings.

The company also acquired the Aero Instrument Company of North Hollywood, California, a small manufacturer of pressure gauges and flow meter switches. The unit was purchased for cash and made a part of the Radioplane Division.

Northrop joined with its subsidiary, Page Communications Engineers, Inc., the Phelps-Dodge Corporation, and Felten and Guilleaume, a long established German cable manufacturing company, to organize the United States Underseas Cable Corporation. This new firm, in which Northrop has approximately a one-third interest, is in the business of planning, designing, and constructing long distance underseas cable systems and associated equipment, and is bidding on a number of major cable communications systems now under study by the military.

NORTHROP'S Norcom communication system.

NORTHROP INTERNATIONAL

The International Division was primarily concerned with furthering the international sales of Northrop products, providing liaison with allied governments, overseas servicing of Northrop products, arranging licensing agreements, conducting surveys for prospective United States production of foreign products, and conducting world-wide market surveys for Northrop products.

During 1960, Northrop International initiated programs to establish agreements with other companies abroad as a basis for improving the corporation's immediate and long-range business potential in several of the major international market areas.

Among the many products presented to the armed forces of the free world by Northrop were the Air Force T-38 Talon supersonic jet trainer, DATICO automatic test and checkout equipment, and a broad range of target and surveillance drones.

NORAIR DIVISION

Progress at Norair during the year was marked by acceleration of Space Age technologies, planned diversification into numerous fields related to the Division's aerospace prime contract responsibilities, and continuation of strong aircraft production programs.

An Air Force contract for 144 more T-38 Talon supersonic trainers brought the total of T-38 aircraft on order to 213 as the Talon prepared to enter service in the Air Training Command. Meanwhile, the Talon test force at Edwards Air Force Base, Calif., passed the 900-flight mark. The Talon's sister aircraft, Northrop's N-156F multipurpose Freedom Fighter, continued through exhaustive evaluation by potential military users. Subcontract manufacture of major airframe sections of KC-135 jet tankers and Boeing 707 and 720 jet airliners continued at a high level.

The Norair-developed Laminar Flow Control (also known as Low Drag Boundary Layer Control) method for increasing aircraft performance won two new Air Research and Development Command contracts. In a two-year program totaling more than $20,000,000, Norair was assembling and testing two multi-engine jet aircraft to demonstrate Laminar Flow Control under operational conditions. Another ARDC contract continued research into supersonic and other sophisticated applications of LFC. The LFC system smooths out boundary layer turbulence by sucking air through wafer-thin, spanwise slots in the wings and exhausting it rearward. The suction eliminates 80 percent of friction drag and increases range, payload, or endurance.

Norair's new Site Activation Department moved swiftly into a new program of installation and checkout of Titan intercontinental ballistic missiles and ground equipment at Ellsworth Air Force Base near Rapid City, S.D. The work is being performed under a multi-million dollar contract awarded by The Martin Co., associate prime contractor for the Titan weapon system. This was the first major launch site activation contract awarded for Titan.

During 1960, Norair continued to develop new approaches to man's conquest of space. Computer techniques for rapid calculation of trajectories and launch times for satellite rendezvous, research into the application of magnetogasdynamics propulsion for an orbiting space vehicle refueling system, and new equipment and methods for investigating the behavior of liquids and gases in zero-gravity attracted wide scientific attention.

The Division also conducted, under classified contracts, studies of orbital and deep space missions. These studies drew on Norair capabilities in space physics, astrodynamics, space propulsion, bioastronautics, space materials and space vehicle design—new advanced research laboratories—built, equipped and staffed during the year—brought additional Norair capabilities to bear on the divisions space programs.

In addition, new equipment, advanced methods and stringent test criteria moved the Division's test laboratories into the realm of hyperenvironments—the conditions simulating the rigors of space travel.

Norair-developed fabrication methods for Space Age materials including Nortobraze, a method of high-temperature brazing which uses electronically-controlled banks of radiant quartz lamps to cut brazing time from hours to minutes in the manufacture of stainless steel honeycomb sandwich structures.

The SM-62 Snark intercontinental guided missile completed its scheduled production. The Snark is now in service with the Strategic Air Command.

New concepts—for missiles, for ground environment to support missile, space vehicle and military and commercial aircraft operations—took major steps toward the hardware stage during the year at Norair.

NORTRONICS DIVISION

New steps in weapon system support and advanced guidance system technology were taken by Nortronics during 1960 with stepped-up emphasis on the Air Force Skybolt astro-nertial guidance system and the Navy Polaris Missile automatic checkout system.

Development of the Skybolt guidance system stemmed from the Division's work on the Mark I stellar-monitored inertial system and its test equipment developed for operational versions of the USAF Snark SM-62, LINS (lightweight inertial navigation system), A-5 astronertial guidance system, and A-8 star tracker for space navigation.

The Skybolt program was being carried out at Nortronics' Electronic Systems and Equipment Department in Hawthorne, California. Scheduled for a 1964 operational date, all elements of the Skybolt system were being developed on an accelerated priority basis. The Nortronics guidance system will provide the capability for directing the missile to target from launch positions as much as 45 degrees off azimuth. Skybolt will contain the guidance platform and computers while the launch aircraft will contain the prelaunch computer. The system will make use of existing bombing-navigation aboard the aircraft.

Related research and development programs underway at Hawthorne in the fields of flight control and airborne electronics include the

"Q" Ball attitude-sensing nose cone for NASA's X-15 research vehicle and ballistic missile application, micro-electronic refrigeration employing the Peltier effect, and completely transistorized airborne computers.

The Navy selected Nortronics' Datico automatic electronic evaluation system for its Polaris Fleet Ballistic Missile System. Datico is based on the concept developed some three years ago under company sponsorship and since employed by the Air Force and Army. Delivery of the first Navy unit was made six months from the date of go-ahead. For Polaris, Datico is used to monitor, checkout and perform the launch countdown sequence for each of the sixteen missiles aboard the submarines. It is used on the submarines, the submarine tenders, at the Naval Weapons Annex and on factory assembly lines.

The Datico work was being conducted at Anaheim, California by Nortronics Systems Support Department. Other major programs at Anaheim include awards from all three branches of the military services for advanced optical display and vision systems. These are extensions of original specialization in optical systems, periscopes and rangefinders. Among the new assignments were development of new reconnaissance photograph viewers for the Navy, a universal articulated telescope and T-57 rangefinder for the Army, and a 600 millimeter ballistic camera for the Air Force. This latter project represents the first such undertaking in this country. The camera is designed to record the exact trajectory of a missile by photographing it against a background of stars.

Volume production on the highly successful Army Hawk was continued through the year at Anaheim. Mobile launchers, tracked loaders and major portions of the missile airframe were designed by Nortronics. In addition to service with the Army, Hawk is slated for employment by the Marine Corps and production by European firms for NATO forces.

Northrop acquired the Military Products Division of American Radiator and Standard Sanitary Corporation in February of this year, and integrated the unit as an operating departing of the Nortronics Division. Known as the Precision Products Department and located in Norwood, Massachusetts, this group was also engaged on the high priority Polaris program. The Norwood unit developed and was producing the Type-11 stablized periscope system for the Polaris submarines to permit celestial navigation while submerged. Precision Products Department of Nortronics has a broad background in gyroscope design, development, and production. At year-end, it was supplying gyroscopes for the Terrier, Talos, Tartar and Nike-Zeus missiles, F-106 aircraft, HU-43B helicopter as well as for the Polaris submarine SINS systems. Additional company-sponsored research and development work was underway in gyroscopes and related systems.

Indicative of the dynamic growth experienced during the year by Nortronics, in addition to substantial increases in contract assignments in a variety of fields, were the facility authorizations for all three operating departments. A new research and science center was under construction at Palos Verdes, California, for the Electronic Systems and Equipment Department. Scheduled for completion early in 1961, this modern facility will provide a campus-like atmosphere for a 600-man creative scientific team and will house the division's executive headquarters. A new three-quarter million dollar addition to one of the three facilities of the Precision Products Department was also underway with completion expected early in 1961. This addition will accommodate a step-up in Polaris system engineering and production and other gyroscope work underway at the Norwood location.

Most recent authorization by Northrop for Nortronics facilities was received by the Systems Support Department in Anaheim where a new one and three quarter million dollar engineering and administration center will be erected starting early in 1961. This facility will be located on the Northrop owned tract where a new underground countermeasure and explosive ordnance laboratory was completed in mid-1960.

Present programs and company-sponsored research have intensified Nortronics' emphasis on broadening its efforts and capabilities to support the entire spectrum of ground, airborne and space systems.

PAGE COMMUNICATIONS ENGINEERS

Page Communications Engineers, Inc., a wholly-owned subsidiary has designed and built telecommunications systems on four continents. The firm has been a leader in the design and construction of long-distance ionospheric-scatter radio communication systems (scattered reflection of radio waves from the electrically charged layer of air 25 to 250 miles above the earth's surface) and long-distance tropospheric-scatter communication systems (scattered rebound of radio waves from that area of the earth's atmosphere extending from the earth's surface up to about 10 miles.

In the past year, Page completed a multichannel, 6,500 mile trans-Pacific scatter network for the Army, linking Hawaii and the Philippines. Another link from the Philippines to Okinawa was in process of completion.

The company designed and was constructing the Air Force tropospheric scatter system connecting England, Spain, and North Africa. Also for the Air Force, it was designing, installing, and testing seven tropospheric scatter circuits in Turkey, linking Ismir, Karamursel, Ankara, Samsun, and Trabzon; three additional circuits were to be installed and operated between Karamursel, Ankara, Samsun, and Sinop.

In addition to the North African and Middle Eastern communications work, Page held contracts for the integration and operation of a national telecommunications network for the Kingdom of Libya, and for the inspection, testing, and acceptance of a communications system for the Japanese air defense network.

Under an Air Force contract, Page established a very high frequency (VHF) ionospheric scatter test range between Stony Point, New York and Carrabelle, Florida. This contract included equipping the two sites, conducting performance tests, and designing and adapting equipment utilizing meteor bursts as a means of communication by reflection of radio waves from the electrically charged trails of meteors.

Another Air Force contract covered design of the communications systems for the National Space Surveillance System. Page recently completed the design of the communications systems for the Navy's Pacific Missile Range.

During the year Page moved into a new building in Washington, D.C.

RADIOPLANE

During 1960 contracts for the production of a total of 700 RP-76 rocket powered target missiles were received from the Army. Production and delivery was in progress at year-end. The contracts also provide for a complete Radioplane furnished flight services program. The RP-76 was being used as a training target by Army Nike Hercules and Ajax missile crews. A supersonic version of the RP-76 was undergoing flight test and evaluation. A drone altitude record of 72,500 feet was set by the RP-76.

The OQ-19 type aerial target continued in full production throughout the year. Foreign contracts included an order from the British Royal Navy for a quantity of KD2R-5 targets for fleet training operations at various stations around the world. Negotations for SD-1 surveillance drones were pending with several foreign customers.

A contract was received for turboprop RP-77D targets to be flown against the Hawk missile. The versatile RP-77D was being considered for other specialized missions such as battlefield surveillance (tactical photography, T. V., SLAR, Communications), CBR (tactical BW/CW, dispensing and sampling) and as a logistic drone (cargo carrier, tactical and logistic missions).

Increase in production contracts marked the SD-1 surveillance drone program. Developed for, and evaluated by the Army Signal Corps, the SD-1 was operational as an aerial photographic reconnaissance drone with the Army in Europe, the Far East and the United States.

The latest of the Q-4 type supersonic drones, the XQ-4B, was being developed to meet a USAF requirement for testing, training and evaluating operational units in the employment of defense weapon systems. Several XQ-4B vehicles were delivered to the Air Force at Holloman Air Force Base, New Mexico where in-flight testing is being accomplished.

Radioplane's paradynamics research and production projects included the landing system for NASA's Project Mercury manned satellite program and associated advanced space vehicle research equipment; human escape and survival systems for supersonic aircraft; decelerator devices for absorbing ground impact loads of air-dropped cargo; missile and target drone parachute recovery systems; and the new "Skysail" high-performance personnel parachute capable of providing safe escape at airspeeds in excess of 400 knots. Numerous successful test drops of boilerplate Project Mercury capsules were accomplished at the Salton Sea range, and a full scale, instrumented capsule was safely lowered by a Radioplane landing system after being fired hundreds of miles downrange from Cape Canaveral by an Atlas Missile. A contract was received for stabilization and recovery equipment for the B-58 (Hustler) emergency escape system. Also, a subcontract was received from Convair for the production of parachute escape and survival packs for the F-106 program.

Radioplane produced recovery components for SAMOS, the surveillance satellite space orbital vehicle. Also in progress was a Radioplane sponsored study of the problems associated with lunar landings of space vehicles and landings on other planets.

PIASECKI AIRCRAFT CORPORATION

DURING 1959, Piasecki completed a comprehensive program of test flights on Sky-Car I, the aerial jeep built and flown by the company under an Army contract. The Sky-Car utilizes the ducted fan principle and is not dependent upon ground reaction for its lift, as are the "ground effect" machines. The Sky-Car can fly high in the air over any rough or sloping terrain, around or over trees, buildings or other high obstacles, whereas the GEM machines must rely solely on the reflection of their downward air pressure against a relatively smooth and level ground surface. As a result of the superior aerial capabilities demonstrated by Sky-Car I, Piasecki received an Army contract to design and fabricate Sky-Car II, a second twin engine aerial jeep which will have greatly increased capacity, speed and range. At year-end, Sky-Car II is well into the fabrication stage. Upon completion, it was to be delivered to the Army for extensive field testing at various Army installations.

In August, the company announced the award of a patent for the Ring-Wing, a unique V-STOL aircraft design that had been under wraps in the development stages for over four years. The company revealed photographs of the full-scale mock-up, and the wind tunnel model built under Navy contract. Extensive wind tunnel tests were performed on the prototype at the Navy's David Taylor Model Basin in Washington. The Piasecki Ring-Wing design incorporates two propellers shrouded by ring wings mounted on either side of the fuselage in place of conventional horizontal wings. A system of flaps is positioned within both rings so they may be lowered into the slipstream, thus creating a downward thrust of air and providing lift while the aircraft is at zero velocity, or during take-off or landing. When the aircraft has achieved forward speed, the flaps are raised and the rings serve as airfoils to maintain lift during forward flight.

International affiliations were advanced by Piasecki during the year. A prime contract to supply engineering to an Italian company for a new helicopter was continued. Work on the Brequet 941, a STOL transport on which Piasecki is cooperating, progressed on schedule and the aircraft was to be completed by June, 1961.

During the year, Piasecki secured a number of contracts in the missile field. The company was assigned the critical responsibility for engineering and manufacture of the complete airframe and thrust cone for three re-entry vehicles, part of the important Air Force Discoverer program. The company was also manufacturing carriages and mating cradles for re-entry vehicle ground handling equipment.

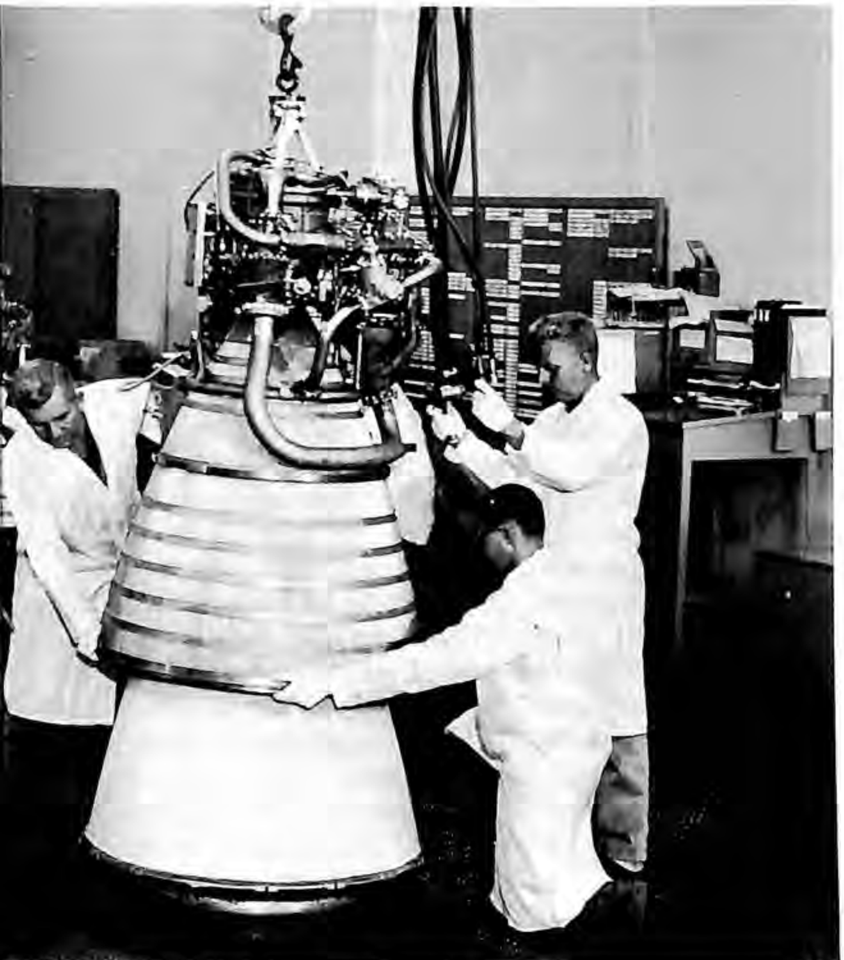
The Mayfield Electronics Division of Piasecki, located near Scranton, Pa., completed a number of development contracts and was awarded a contract for a prime system from the Army Signal Corps.

PRATT & WHITNEY Aircraft's LR-115

PIPER AIRCRAFT CORPORATION

THE YEAR 1960 far exceeded any previous year for Piper Aircraft. Gross sales for the fiscal year ending September 30, totaled slightly over $40,000,000, topping the previous high by 17½ per cent.

Production of all Piper models totaled 2,595. Included in this total were 308 high performance twin-engine Aztecs; 106 twin-engine Apaches; 856 Comanches with a choice of 250 or 180 horsepower; 594 160 horsepower Tri-Pacers and 150 horsepower Caribbeans; 356 Super



liquid hydrogen rocket engine.

Cubs with a choice of 150 or 90 horsepower and 375 Pawnees, which is Piper's Agricultural model.

The Piper engineering department designed two new models in 1960. Deliveries were to begin late in the year on the "Colt," a 108 horsepower, two-place trainer. The Cherokee was licensed in November by the FAA.

The building and expansion program continued to progress in 1960. Facilities were expanded to over 150,000 square feet in Vero Beach, Florida to provide offices and factory for the production of the Cherokee. A new three-story engineering building is nearing completion in Lock Haven.

Piper received a contract in January from the Navy for 20 Aztecs, which were to be delivered late in 1960. The Navy had an option to purchase 130 additional Aztecs, designated the UO-1. Max Conrad again made major aviation news in July by flying a Piper Comanche sixty hours and 6,921.28 non-stop miles from Minneapolis to Chicago to Des Moines. The flight more than doubled the past world record for a non-stop distance record in a closed circuit.

PRATT & WHITNEY AIRCRAFT DIVISION

UNITED AIRCRAFT CORPORATION

IN 1960, Pratt & Whitney Aircraft delivered the nation's first liquid hydrogen rocket engine for deep space work, and made significant strides in developing a nuclear-powered aircraft engine.

New commercial and military planes, using P&WA Turbo Wasp engine power, also began flying during the year. Two of these were turbofan-powered airliners, a long-range Boeing 707, and the medium range Boeing 720B, equipped with JT3D engines. Planes and engines underwent extensive testing prior to regular passenger service scheduled early in 1961.

Pratt & Whitney Aircraft pure jet engines, which ushered in the American commercial jet age October 26, 1958, gave outstanding performances. The list of domestic and foreign airlines relying on P&WA gas turbine engines lengthened to a total of 30.

A new turbofan engine being developed by the company will power the Missileer, a special missile launching Navy aircraft. The craft will be designed for the specific mission of launching the Eagle, a long-range air-to-air guided missile. P&WA won a Navy competition with the design of the TF30 turbofan late in 1959. The Missileer will be propelled by two TF30s, each engine in the 10,000-pound thrust class.

In its wide diversification program, the company established a new Industrial Power department to develop new applications of existing products and to design new products for use in the industrial power field. A first major step outside the aviation field was to fetter the basic J-57 engine to a ground installation to pump natural gas through pipelines.

The United States' first liquid hydrogen rocket engine, the LR-115, was delivered by P&WA's Florida Research and Development Center in August. It is designed to power the Centaur space vehicle and boost multi-ton payloads into high orbits. Centaur, which was being developed for the National Aeronautics and Space Administration, was scheduled for first flight in 1961.

The LR-115 engines, harnessed in a pair, will power the Centaur as an upper stage of an Atlas booster. This system will be capable of putting a 7,500-pound satellite in a 300-mile-high orbit around the earth, sending a 2,000-pound payload on a deep space probe, or "soft-landing"

750 pounds of instruments on the moon.

In another space project for which the LR-115 has been chosen, Centaur will serve as an upper stage of the huge Saturn missile atop a cluster of rockets delivering approximately 1,500,000 pounds of thrust, and aimed to lift 35,000 pounds to a 300-mile orbit.

The LR-115, which delivers 15,000 pounds of thrust, was designed to make multiple starts in space after coasting for hours. Because of these restart capabilities, a satellite could be placed so exactly in orbit that it would remain over a single point on the earth's surface 24 hours a day. A more powerful version of the engine, the LR-119, also will be supplied by P&WA.

In developing the Centaur engine, P&WA pioneered a new technology in the handling of hydrogen as a cryogenic, or very cold, fuel. This fuel flows colder (minus 423 degrees Fahrenheit) and burns hotter than any other liquid rocket fuel. It is also the lightest fuel and packs the greatest specific impulse punch (pounds of thrust per pound of propellant per second of burning.) A decade ago liquid hydrogen was a mere laboratory curiosity; today it is an industrial product of high importance, and one which gives promise of playing a major role in man's conquest of space.

Pratt & Whitney Aircraft used more than 8,000,000 gallons of liquid hydrogen in developing the engine and in other associated programs. This is more than that used by all other consumers in the nation.

The Centaur engine employs a regenerative cycle known as a "bootstrap," which eliminates the need for a separate gas generator to power the fuel pumps. Liquid hydrogen fuel in the LR-115 is used to power the engine's pumps before passing into the thrust chamber to be burned. Liquid hydrogen's high specific impulse makes possible heavier payloads than in the past.

The Air Force reported in 1960 that P&WA made "significant strides" in developing a nuclear-powered aircraft engine. The company, in cooperation with the Atomic Energy Commission and Air Force, has been working on an indirect cycle powerplant system at the Connecticut Aircraft Nuclear Engine Laboratory (CANEL) in Middletown since 1953. Facilities also will be made available at the commission's National Reactor Testing Station in Idaho.

The indirect cycle system, using a live reactor for its energy source, has a liquid metal coolant which serves as the heat carrier from the reactor to a radiator in a turbojet where the heat is exchanged to the air to produce thrust.

In the jet age, planes using P&WA JT3 and JT4 engines, commercial versions of the J-57 and J-75, continued to shatter records and increase the popularity of air travel.

Since the start of commercial service the Boeing 707s and Douglas DC-8s powered by Pratt & Whitney Aircraft engines had accumulated by year-end a total of 2,600,000 engine hours. The combined total for commercial and military usage of the engines was nearly 12,000,000 engine hours.

The jet airliners, now serving all continents except Antarctica, established numerous speed and load records. The five Boeing 707s of Sabena Belgian Airlines were used with great effect to evacuate people from the Congo during the mutiny there. Thousands of Belgian nationals were flown out of the Congo. In one memorable flight a 170-seat plane powered by P&WA JT4 engines air-lifted a total of 303 persons.

By September 20, the Federal Aviation Agency granted Continental Air Lines the first 1,400-hour time between overhaul on its JT3 engines. This TBO period also was granted later to other airlines using the engines. Engine overhaul time was 800 hours when Continental began its jet service in the summer of 1959.

Sabena Belgian World Airlines was granted a 1,400 hour time between overhaul on new JT4 engines.

By the end of 1960 more than 700 JT3s and more than 950 JT4s had been delivered for use in the commercial Boeing 707s and 720s and the Douglas DC-8s. Hundreds of the military versions of these engines were delivered for installation in a variety of fighter-interceptor, tanker-transport and bomber aircraft.

The company's JT3D commercial and TF33 military turbofan programs made significant progress in 1960. Engines were delivered to Boeing and Douglas for installation in their planes made for various airlines. The Boeing 707-120B for American Airlines made its first flight with JT3D engines on June 22. Engine performance was reported satisfactory on this first production turbofan jetliner. Turbofan engines also were installed and flown on a Boeing 720B short range plane, also for American Airlines.

The turbofan engine produces 17,000 pounds of thrust at takeoff and gives improved performance and efficiency. The engine differs from earlier turbojets in having a large fan, powered by the engine turbines, at the front of the engine. This enclosed, many-bladed fan pushes air back past the engine as well as through it.

American Airlines will convert its entire fleet of Boeing 707s to the advanced 707-120B configuration which will be 35 miles per hour faster than the 707s now in service. Maximum cruising speed will be 610 miles per hour. The 720B will have even higher cruise speeds. QANTAS Empire Airways of Australia also has ordered turbofan-powered 707s and will have its present fleet of seven Boeing jetliners converted to 707-120Bs. KLM Royal Dutch Airlines and Iberia of Spain have ordered turbofans for their Douglas DC-8s. The other airlines ordering the turbofans are United, Lufthansa, Ethiopian, Western, Avianca of Colombia, and Hawaiian.

The Air Force also chose the turbofan for the B52H model of the long-range, eight-engined Boeing bombers. The turbofan engine is expected to stretch the bomber's unrefueled range of "more than 9,000 miles" by a good margin.

The end of June saw the beginning of another chapter in aviation history—the FAA certificate of airworthiness was awarded to the Boeing 720 intermediate-range jetliner. The 720 is powered by Pratt & Whitney Aircraft JT3 engines, each delivering 12,000 pounds of thrust at takeoff. United Air Lines and American Airlines put the 720 into regular service in 1960.

Deliveries of the JT12, or J60 in the military version, were made. This is the new 436-pound single-spool, axial-flow turbojet introduced in 1958. The USAF selected the 600-mile-per-hour Lockheed JetStar for training future bombardier-navigators, and the plane is powered by the JT12 which develops 3,000 pounds of thrust. This small but rugged engine also was picked to power the North American T39 Sabreliner, the Canadair CL41, and two unmanned surveillance drones being developed for the Army by Republic and Fairchild. Successful flight tests were carried out. A design of the engine, with afterburner, is capable of Mach 2 operation.

Pratt & Whitney Aircraft widened its engine line in 1957 with the 8,500-pound thrust J-52. In April, 1960, a Navy low-level attack bomber with seeing-eye ability was unveiled. This Grumman A2F Intruder is the first manned aircraft to use the P&WA J-52. This engine also is used in the North American Hound Dog missiles carried by the B-52s.

The PT6, a small, lightweight free turbine engine weighing only 250 pounds, was introduced by Canadian Pratt & Whitney Aircraft. It is designed for turboprop use in light planes and turboshaft installations in helicopters. It develops 500 equivalent shaft horsepower. At the other end of the P&WA power spectrum is the J-58, a big single-spool turbojet in the 30,000-pound thrust class. This engine is intended for operation at high altitude and high Mach numbers.

Production of the T34 propeller turbine, which delivers more than 6,000 equivalent shaft horsepower, continued for the USAF's four-engined Douglas C-133 transport.

A new and versatile gas turbine engine with air, ground and marine capability was developed during the year. Designated the JFTD12, it features a free turbine drive which extracts energy from the exhaust gases of the jet to provide a source of shaft horsepower. The first installation of the new engine was slated for the large twin-engined Sikorsky S-64 Skycrane helicopter. In this application the JFTD12 will develop 4,050 shaft horsepower. An industrial version of the engine, known as the FT12, will have a maximum rating of 3,000 horsepower. Prospective uses of the FT12 include primary and boost power for ships, high pressure pumps and compressors, electric power generation, and propulsion for large ground vehicles such as military tanks and earth-moving equipment.

In cooperation with Cooper-Bessemer Corporation of Mount Vernon, Ohio, an entirely new concept of stationary power was demonstrated late in 1960. A Pratt & Whitney Aircraft J-57 engine was modified to drive a Cooper-Bessemer gas turbine, converting the turbojet's thrust into rotative horsepower. The first unit of 10,500 horsepower was installed at the Clementsville, Ky., compressor station of the Columbia Gulf Transmission Co., operator of Columbia Gas System's long-distance natural gas pipeline. Natural gas taken directly from the pipeline substituted for coventional jet fuel. Besides use in the natural gas pipeline application, the companies saw the power package as opening new sources of lower cost power in chemical and petro-chemical processing, and in electrical power generation.

During the year Pratt & Whitney Aircraft also announced an expanded program in development and manufacture of fuel cells for space vehicles and commercial uses. The enlarged program, undertaken in conjunction with the Patterson-Moos division of Leesona Corporation of Cranston, Rhode Island, covers the carbox fuel cell, a power-producing unit which can use low-cost hydrocarbon fuels with air as an oxidizer. The carbox cell has been under development by Leesona and the National Research Development Corp. of England. Previously, Pratt & Whitney Aircraft announced it was working with Leesona on the hydrox fuel cell, which employs hydrogen as a fuel and oxygen as oxidizer. The fuel cell is a powerplant which converts chemical energy directly into electricity without the need of conventional electrical generators.

In its highly promising solid rocket missile case program, Pratt & Whitney Aircraft continued to make significant technical progress. This program was based primarily on the company's metalworking capabilities, such as its unmatched flow-turning experience. Deliveries were made for the Minuteman and Pershing missiles. Advanced development was under way on Polaris cases.

Employment at the year-end was approximately 37,500.

REPUBLIC AVIATION CORPORATION

IN 1960 Republic Aviation Corporation experienced the expansion of programs initiated in many areas during previous years, while undertaking new projects in varied fields. Significant high points were the delivery to the Air Force of the F-105 'D' Thunderchief all-weather fighter-bomber, the operational status placed on the company's $14 million Research and Development Center, and the receipt of follow-on and new contracts in missile and aerospace areas.

During the year, the Federation Aeronautique Internationale officially certified Republic's 100 kilometer closed course world's speed record of 1,167 miles per hour, set December 11, 1959, by Brigadier General Joseph H. Moore in an F-105 Thunderchief.

October marked the formal introduction of the F-105D into the USAF Tactical Air Command's combat training program at Nellis Air Force Base. Conducted by the 4520th Combat Crew Training Wing, select Air Force pilots will culminate their training in the F-105D which will be used as a "flying classroom desk."

Earlier in the year, the four squadrons of TAC's 4th Tactical Fighter Wing were brought to full strength. The 333rd, 334th, and 336th squadrons are equipped with the nuclear-carrying, Mach 2 F-105B. The all-weather, electronic-packed F-105D fills the complement of the 335th squadron. In May, the 4th TFW was honored with two flying safety awards from USAF and TAC. The awards were for an accident-free record from July through December, 1959, covering 12,326 hours flown while pilots were transitioning into the F-105. Plans called for the F-105D to serve also with the Air Force in Europe and the Pacific.

Evidence of the F-105 Thunderchief's automatic flight and weapons capability was revealed in October.

Republic and the USAF Air Proving Ground Center announced that two F-105s had successfully completed a round-trip flight between Eglin Air Force Base, Florida, and George Air Force Base, California, in two 1600-mile hops described as "completely under automatic control," except for routine pilot control at takeoffs and landings. The advanced all-weather F-105s have logged scores of thousands of miles of "hands-off" automated flight.

At the USAF World-Wide Fighter Weapons Meet at Nellis Air Force Base, Nevada, the F-105 demonstrated a new nuclear bombing technique which provides greater accuracy and an additional margin of safety. Termed simply the "laydown" bombing method, it employs a delayed action fuse and a spiked nose on the bomb. "Laydown" enables the F-105 to approach the target at an extremely low altitude, hence greater accuracy, and release the weapon which noses over to stick in the target. The delayed action fuse gives the pilot the necessary seconds to speed away from the effects of the resultant blast.

Two other bombing methods were displayed: The "LABS" or toss bombing delivery and the drogue retarded method which employs a drogue chute to float the store to explode at a pre-set altitude.

In addition to firing the Sidewinder missile at the Weapons Meet, the F-105, it was announced, will be equipped with the GAM-83 Bullpup air-to-surface missile. Use of the Bullpup, a pilot-guided missile which can be launched effectively more than two miles from the target, will make the striking power of the Thunderchief even greater.

Maintenance and service on Republic's F-84F Thunderstreak and RF-84 Thunderflash was still being provided. The 'F' with a primary mission of fighter-bombing and the 'RF' with its mission of photo-reconnaissance were in service with 13 allied and NATO nations. The earlier F-84 Thunderjet was in service with seven allied nations.

Looking to the future generation of military aircraft, Republic logged its sixth year of investigation in Short Takeoff (STOL) and Vertical Takeoff (VTOL) fighter-bombers. Already several advanced designs have evolved.

ELECTRICAL testing harness draping over an F-105D fuselage from bridge-like frame.

The results of 18 months of a plant-wide cost reduction program, believed to be unique in the industry, were announced by Republic in July. Accumulated savings of some $47 million were realized in the cost of producing the F-105D Thunderchief. As a result of almost 32 per cent savings on "on-site" costs and an estimated 25 per cent savings on "off-site" cost (for 1960 orders over fiscal 1959's) the average unit price of the F-105D was some $450,000 less in 60's contract than each jet cost in fiscal 1959's orders.

In the field of research and development, 1960 proved to be a year of much advancement and coordination in many areas as part of a multi-million dollar program implemented in 1958 to speed development of advanced forms of aircraft, missiles and spacecraft. Highlight of the year was declaring operational Republic's new $14-million Research and Development Center. The completed facility is unique in that it houses under one roof a wide variety of scientific laboratories comprising the most modern equipment in the industry. The Center includes laboratories for experimentation in Space Environment and Life Sciences, Re-Entry Simulation, Materials Development, Nuclear Radiation, Electronics, Guidance and Control, and Fluid Systems in addition to a Wind Tunnel.

In July, the Fluid Systems Laboratory received its third contract in the field of high temperature hydraulics from the USAF. The third phase contract called for the development of a prototype hydraulic aileron power control system capable of operating at temperatures ranging from 20 to 1000 degrees Fahrenheit and for tests and development of leakproof seals for fluid power systems. Under Air Force contracts, the first phase of research on the hydraulic system resulted in the development of a fluid capable of operating within the 20 to 1000 degree range. Phase two developed the control system components to be used.

Earlier in the year, the company received a follow-on contract from the National Aeronautics and Space Administration for specific orbit determination programs, including lunar orbit studies and planetary missions. Work continued in the space trajectory studies field, under contracts received from the Air Force's Wright Air Development Center and Cambridge Research Center in 1959.

A 30-foot-long space simulator, a huge 42-ton vacuum chamber which is capable of simulating conditions man will encounter at altitudes of 300 miles, was installed in the company's Space Environmental and Life Sciences Laboratory in September. It will provide the means for study of man, space suits and survival systems and, because of its large size, complete space compartments and capsules.

Research and Development continued experimentation on other projects concerned with the support of life in space including the growth of plants under reduced pressures, a water recovery system, and further development of a closed ecological system.

It was announced in March that a prototype magnetic pinch plasma engine, developed by Republic, had been run continously for more than 118 hours. Significantly, it marked the first time continuous cycling of the plasma "pinches," that give the engine its thrust, had been achieved. It implies a major advance in development of the engine for use to "steer" moon probes, control reconnaissance and communication satellites, and to propel interplanetary spaceships. Development of the engine is under contracts from the Office of Naval Research and the Air Force Office of Scientific Research. Later, Republic announced that a second engine had been constructed and was undergoing experimentation.

Republic continued to assemble and market in North America the Alouette jet-powered helicopter designed by Sud Aviation of France. The five-place helicopter is the only jet-powered helicopter licensed for commercial operation in the Western Hemisphere. Earlier this year, the Alouette was equipped with the 480-horsepower Artouste II-C gas turbine engine. Its diversified use by operators located in varied climates require the Alouette to operate at a temperature of –35 degrees Fahrenheit in Alaska and 105 degrees Fahrenheit in the Gulf of Mexico.

Later, Republic marked the first delivery of custom-outfitted, passenger models of the Alouette. Such models are being used for commercial air taxi service.

The Missile Systems Division continued production of the SD-4 Swallow advanced combat surveillance drone and ground control system under a $30-million contract from the Army Signal Corps. First flight of the 30-foot, jet-powered, pilotless craft was scheduled for late in the year. Employing advanced observation equipment such as photography, radar and infrared, the Swallow is designed to collect and transmit information on enemy installations and movements.

An additional contract for determining the feasibility of developing a simple, lightweight, low-cost aerial reconnaissance drone system was awarded to the Missile Systems Division in August by the Marine Corps.

In March, the company announced development of a tiny, dice-sized submodule—a compact circuit unit designed for off-the shelf electronic components. Each module, holding from 12 to 18 components and weighing only two grams, will be used in the guidance system of the SD-4 Swallow drone. The module is suitable for use in any all-purpose digital computer whether for military or commercial use and is highly desirable because it has a packing density of a quarter of a million parts per cubic foot, or five times the density attainable through standard circuit techniques.

Under contract, the missile division announced that it would build automatic guidance systems for the Navy's Bullpup missile. The system will be the first such automatic control for air-to-surface missiles. Study contract work continued on anti-ICBM and highly-sophisticated ballistic missile defense systems.

Under a program designed to broaden distribution and marketing of commercial products developed by Republic and which were not feasible for production within the company, a licensing agreement was made with Pearce-Simpson, Inc., Florida, to manufacture, sell, and service nationally, a product line of electronic check-out equipment for industrial, marine, and military application.

During the year, the Special Products and Services department continued the development and extension of its particular line. An oval-shaped radar reflector constructed of reinforced plastic, developed and formulated at Republic, was in production. It is used as the antenna in a guidance system employed with missile installations aboard Naval vessels. Another type radar reflector, this one all-metal, was being produced for use with a Marine Corps ground radar system for directing mortar fire and detection. Republic designed and developed automatic battery chargers and testers and other items, in the line of ground support equipment, are being produced for a wide variety of applications.

Two significant financial agreements occurred in 1960 which strengthened Republic's position in the aerospace field. In April, the company acquired a substantial minority interest in the Royal Netherlands Aircraft Factories, Fokker, Holland, in a move designed to bring about participation by both companies in aircraft and missile projects in the respective countries.

In May, ACF Industries, Inc., a leader in the atomic energy and many other fields, acquired approximately 15 per cent of Republic stock. The companies, which have worked together on studies of nuclear-propelled rockets, have capabilities which will supplement each other in promising fields of future growth and development.

Republic closed the third quarter of 1960 with a backlog amounting to $738,000,000 a rise of 45% over the $511,000,000 at the beginning of the year.

For the nine months' period ending September 30, 1960, a net income of $1,572,548 on sales totaling $115,264,645 was reported.

RYAN AERONAUTICAL COMPANY

PRIME CONTRACTS ROSE to a new high as quantity production of Ryan-developed jet target missiles and airborne electronic automatic navigational systems entered high gear in 1960.

Equally significant was the company's establishment of three subsidiaries which project

Ryan's capabilities into the fields of aerospace research, complex data handling, and specialized communications.

Diversification, the keynote of Ryan operations, was bolstered in preparation for the changing demands of the '60's by acquisition of Aerolab Development Company, Pasadena, Calif.; and establishment of two new subsidiaries, Ryan Transdata, Inc., with headquarters in San Diego, and Ryan Communications, Inc., at Canoga Park, Calif.

Aerolab Development Company, identified with its unique multi-stage high altitude space probes and rocket-fired free flight tests of dynamically similar models, performed a notable feat with its Argo D-8 four-stage solid propellant rocket September 19, 1960, for the National Aeronautics and Space Administration.

The D-8 successfully boosted a NERV (Nuclear Emulsion Recovery Vehicle) to an altitude of about 1,200 miles and to a distance of about 1,200 miles southwest of the launching point at the Naval Missile Facility, Pt. Arguello, Calif. The 83-pound capsule, containing exposed nuclear emulsion plates to measure radiation in the lower Van Allen Belt, and mold spores to test the effect of radiation on life, was recovered by a Navy destroyer. It was the highest altitude travelled by any space vehicle which had been recovered to that date, and was the first West Coast launching of a space vehicle by NASA.

Ryan Transdata, Inc. will automatically convert great volumes of intricate information to a form enabling industrial and government executives and military commanders to make rapid, accurate decisions. It will develop equipment needed to gather information to be inserted into standard computers, and those which will provide read-out of computer-generated data.

Ryan Communications, Inc. will develop solutions of communications problems of military, government and private industry customers, planning the most efficient type of equipments for use in widely varied fields of wire and radio transmission, including such exotic methods as space-aided communications.

Deliveries of the Q-2C, most advanced version of the Ryan Firebee, American's most widely used remote-controlled jet target, were started in 1960 to the Air Force and the Navy from assembly lines in the San Diego plant.

Ground-launching capability, to supplement air-launching techniques, was being built into

VIBRATION EXCITER.

Q-2Cs on the assembly line to provide a versatility of operation independent of weather conditions and other factors controlling the use of aircraft.

Automatic navigational systems for Navy fixed-wing planes and helicopters, Army planes, and British Navy helicopters, were turned out in accelerating schedules at the Torrance, Calif. production facility of the Ryan Electronics Division. Development work on the systems was performed at the Division's Kearny Mesa engineering research center in San Diego.

Deliveries of Firebees and automatic navigators were instrumental in setting the new record of approximately $70 million in sales on prime contracts during the 1960 fiscal year—twice the prime contract sales for 1959.

With Ryan research efforts at an all-time high, the company's engineering effort was directed into several new fields, including solar energy and soft lunar landings.

A contract to build a model of a mirror to direct the sun's rays into the power plant of a space vehicle while in orbit was awarded by the Turbo Division of Sundstrand Corp. Another order was obtained from the Aeronutronic Division of Ford Motor Company to provide an altimeter for a lunar capsule. The Ryan Electronics altimeter will command detachment of an instrument-loaded 300-pound capsule from a Ranger spacecraft at a distance of 20 to 25 miles from the moon's surface.

Other major development efforts were performed in 1960 in boundary layer control: V/STOL aircraft, including a study for the

Air Force of the Ryan Vertifan concept, in which one or more fans, imbedded in an airplane wing, are powered by a turbine driven by a jet engine exhaust to provide lift; ground effects machines; and high energy, or "explosive" forming.

A new high-energy forming production facility for explosive shaping of complex parts made of tough "space age" metals for use in missile, aircraft and space vehicle assemblies went into commission during 1960 at San Diego, Calif., as Ryan expanded its pioneering efforts in this field.

Indicative of the facility's potential was the variety of parts produced during its first few weeks of operation—components for the Polaris missile, tailpipes for the Q-2C Firebee, spherical units for the tailpipes of a new carrier-based Navy jet, and radar reflectors for aircraft antennas.

Far afield from Ryan's Southern California operations, a crew of Aerolab engineers launched a special study in Washington, D.C. for the Post Office Department to speed the handling of mail by electronic and other automatic techniques.

Ryan's airframe assembly lines continued to produce giant fuselage sections for the Boeing KC-135 jet tanker-transport and Douglas DC-8 Jetliner power pods and pylons, as well as various high temperature components for missiles and jet and piston engines.

Estimated business volume for the fiscal year 1960 was expected to be at least $110 million, highest in the company's history, and compared with the previous record set in 1959, of $84,745,349.

SCHWEIZER AIRCRAFT CORP.

THE MAJOR PRODUCTION items at Schweizer Aircraft during 1960 were the AG-CAT Crop Duster bi-planes and the tail surfaces and ailerons for the Gulfstream G-159 executive type plane for Grumman Aircraft Engineering Corp. Other subcontracts included work for Sperry, Bell Helicopter, Fairchild and others.

Steady increase in soaring interest brought an increase in sailplane production. Schweizer production included the 1-26, one design, single place sailplane; the 2-22C, two-place trainer and the 1-23H high performance sailplane; and the 1-23H-15, Standard Class version. Activity at the Schweizer Soaring School continued to increase.

The major development project at Schweizer Aircraft was a new two-place light plane, advanced version of the 1-30 which has been flying since 1958. The two-place version, the 2-31, was undergoing test flights at year-end.

SIKORSKY AIRCRAFT DIVISION

UNITED AIRCRAFT CORPORATION

OUTSTANDING PROGRESS in the development of the Navy's HSS-2, an advanced helicopter weapons system, highlighted a year of steady accomplishments for Sikorsky Aircraft.

The twin-turbine helicopter flew its design mission repeatedly. In almost every instance, the design specifications were exceeded.

The boat-hulled HSS-2 is an anti-submarine warfare weapons system. In addition to being the Navy's first all weather helicopter, it is the Navy's first helicopter that can both search out and destroy enemy submarines while achieving maximum designed range.

The big helicopter was put through the most extensive test program ever undertaken for a new rotary wing aircraft. By late-October, HSS-2s had logged an aggregate of more than 1,100 flight hours in test and demonstration flights at East Coast Naval air installations and at the Sikorsky plant in Stratford, Conn.

Only the Board of Inspection and Survey (BIS) trials, scheduled to get under way early in 1961, remained to be completed before fleet deliveries of the HSS-2 commence some time in the first half of 1961. All other Navy trials were successfully passed. These included the armament demonstration, special weapons demonstration, sonar evaluation and demonstration, cold weather test in the climatic hanger at the Eglin Air Base, contractor's demonstration, and all ground tests required for fleet acceptance.

Impressive test statistics complied as of October 15 also included:

- More than 70 test plans completed in 1,000 separate flights to determine structural, aerodynamic and equipment characteristics.
- 1,500 hours main rotor testing.
- 1,200 hours tail rotor testing.
- In fatigue labs, more than 100 main and tail rotor components tested and more than 75 main and tail rotor blade tests conducted.
- 2,000 hours bench testing on main, tail and intermediate transmissions.
- 450 hours tiedown testing.
- 500 hours turbine test bed.

As a result of this extensive testing, many design changes were incorporated into the aircraft without an expensive retrofit program. Almost all the components had exceeded the 1,000-hour design guarantee or achieved unlimited life.

This advanced weapons system was brought from initial contract to fleet delivery in little over three years.

The HSS-2 can alight on and take off from water in an emergency. It is in the weight class of a medium transport helicopter and has the capability to fly and land on a single engine at full gross weights.

The first flight of the S-61L, a commercial derivative of the HSS-2, took place late in 1960 and was another of the year's highlights at Sikorsky. The S-61L will carry from 25 to 28

BUILT-IN stair, a new passenger convenience.

passengers. Five of these aircraft were ordered by Los Angeles Airways and six by Chicago Helicopter Airways. Certification by the Federal Aviation Agency and first deliveries were expected in the last half of 1961.

The single-turbine Sikorsky S-62, the first amphibious helicopter ever built with a boat hull, was certified by the FAA on July 6 for commercial operations. It was the first American turbine-powered helicopter to receive such certification. It also was the first helicopter of any type to be certified under the FAA's new helicopter transport regulations (C.A.R. Part 7), which are far more stringent than previous requirements. The FAA certificate permits the S-62 to carry a pilot, a co-pilot and 11 passengers.

Los Angeles Airways purchased an S-62 for use in its passenger and mail routes in the Greater Los Angeles area. The S-62 thus became the world's first turbine-powered helicopter acquired for scheduled airline service.

Petroleum Helicopters, Inc., of Lafayette, La., purchased an S-62 to carry men and equipment to the offshore oil rigs in the Gulf of Mexico.

Two S-62s were purchased by the India Air Force for use in high-altitude work. During evaluation tests in India, the S-62 delivered a 2,000-pound payload to a 14,000 foot elevation in the Himalayas, an unprecedented performance for a helicopter of this weight class.

The S-62 operated successfully on a worldwide basis in 1960. In addition to demonstrations in India, Japan and Europe, it was shown to military and commercial operators throughout the United States. The simulation of airline flights in Boston, San Francisco and Los Angeles attracted wide attention.

Sikorsky moved ahead during the year with plans to build a turbine-powered S-64, which is a universal military transport vehicle of the Sikorsky Skycrane family. Design work was well advanced, and first flight was anticipated for the Fall of 1961. The S-64 will be powered by two Pratt & Whitney JFTD-12 gas turbine engines and is expected to carry a nine-ton payload.

The S-60 Skycrane, powered by two Pratt & Whitney R-2800 piston engines, operated as a prototype for the S-64. The S-60 was built as a research vehicle and made its first flight April 13, 1959. It was very active during 1960 in development work supporting the S-64 project. In cooperation with the Army Transportation Corps, the S-60 put on an amphibious landing demonstration removing cargo from the hold of a ship anchored off Fort Story, Va. The S-60 also proved to be a self-sufficient aerial minesweeper in a demonstration over the Gulf of Mexico. This experiment was conducted jointly by the Navy Mine Defense Laboratory and the Navy Air Mine Defense Development Unit, both based at Panama City, Fla. The S-60 carried new lightweight minesweeping gear with a mine countermeasures pod attached beneath the airframe.

Two other demonstrations by Sikorsky helicopters attracted wide attention. At the Naval Air Test Center at Patuxent River, Md., a 12½-foot, 570-pound Navy Martin Bullpup missile was fired from a Marine Corps Sikorsky HUS-1 helicopter hovering at a 1,500-foot altitude. It was the first radio-controlled missile ever fired from a helicopter. A helicopter aerial recovery of a package suspended from a decending parachute was carried out over the Sussex County Airport in Georgetown, Dela. The demonstration, sponsored by Sikorsky Aircraft and All-American Engineering Co., opened up new possibilities for recovery of missile nose cones, data capsules, and drones. A Sikorsky S-55 helicopter, with special recovery gear suspended beneath the fuselage, made four air-to-air pickups at altitudes ranging from 1,000 to 6,000 feet. The parachutes were released from a light plane at an altitude of 8,000 feet.

The biggest order announced by Sikorsky during the year was a $45,000,000 contract received from the Navy for further production, spare parts and associated items for the HSS-2. The Marine Corps placed a $19,000,000 reorder for the HUS, the Navy awarded a $4,688,319 contract for additional HSS-1Ns, and the U.S. Army Transportation Materiel Command placed a $3,438,094 contract for the modification of a quantity of H-37 helicopters.

Chicago Helicopter Airways purchased two more S-58s to help meet its rapidly-increasing volume of business. This gave Chicago a fleet of eight S-58s.

The Japanese Self Defense Forces, which operate both the S-55 and S-58, ordered four more S-58s for naval use. Sikorsky also licensed Mitsubishi Heavy Industries, Ltd., of Japan to manufacture and sell the S-61.

Although turbine helicopters predominated in Sikorsky's production during the year, the company continued to produce its piston-powered S-55, S-56 and S-58 helicopters for the Navy, Marines, Army and Coast Guard, as well as commercial and foreign customers.

In addition to work with its present and programmed aircraft, Sikorsky continued extensive basic research and examination into high speed helicopter flight and alternate means of VTOL flight. As a result of this research, the company predicted higher performing helicopters in the near future both from the standpoint of speed and size.

Two major executive changes were made at Sikorsky during the year. James W. Clyne was named manager of sales and service in a move which consolidated two departments to meet growing sales and service demands. Carlos C. Wood was appointed engineering manager, succeeding Michael E. Gluhareff, who reached retirement age October 1.

Both Clyne and Wood came from Douglas Aircraft Co. Clyne had been director of international commercial sales and president and a member of the board of directors of Douglas Aircraft Co. (Japan) Ltd. Wood had been director of advanced engineering planning for Douglas at Santa Monica. He was a prominent member of the technical team that produced some of the world's most successful transport and combat airplanes and was co-holder of the design patent on the DC-6.

Mr. Gluhareff was retained as an engineering consultant.

June 3 marked the 50th anniversary of the first airplane flight of Igor I. Sikorsky, founder and retired engineering manager of Sikorsky who still serves the company as a consultant. Mr. Sikorsky's pioneering aeronautical achievements include the world's first four-engine airplane, amphibians and ocean-spanning flying boats, and the Western Hemisphere's first practical helicopter.

L. B. SMITH AIRCRAFT

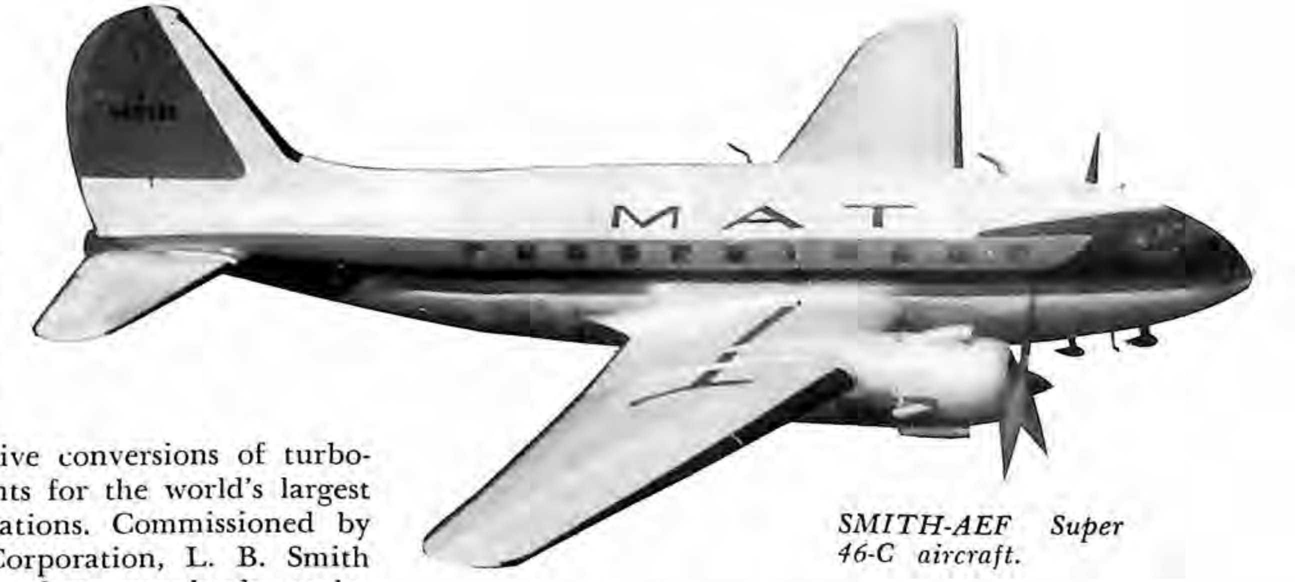
SINCE ITS FOUNDING in 1948, L. B. Smith Aircraft Corporation has continually emphasized diversification while developing skill and experience in the various fields of aircraft engineering, manufacture, conversion and modification. Of particular import among the products resulting from these activities have been the production of: the Smith-AEF transport category Super 46-C, the pressurized Tempo II executive transport and some noteworthy "firsts" in aircraft engineered-conversions, seat design and manufacture.

Development, production, certification and customer delivery of the first production-line Tempo II (detailed in the "Planes and Engines in Production" section) marked L. B. Smith Aircraft's entry into the advanced executive aircraft field. The ten passenger aircraft, the first executive version of the Douglas B-26 available with an F.A.A. Approved 46 Flight Manual, were in production at the company's Miami facility during 1960.

More than thirty 50,650 pound take-off gross Smith-Super 46-C's have been produced and delivered to airlines and supplemental carriers in all parts of the world. Designed for both cargo-passenger or convertable use, a large number of these planes are equipped with sixty passenger configuration seating that was developed by L. B. Smith's seat, galley and lavatory manufacturing division, Aerosmith Products.

In the field of executive interior conversion,

L. B. Smith Aircraft's research, engineering and production facilities produced hundreds of interiors for a wide variety of modern business aircraft. Among them, the company produced the first four executive conversions of turboprop Vickers Viscounts for the world's largest steel and oil corporations. Commissioned by Lockheed Aircraft Corporation, L. B. Smith Aircraft produced the first, completely engineered, executive interior designed for the new JetStar. This particular interior was installed in a full scale, mobile mock-up of the JetStar's fuselage, also produced by L. B. Smith, which toured many parts of the country during 1960. It is to be reproduced in Lockheed's first jet demonstrator.



SMITH-AEF Super 46-C aircraft.

Aerosmith Products engineered and produced the modern and mobile JetStar chair. Making use of L. B. Smith Aircraft's plastic and fiberglas production facilities, the new chair was formed of weight saving fiberglas which provided the means to give the chair its distinctive shape, necessary strength, and at the same time, cut its weight by twenty to thirty percent over comparable all-metal constructed chairs.

One of the most unusual of Aerosmith's seat products, produced in 1960, was the crew seat for the Vertol Model No. YHC-1B. This crew-seat equipment, requiring detailed engineering and production techniques, has the ability not only to slide fore and aft, move up and down, but will incline to any desired angle at any set point of its vertical/arched travel. Thus, the pilot can be in an upright position at all times regardless of the helicopter's operating attitude.

One of the few companies in the conversion field capable of designing and producting fiberglas and plastic products within its own shops, L. B. Smith Aircraft expanded this area of operation during 1960. Radomes, spinners, airscoops, airconditioning and pressurization ducting and a wide variety of cabin accessories were being produced by this department for both business and commercial aircraft. These items were produced for the industry at large and for L. B. Smith's and Aerosmith's own conversion and manufacturing shops.

A new, L.B. Smith Aircraft design studio was established during 1960 under the direction of aircraft interior stylist, Mr. Nicholas Auriemma. Complete, full color renderings of interiors are made available through this facility operation, enabling the company's customers to have expert and technical advice at their disposal, during the planning and development of custom interior installations.

TEMCO ELECTRONICS & MISSILES CO.

IN JUNE, Temco Aircraft Corporation and Ling-Altec Electronics, Inc., combined to form Ling-Temco Electronics, Inc., and Temco Aircraft became Temco Electronics & Missiles Co.

As prime contractor, and one of the industry's last weapons systems managers, for the Corvus air-to-surface missile, TEMCO guided the Corvus through a series of successful tests at the Pacific Missile Test Center, Point Mugu, Calif., climaxed by the first full-mission flight on July 7. But on July 11, the Navy announced that the Corvus project had been cancelled. The Navy arranged an orderly phaseout program, and the test schedule was extended several months into 1961.

TEMCO continued its diversification, with TEMCO Electronics finding growing markets for its video correlator and READ (Radar Echo Augmentation Device) systems among others, with TEMCO Aerosystems adding to its volume of classified contracts, with subsidiary Fenske, Fedrick & Miller reporting spectacular sales of $5,000,000 for its Iconorama systems and predicting $23,000,000 for 1961, with TEMCO Industrial introducing the Temco-matic electro-mechanical central control unit for coin-ops, with TEMCO Missiles working with exotic metals such as columbium and new processes such as shear forming and filament winding and dip braizing.

Other activities of the divisions:

TEMCO MISSILES

This division has responsibility for major airframe subcontract work and for such prime products as the Corvus. Airframe production includes brazed steel honeycomb panels for the B-70, 58-foot aft fuselage sections of the Boeing B-52H, and many smaller missile and aircraft parts. Wings and ailerons were being manufactured for the Raytheon Hawk Army Missile, wings components for the Lockheed Electra and P3V, and wings for the Lockheed P2V.

Metallurgical research programs, especially into metalbonding techniques, resulted in new contracts. Components for the Boeing 707 and KC-135, the Convair B-58 escape capsule and the Bell Helicopter HU1-A were added, along with missile shipping and storage containers, rocket engine casings and other space-age metal work for such missile systems as the Minuteman, Polaris, Terrier, Sergeant, and Davy Crockett.

TEMCO OVERHAUL AND AEROSYSTEMS

Major overhaul and modification contracts, along with classified refitting of aircraft, continued to grow at this division, located at Greenville, Texas. Work in progress included IRAN (Inspect & Repair as Necessary) contracts on KC-97s and C-133 Cargomasters, PARC (Periodic Aircraft Reconditioning Cycle) agreements for C-121G transports, all for the Air Force. The Air Force contracted with the division for its first on-base maintenance—of C-118 transports at McGuire AFB in New Jersey. Follow-on contracts on this work totaling more than $10 million were announced in August. The division also is a member of a team, headed by Airborne Instruments Laboratory, for design and development of a classified airborne electronics system, and was engaged in other classified programs.

TEMCO ELECTRONICS

This division is making major contributions on classified programs of other divisions, including the Corvus missile, and is developing and producing electronic systems of its own design. One of the new products, a video correlator, continued to bring contracts from military customers and offered possibilities for commercial sales. Systems under development are in the fields of automatic controls, instrumentation, radio frequency and antenna systems, radar devices.

TEMCO INDUSTRIAL

This division, a year old in September, is fabricating metal and other products for commercial firms needing a southwestern facility. TEMCO Industrial also is introducing its own proprietary products, highlighted by the Temco-matic, an electro-mechanical central control unit for coin-operated devices.

MICROMODULAR COMPONENTS

This division was created in August to utilize the experience of a group of young experts in this new field. Established in Anaheim, Calif., the division accented reliability in its production of transistorized computer logic circuit modules, custom semi-conductor assemblies and high-voltage and low-voltage rectifiers.

FENSKE, FEDRICK & MILLER, INCORPORATED

This firm, 100 percent owned subsidiary of TEMCO, is in production on the Iconorama, a multi-channel air and sea traffic plotting system which provides commanders with a graphic picture of combat situations almost instantaneously. Iconorama receives inputs from radar tracking networks and displays the information on a large screen or map in either two or three dimensions and in color. Contracts were in force with North American Air Defense Command, Strategic Air Command Headquarters, the Joint Chiefs of Staff and BMEWS. In addition, more than 50 other contracts were received for use of FF&M devices, including Iconorama, in various Inconorama systems.

FIRST-STAGE booster for Minuteman

THIOKOL CHEMICAL CORPORATION

DURING the 1960 period, Thiokol Chemical Corporation made major breakthroughs in the field of both the solid and liquid propulsion systems.

The X-15, propelled by two Thiokol Reaction Motors Division XLR11 engines, broke world speed and altitude records with a record speed of 2150 miles per hour and altitude of over 136,000 feet. Installation of the larger XLR99 engine, which should eventually permit 4000 miles per hour speeds in the X-15, was completed and initial tests sucessfully performed.

In the space research fields, Thiokol solid propellant rocket engines in NASA's Little Joe, Scout series gave outstanding reliability performance.

For the military, 1960 saw the sucessful completion of the first stage motor for the Minuteman, the largest solid propellant motor to become operational. The first eight test launches of the test prototypes of this missile were so successful that the original schedule of eighteen silo test shots was dropped. The Air Force awarded Thiokol a contract for the development of a 34 million dollar plant which will house the Wasatch Division producing the Minuteman first stage.

ICBM encased in handling harness.

Rapid strides were made in the development of the anti-missile missile, Nike Zeus. Test launches during 1960 showed the ability of this missile with its 450,000 pound thrust rocket booster developed by Thiokol to reach instantaneously into high altitudes to intercept incoming missiles.

The Pershing and Sergeant missiles also showed rapid development and progress with highly successful firing records.

The growth of Thiokol during 1960 continued very rapidly. A new Rocket Operations Center was established in Ogden, Utah, to coordinate the activities of Thiokol's twelve production plants. With three operations now in Utah, total payroll in this area increased to more than two million dollars monthly, with many of the nation's key missiles—Minuteman, Mace and Bomarc boosters—being produced here.

One of the key developments by Thiokol in 1960 was the establishment of a Nuclear Development Center at Parsippany-Troy Hills, New Jersey, and the award by the Air Force of a $500,000 contract for the study of nuclear propulsion systems.

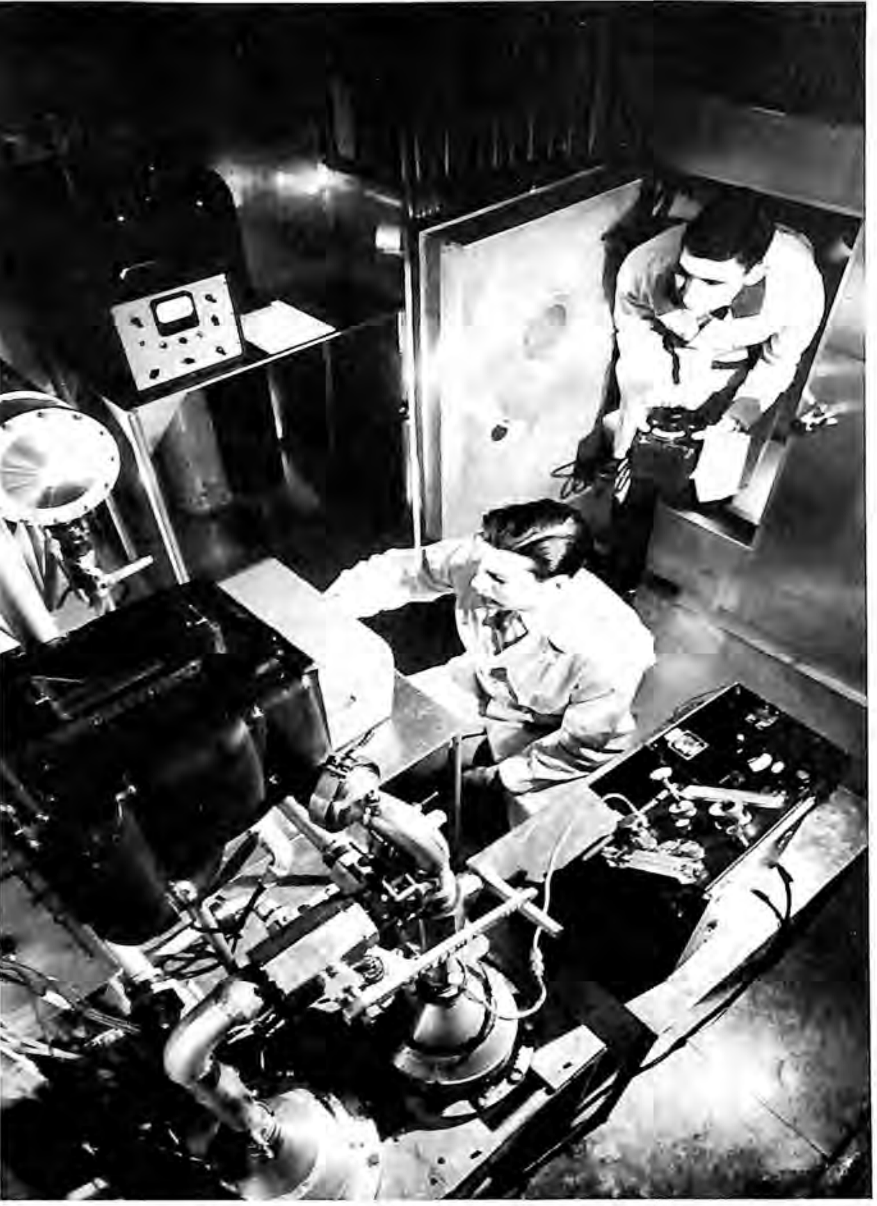
Other supporting elements of Thiokol made major contributions to the aircraft industry. A B-58 escape capsule catapult launch, developed by the Hunter-Bristol Division, has been successfully demonstrated to eject pilots from supersonic aircraft, even at deck altitudes, to safety. Developments in the shaped charge technique have shown the ability of controlled charges to separate stages of space vehicles in flight. Also, shaped charges have been successfully demonstrated as destruct mechanisms for solid motors.

UMBAUGH AIRCRAFT CORPORATION

UMBAUGH CONTINUED development work on the Umbaugh-18, a two-place version of the low-cost helicopter which completed flight testing in a single place configuration in 1959. The company was preparing the Umbaugh-18 for Federal Aviation Agency certification tests.

Production of the helicopter was to be handled by Fairchild Engine and Airplane Corporation under a subcontract agreement.

The Umbaugh-18 has a three-bladed rotor which is not powered by the engine during flight, but receives its energy from the forward or downward motion of the aircraft. Forward



EXPERIMENTS in carbon dioxide removal are conducted in Hamilton Standard's moon room.

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The corporation's Research Laboratories received an Air Force contract from the Air Research and Development Command for the study of a new type of ion engine. Such an engine would be utilized in space propulsion systems for vehicles operating between satellite orbits and capable of performing interplanetary missions. United's ion research engine was run with a wide variety of inexpensive propellants. It showed promise of providing the capability for transporting larger payloads on space missions than other forms of electrical propulsion.

United Technology Corporation, the California subsidiary formerly called United Research Corporation of Menlo Park, was awarded a contract by the National Aeronautics and Space Administration for feasibility studies on conical, segmented, solid-rocket motors.

All four operating divisions of United—Pratt & Whitney Aircraft, aircraft and rocket engines; Hamilton Standard, propellers and modern missile and turbine accessories; Sikorsky Aircraft, helicopters; and Norden, electronic guidance and navigation equipment—continued to broaden their dimensions during the year. Because each division functions autonomously, reports of the company's technical and manufacturing activities for 1960 are found under the names of the individual divisions.

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The corporation's Weather System Center, contractor for a new, high-speed, automatic weather service, moved ahead at an accelerated pace on its program to provide a system for the combined use of military and civilian aviation. Working with a team of seven associate comppanies, United's Weather System Center expects to have a test facility in full operation by mid-1961.

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The corporation continued to widen its activities in the European Common Market with the acquisition of a 20 per cent interest in Societe Precilec, an established electronics manufacturing company in France, and an equal interest in Societe Somalec, an engineering organization affiliated with Precilec. United already has interests in Societe Nationale d'Etude et de Construction de Moteurs d'Aviation (SNECMA), the largest aircraft engine company in France; Weser Flugzeugbau, a major West German aircraft manufacturing company; and Microtecnica, S.p.A., a leading manufacturer of electromechanical products in Italy. It also had licensing agreements with a number of other companies in Asia and Europe.

United Aircraft maintained a high level of development and production during 1960. In 1959, the last full year for which figures are available, United Aircraft reported a net income of $28,638,353 on sales totaling $1,080,980,782. Total current assets at December 31, 1959, amounted to $397,416,596, compared to total current liabilities of $235,513,571. Contracts, orders, and government letters of intent amounted to $1,000,000,000. The corporation's employment as of December 31, 1959, was 57,423.

HAMILTON STANDARD DIVISION

During 1960, Hamilton Standard continued its diversification program, undertaking new product lines both within and outside the aerospace industry.

In the environmental control field, new contracts were awarded to the division to provide systems for the Boeing B-52H and Douglas A4D-5. With the addition of these aircraft. Hamilton Standard environmental systems were specified for over two dozen types of the most modern fighters, bombers, and commercial aircraft. Included were such Mach 2 aircraft as the Century Series Lockheed F-104, Republic F-105, and Convair F-106; the Convair B-58 bomber; and the Chance Vought F8U series fighters, including the all-weather -2N version. A vapor cycle system, introduced into commercial service on the Convair 880 during the year, was giving excellent service. In the small transport field, first deliveries of the system were made to Lockheed for use on the JetStar. Despite a reduction in the B-70 program early in the year, Hamilton Standard's environmental control system was retained and development continued during 1960.

Engine control activity during the year continued strong, with principal production centered on the main controls for both military and commercial versions of the Pratt & Whitney J57 and J75 pure jet and turbofan engines. New engine control contracts awarded during the year included those for the Continental 217 and Pratt & Whitney Aircraft JT12. Among the other engines using Hamilton Standard controls are the P&WA J52 and J58; Canadian Pratt & Whitney Aircraft PT6; General Electric J79, T58 and T64; Lycoming T55; and Continental J69.

A small scale prototype of the air induction control for the North American B-70 was completed and tested successfully during the year.

In the propeller field, the division had more new propellers under development during 1960 than at any time in the company's history. The announcement of one of these new propellers, called the variable camber, created considerable industry interest. The variable camber concept mounts propeller blades in tandem, where they work in pairs to simulate an over-all change in camber for varying flight conditions. The test program indicated that this results in greatly increased thrust and/or range. In production during 1960 were the 54H60 model for the Lockheed C-130B and Electra; the 53C51 for the Grumman AO-1; and several types of Hydromatics for the deHavilland Caribou, Douglas DC-6 and DC-7, and Lockheed Constellation.

Jet engine starter activity during 1960 was highlighted by the award of contracts to provide pneumatic types for the Lockheed P3V, Grumman W2F, and Canadian Lockheed F-104. Meanwhile production continued on pneumatic and combustion types for use on aircraft such as the Convair B-58, Boeing B-52 and KC-97, and Convair F-106.

Hamilton Standard's Ground Support Equipment group, established as an integrated department last year, acquired a significant amount of business in 1960 and had a variety of equipment in production during the year. Among the equipment: air conditioning ground carts to be used in the Titan and Minuteman missile programs; jet engine control test stands; mobile control tower and electronic shop carts for the Air Force; and electrical simulator carts.

Another of Hamilton Standard's integrated departments, Electronics, continued to provide a variety of electronic controls to military and commercial customers, including the automatic stablization equipment for the Sikorsky HSS-2 amphibious helicopter. Major efforts during 1960 were directed toward power conversion equipment, and units were under construction for all three services, as well as for commercial customers. Late in the year, the department was selected to provide electronic equipment for both the Boeing and Grumman hydrofoils.

In the field of solar power, Hamilton Standard in 1960 received a contract to design and develop a multi-cell generator for the Air Force.

A major stride into the space vehicle field was taken by Hamilton Standard during the year when United Aircraft Corporation's Missiles & Space Systems group was reconstituted to form an additional operation of Hamilton Standard.

The division also moved into the metal fabrication field with the acquisition of North American manufacturing rights to an electron beam process developed by the Carl Zeiss Foundation of West Germany. The Hamilton-Zeiss electron beam machine can cut or weld the hardest known material, and the beam can be focused to spot size as small as .0008 of an inch for microminiaturized work. During 1960, contracts for the manufacture of several machines were received, and the armed services initiated two study contracts involving use of the machine—one for electron beam welding of space age metals, and the other for microminiaturization welding.

Hamilton Standard expanded further into the overseas market during the year by purchasing a 50 per cent interest in Microtecnica, S.p.A., of Turin, Italy. The Italian firm, a leader in the European industrial field, will build Hamilton Standard jet equipment products under license.

NORDEN DIVISION

Consolidation of a large part of operations into two new facilities, continued advancements in the engineering and development of new systems and products, and increased production of widely accepted electronic components marked the 1960 activities of United Aircraft Corporation's Norden division.

On November 15, the division began moving a major portion of its operations into a new 350,000-square-foot engineering-research and manufacturing facility located on an 80-acre tract in Norwalk, Connecticut. This move, scheduled to be completed in January, 1961, involved approximately 1,400 of the division's employees who have been working in leased plants and laboratories in Milford and Stamford, Conn., and White Plains, New York.

One month earlier, on October 17, the division's Data Systems department, whose engineers have been responsible for many of the new concepts in digital computer art, occupied a new 50,000-square-foot engineering-research and manufacturing facility at Costa Mesa, California. This department's 200 employees previously were housed in leased facilities at Gardena and Santa Ana, California.

The Ketay department of Norden did not figure in the plant consolidation. It continued its research, design, development, and production of precision servo components in a modern 82,500-square-foot plant at Commack, Long Island, New York.

The division was engaged in three basic areas: the design and manufacture of military systems and components at Norwalk; the development and manufacture of rotating components at Commack; and the development and production of commercial and industrial control systems and processing equipment at Costa Mesa. Divisional offices are at Norwalk.

Among the 1960 highlights was the award of a nine-month study contract from the Maritime Administration. This was the first step by the Maritime Administration in a long-range program to investigate the possibilities of application of automation to American merchant ships. The contract, awarded in May, called for Norden to investigate and suggest solutions to problems involved in the instrumentation and mechanization of merchant ships to operate automatically. Ideally, an automatically operated merchant ship is visualized as one that could sail without the services of its crew from the point where the pilot is dropped as it clears the harbor outbound to the point where the pilot boards the ship at its port of destination. Such a ship must be capable of self-sustained, unmanned operation for at least 30 days without any maintenance, and for at least 90 days with only minor maintenance. First steps in the program, however, involve study of semi-automatic ships. In carrying out this contract, Norden called on two other United Aircraft divisions, Pratt & Whitney Aircraft for propulsion, and Hamilton Standard for control.

Included among the Norden achievements during 1960 was the successful flight testing of its small, all-attitude, inertial platform. This provides a basic module around which a diverse line of guidance, navigation and attitude control systems will be built for missile, aircraft, drone and ship applications. The platform's components, including the highly accurate gyros, pancake synchro, and accelerometer, were designed and built by Norden and are additional new product lines.

In 1960, Norden also delivered to the Navy for field testing a contact analog display system which orients man in the unnatural environment beneath the sea. This compact system provides a pictorial pathway for a submarine, displaying on a single screen all pertinent parameters: pitch, roll, heading, speed, surface and bottom positions. It also has applications for a variety of aircraft and space vehicles.

Also in 1960, deliveries were made of certain units of a terrain clearance system for use in jet aircraft. It employs advanced radar principles with television, presenting visually to pilots the positions of their aircraft while flying in bad weather.

Deliveries of advanced bomb director sets continued as scheduled for the Navy's Douglas A3D Skywarrior, and a television theodolite was delivered and satisfactorily field tested at Eglin Air Force Base.

Another 1960 achievement was the delivery of a photographic overlap computer to Wright Air Development Division. It provides an aerial photographer with a view of the terrain within the camera field of view and automatically actuates the shutter to give a predetermined amount of overlap on consecutive photographs.

In the data processing and mark sensing field, a unique new automatic scoring machine was delivered to Educational Testing Service, a nationwide organization at Princeton, New Jersey, that provides tests and testing service for schools, colleges, and professional associations. This machine is capable of grading more than 20 different, randomly mixed college board entrance examinations at the rate of 6,000 an hour.

In this same field, Norden also delivered to the County of Los Angeles an electronic vote tallying system. It uses ultra-violet light and mark sensing principles and is designed to bring about substantial savings in election costs by decreasing for precinct workers the burden of tallying votes, reducing the number of precincts needed, and providing earlier election returns. The system reads and counts votes on paper ballots at the rate of 600 a minute.

Also in 1960, the division increased deliveries of its automatic positioning systems for machine tools. A new concept in numerical control, these modumatic systems feature display of actual position and allow machine tool manufacturers to automate to any degree.

In its wide range of components, the division in 1960 increased production and shipments of encoders, transducers, pressure ratio indicators, and gas pressure systems.

New analog-digital converter types, directed toward higher accuracy and improved performance, were successfully engineered and produced. The Ketay department's line of rotating components was enlarged and further component miniaturization programs were successfully completed. New Size 5 and Size 11 synchros were added and produced as were Size 08 resolvers and ultra-accurate vernier resolvers. A two-inch floated rate gyro was added to the product line, and engineering work progressed on a one-inch gyro. Packaging of servo components was initiated and new developments included a magnetic encoder and high-temperature, nuclear resistant units.

VANGUARD AIR AND MARINE CORP.

VANGUARD CONTINUED with the development of the first fan-in-wing VTOL airplane during 1960, and accentuated its diversification program by the acquisition of a new aircraft sheet metal manufacturing division.

The Vanguard "Omniplane" fan-in-wing VTOL airplane completed the first phase of its test program in the Ames 40 x 80 ft. full-scale wind tunnel. Additional contracts were received from the Air Research and Development Command, USAF, for installation of a Lycoming T53 shaft turbine engine in the "Omniplane" and for additional development and test work. Engineering design of advanced versions of the fan-in-wing concept was in process.

In August, Vanguard was strengthened by the acquisition of the Northeast Metals Industries Division which has extensive sheet metal fabrication facilities primarily engaged in the production of products and components for customers in the electronic, aircraft and missile field.

Further expansion plans were nearing completion at the end of the year.

WESTERN ELECTRIC COMPANY

DURING 1960 the Western Electric Company continued to play a major role in aerospace projects. The armed forces called upon the company to fulfill major national defense responsibilities on the basis of the unique abilities developed by Western Electric in doing its job in the telephone industry, and on the strength of its past performance in accomplishing highly technical, complex projects encompassing a broad scope and involving large-scale operations. Among space projects in the non-military field, Western Electric continued management for the tracking and ground instru-

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Construction was completed during the year of major new plants for the Norden division and for United Technology Corporation, and of expanded test facilities for Pratt & Whitney Aircraft's Florida Research and Development Center. All the construction was company-financed. The new Norden plants are at Norwalk, Connecticut, and Costa Mesa, California, while UTC's new development and test facility is at Sunnyvale, California.

The corporation continued to widen its activities in the European Common Market with the acquisition of a 20 per cent interest in Societe Precilec, an established electronics manufacturing company in France, and an equal interest in Societe Somalec, an engineering organization affiliated with Precilec. United already has interests in Societe Nationale d'Etude et de Construction de Moteurs d'Aviation (SNECMA), the largest aircraft engine company in France; Weser Flugzeugbau, a major West German aircraft manufacturing company; and Microtecnica, S.p.A., a leading manufacturer of electromechanical products in Italy. It also had licensing agreements with a number of other companies in Asia and Europe.

United Aircraft maintained a high level of development and production during 1960. In 1959, the last full year for which figures are available, United Aircraft reported a net income of $28,638,353 on sales totaling $1,080,980,782. Total current assets at December 31, 1959, amounted to $397,416,596, compared to total current liabilities of $235,513,571. Contracts, orders, and government letters of intent amounted to $1,000,000,000. The corporation's employment as of December 31, 1959, was 57,423.

HAMILTON STANDARD DIVISION

During 1960, Hamilton Standard continued its diversification program, undertaking new product lines both within and outside the aerospace industry.

In the environmental control field, new contracts were awarded to the division to provide systems for the Boeing B-52H and Douglas A4D-5. With the addition of these aircraft. Hamilton Standard environmental systems were specified for over two dozen types of the most modern fighters, bombers, and commercial aircraft. Included were such Mach 2 aircraft as the Century Series Lockheed F-104, Republic F-105, and Convair F-106; the Convair B-58 bomber; and the Chance Vought F8U series fighters, including the all-weather -2N version. A vapor cycle system, introduced into commercial service on the Convair 880 during the year, was giving excellent service. In the small transport field, first deliveries of the system were made to Lockheed for use on the JetStar. Despite a reduction in the B-70 program early in the year, Hamilton Standard's environmental control system was retained and development continued during 1960.

Engine control activity during the year continued strong, with principal production centered on the main controls for both military and commercial versions of the Pratt & Whitney J57 and J75 pure jet and turbofan engines. New engine control contracts awarded during the year included those for the Continental 217 and Pratt & Whitney Aircraft JT12. Among the other engines using Hamilton Standard controls are the P&WA J52 and J58; Canadian Pratt & Whitney Aircraft PT6; General Electric J79, T58 and T64; Lycoming T55; and Continental J69.

A small scale prototype of the air induction control for the North American B-70 was completed and tested successfully during the year.

In the propeller field, the division had more new propellers under development during 1960 than at any time in the company's history. The announcement of one of these new propellers, called the variable camber, created considerable industry interest. The variable camber concept mounts propeller blades in tandem, where they work in pairs to simulate an over-all change in camber for varying flight conditions. The test program indicated that this results in greatly increased thrust and/or range. In production during 1960 were the 54H60 model for the Lockheed C-130B and Electra; the 53C51 for the Grumman AO-1; and several types of Hydromatics for the deHavilland Caribou, Douglas DC-6 and DC-7, and Lockheed Constellation.

Jet engine starter activity during 1960 was highlighted by the award of contracts to provide pneumatic types for the Lockheed P3V, Grumman W2F, and Canadian Lockheed F-104. Meanwhile production continued on pneumatic and combustion types for use on aircraft such as the Convair B-58, Boeing B-52 and KC-97, and Convair F-106.

Hamilton Standard's Ground Support Equipment group, established as an integrated department last year, acquired a significant amount of business in 1960 and had a variety of equipment in production during the year. Among the equipment: air conditioning ground carts to be used in the Titan and Minuteman missile programs; jet engine control test stands; mobile control tower and electronic shop carts for the Air Force; and electrical simulator carts.

Another of Hamilton Standard's integrated departments, Electronics, continued to provide a variety of electronic controls to military and commercial customers, including the automatic stablization equipment for the Sikorsky HSS-2 amphibious helicopter. Major efforts during 1960 were directed toward power conversion equipment, and units were under construction for all three services, as well as for commercial customers. Late in the year, the department was selected to provide electronic equipment for both the Boeing and Grumman hydrofoils.

In the field of solar power, Hamilton Standard in 1960 received a contract to design and develop a multi-cell generator for the Air Force.

A major stride into the space vehicle field was taken by Hamilton Standard during the year when United Aircraft Corporation's Missiles & Space Systems group was reconstituted to form an additional operation of Hamilton Standard.

The division also moved into the metal fabrication field with the acquisition of North American manufacturing rights to an electron beam process developed by the Carl Zeiss Foundation of West Germany. The Hamilton-Zeiss electron beam machine can cut or weld the hardest known material, and the beam can be focused to spot size as small as .0008 of an inch for microminiaturized work. During 1960, contracts for the manufacture of several machines were received, and the armed services initiated two study contracts involving use of the machine—one for electron beam welding of space age metals, and the other for microminiaturization welding.

Hamilton Standard expanded further into the overseas market during the year by purchasing a 50 per cent interest in Microtecnica, S.p.A., of Turin, Italy. The Italian firm, a leader in the European industrial field, will build Hamilton Standard jet equipment products under license.

NORDEN DIVISION

Consolidation of a large part of operations into two new facilities, continued advancements in the engineering and development of new systems and products, and increased production of widely accepted electronic components marked the 1960 activities of United Aircraft Corporation's Norden division.

On November 15, the division began moving a major portion of its operations into a new 350,000-square-foot engineering-research and manufacturing facility located on an 80-acre tract in Norwalk, Connecticut. This move, scheduled to be completed in January, 1961, involved approximately 1,400 of the division's employees who have been working in leased plants and laboratories in Milford and Stamford, Conn., and White Plains, New York.

One month earlier, on October 17, the division's Data Systems department, whose engineers have been responsible for many of the new concepts in digital computer art, occupied a new 50,000-square-foot engineering-research and manufacturing facility at Costa Mesa, California. This department's 200 employees previously were housed in leased facilities at Gardena and Santa Ana, California.

The Ketay department of Norden did not figure in the plant consolidation. It continued its research, design, development, and production of precision servo components in a modern 82,500-square-foot plant at Commack, Long Island, New York.

The division was engaged in three basic areas: the design and manufacture of military systems and components at Norwalk; the development and manufacture of rotating components at Commack; and the development and production of commercial and industrial control systems and processing equipment at Costa Mesa. Divisional offices are at Norwalk.

Among the 1960 highlights was the award of a nine-month study contract from the Maritime Administration. This was the first step by the Maritime Administration in a long-range program to investigate the possibilities of application of automation to American merchant ships. The contract, awarded in May, called for Norden to investigate and suggest solutions to problems involved in the instrumentation and mechanization of merchant ships to operate automatically. Ideally, an automatically operated merchant ship is visualized as one that could sail without the services of its crew from the point where the pilot is dropped as it clears the harbor outbound to the point where the pilot boards the ship at its port of destination. Such a ship must be capable of self-sustained, unmanned operation for at least 30 days without any maintenance, and for at least 90 days with only minor maintenance. First steps in the program, however, involve study of semi-automatic ships. In carrying out this contract, Norden called on two other United Aircraft divisions, Pratt & Whitney Aircraft for propulsion, and Hamilton Standard for control.

Included among the Norden achievements during 1960 was the successful flight testing of its small, all-attitude, inertial platform. This provides a basic module around which a diverse line of guidance, navigation and attitude control systems will be built for missile, aircraft, drone and ship applications. The platform's components, including the highly accurate gyros, pancake synchro, and accelerometer, were designed and built by Norden and are additional new product lines.

In 1960, Norden also delivered to the Navy for field testing a contact analog display system which orients man in the unnatural environment beneath the sea. This compact system provides a pictorial pathway for a submarine, displaying on a single screen all pertinent parameters: pitch, roll, heading, speed, surface and bottom positions. It also has applications for a variety of aircraft and space vehicles.

Also in 1960, deliveries were made of certain units of a terrain clearance system for use in jet aircraft. It employs advanced radar principles with television, presenting visually to pilots the positions of their aircraft while flying in bad weather.

Deliveries of advanced bomb director sets continued as scheduled for the Navy's Douglas A3D Skywarrior, and a television theodolite was delivered and satisfactorily field tested at Eglin Air Force Base.

Another 1960 achievement was the delivery of a photographic overlap computer to Wright Air Development Division. It provides an aerial photographer with a view of the terrain within the camera field of view and automatically actuates the shutter to give a predetermined amount of overlap on consecutive photographs.

In the data processing and mark sensing field, a unique new automatic scoring machine was delivered to Educational Testing Service, a nationwide organization at Princeton, New Jersey, that provides tests and testing service for schools, colleges, and professional associations. This machine is capable of grading more than 20 different, randomly mixed college board entrance examinations at the rate of 6,000 an hour.

In this same field, Norden also delivered to the County of Los Angeles an electronic vote tallying system. It uses ultra-violet light and mark sensing principles and is designed to bring about substantial savings in election costs by decreasing for precinct workers the burden of tallying votes, reducing the number of precincts needed, and providing earlier election returns. The system reads and counts votes on paper ballots at the rate of 600 a minute.

Also in 1960, the division increased deliveries of its automatic positioning systems for machine tools. A new concept in numerical control, these modumatic systems feature display of actual position and allow machine tool manufacturers to automate to any degree.

In its wide range of components, the division in 1960 increased production and shipments of encoders, transducers, pressure ratio indicators, and gas pressure systems.

New analog-digital converter types, directed toward higher accuracy and improved performance, were successfully engineered and produced. The Ketay department's line of rotating components was enlarged and further component miniaturization programs were successfully completed. New Size 5 and Size 11 synchros were added and produced as were Size 08 resolvers and ultra-accurate vernier resolvers. A two-inch floated rate gyro was added to the product line, and engineering work progressed on a one-inch gyro. Packaging of servo components was initiated and new developments included a magnetic encoder and high-temperature, nuclear resistant units.

VANGUARD AIR AND MARINE CORP.

VANGUARD CONTINUED with the development of the first fan-in-wing VTOL airplane during 1960, and accentuated its diversification program by the acquisition of a new aircraft sheet metal manufacturing division.

The Vanguard "Omniplane" fan-in-wing VTOL airplane completed the first phase of its test program in the Ames 40 x 80 ft. full-scale wind tunnel. Additional contracts were received from the Air Research and Development Command, USAF, for installation of a Lycoming T53 shaft turbine engine in the "Omniplane" and for additional development and test work. Engineering design of advanced versions of the fan-in-wing concept was in process.

In August, Vanguard was strengthened by the acquisition of the Northeast Metals Industries Division which has extensive sheet metal fabrication facilities primarily engaged in the production of products and components for customers in the electronic, aircraft and missile field.

Further expansion plans were nearing completion at the end of the year.

WESTERN ELECTRIC COMPANY

DURING 1960 the Western Electric Company continued to play a major role in aerospace projects. The armed forces called upon the company to fulfill major national defense responsibilities on the basis of the unique abilities developed by Western Electric in doing its job in the telephone industry, and on the strength of its past performance in accomplishing highly technical, complex projects encompassing a broad scope and involving large-scale operations. Among space projects in the non-military field, Western Electric continued management for the tracking and ground instrumentation system for Project Mercury, the National Aeronautics and Space Administration's manned orbital flight program.

The communications system for Project Mercury, for which Western Electric is prime contractor, is actually a vast data handling system. It provides the following transmission functions: teletypewriter messages between the tracking stations, Goddard Space Flight Center, and Cape Canaveral, Florida; acquisition information from Goddard to tracking and telemetry stations; commands and instructions from Canaveral to the stations; digital tracking data from the tracking stations to Goddard; telemetry summary messages between stations and Canaveral; high-speed data transmission between Goddard and Canaveral for computation and display; and voice communications between stations, Goddard and Canaveral.

The system involves 58,000 route miles of communications facilities. The entire system comprises 125,000 circuit miles—about 88,000 miles of teletypewriter circuits, 32,000 miles of telephone circuits and 5,000 miles of high-speed data circuits.

In the guided missile field, Army and Western Electric engineers developed critical system components under a full-scale research and development program for Nike Zeus, the latest members of the Nike missile family. Before development was authorized, the Western Electric Company had anticipated the military demand for precision deposited carbon resistors and had put into operation a plan to develop production equipment to produce resistors in quantity and with a quality far in excess of any previous requirements. Now in its final stage this program, with computer controlled production, is expected to produce deposited carbon resistors with extremely high reliability. For a system designed to destroy enemy ballistic missiles traveling at speeds in excess of 15,000 miles per hour, reliability becomes an imperative requirement.

Another Western Electric Company Program covered the development of techniques and facilities toward fully automatic or semiautomatic production of millions of ultra-high speed transistors. High speed and complex electronic equipment used in the Zeus System make transistors ideal components. The new production process now under development is expected to produce the mesa transistor at a lower cost, higher reliability and more uniform electrical characteristics than current hand assembly methods.

GROUND guidance equipment for Terrier

For some years the Western Electric Company has been the prime contractor for the Army's Nike guided missile systems. This work began with the Nike Ajax, the nation's first fully operational system, which has been guarding key cities and strategic areas of the nation for more than seven years. Following the Ajax was the Nike Hercules system which in 1960 was operational in many important U.S. defense areas. Active development continued on the Nike Zeus anti-missile missile system. Bell Telephone Laboratories continued with its assigned responsibilities in the research, development and design areas for the Nike Zeus system. Western Electric Company, the manufacturing and supply arm of the American Telephone and Telegraph Company, continued as the prime contractor for research and development on this anti-missile system.

In addition to activity on the Nike missiles, a number of very important projects for the Army, Navy and Air Force were also under way. These included data transmission systems, weapons direction equipment, improved ground guidance systems for the advanced Terrier missile as well as ground-based radar and airborne guidance systems for the Titan intercontinental ballistic missile.

During 1960 the Titan guidance system was used to direct the Thor-Able vehicle which

missile brought ashore in amphibious exercise.

placed the TIROS I satellite into a near-perfect circular orbit. The National Aeronautics and Space Administration planned to use this system in future "Delta" space projects. This guidance system also put the "Echo" satellite into a very precise orbit. Echo is the aluminized passive reflector for radio communication signals recently demonstrated by Bell Telephone Laboratories. Systems of passive or active satellites based on these Echo experiments promise to pave the way for a new era in global communications.

The Western Electric Company continued to play a key role as prime contractor for the rearward communications system for BMEWS (Ballistic Missile Early Warning System). This system, as the name implies, is an electronic system providing detection and early warning of attack from enemy intercontinental ballistic missiles. On October 1, 1960, a demonstration took place at headquarters of the North American Air Defense Command in Colorado Springs, and thousands of miles to the north in Thule, Greenland.

Seconds after a huge detection radar searched the Arctic skies to pick up the simulated attack of a ballistic missile, the information needed to alert the continent and launch a counterattack was flashed to NORAD headquarters. America's Ballistic Missile Early Warning System had achieved "initial operation capability."

But unseen between the two scenes of the demonstration, 6,000 miles of data transmission circuit made the test possible by flashing the message with complete accuracy in the wink of an eye—the "payoff" of two and one-half years of unremitting work and international cooperation between military agencies and telephone companies of three nations.

Led by Western Electric as prime contractor for the Air Force, hundreds of Canadian, Danish and American engineers had developed and built the longest and most reliable data transmission circuit in the world—the first of a number that ultimately will link all three detection sites with Colorado Springs in the BMEWS Rearward Communications System.

Work also continued on an eastern segment of the Distant Early Warning Line, DEW East, which will extend the chain of radar warning stations to Iceland, 1,200 miles east of the terminal on Baffin Island in Canada. As an adjunct to the Early Warning System, Western Electric was awarded a contract to design and install a communications network in support of the Air Force facilities in the Aleutians. This project calls for greater spacing between stations and requires advances in "forward propagation tropospheric scatter" radio techniques, so called because the radio waves are reflected off the troposphere. This network will extend existing communications facilities in the completed Aleutian portion, and also in the Alaskan White Alice communications system.

1960 marked another Bell Telephone Laboratories-Western Electric Company achievement in aerospace activities by the announcement of the development and installation of a MISSILE IMPACT LOCATING SYSTEM (MILS). This system locates the impact point of a ballistic missile or re-entry vehicle hitting the surface of the ocean. Noise signals generated by the landing are used to locate the spot where the missile hits the water. In operation in 1960, these underwater detection systems are aiding recovery teams in finding and retrieving missile nose cones after space flights.

Other continuing communications work in aerospace included the coordination of work for the SAGE System of continental air defense, engineering and implementation projects under BMEWS in connection with Operation Polevault, communication and testing for TEXAS TOWERS and a study contract for an Army Communications System covering a world-wide communications network.

WESTINGHOUSE ELECTRIC CORPORATION

PLANS WERE ANNOUNCED by Westinghouse in 1960 for a new "Astroelectronics Laboratory" to be erected on a site in the Comejo Valley 40 miles northwest of Los Angeles. The new laboratory will work closely with the military services and the defense industry on the West Coast in the development of advanced electronic techniques for missile and space areas. The facility will place special stress on the design and development of molecular electronics, semiconductors and thermoelectrics, and sensing tubes. A temporary facility at the site was occupied in July by an advance group of scientists, engineers, and technicians, who plan future operations. Permanent facilities, scheduled for occupancy in early 1961, will contain facilities of the semiconductor department and electronic tube division. The semiconductor laboratory will place emphasis on semiconductor elements performing multicircuit functions, while the tube division facility will stress microwave and sensing tube devices.

An astronuclear laboratory for the development of nuclear energy for outer space was instituted in the Pittsburgh district as a prominent part of a new atomic power division. The division also included existing activities of the Company for the development of commercial applications of atomic energy for electric power generation.

In another expansion of facilities, plans were announced for a 30-percent expansion of the company's semiconductor department at Youngwood, Pa. Providing additional laboratory and manufacturing area, the new structure will be adjacent to the present plant and will be primarily devoted to the development and processing of semiconductor materials, including new forms of silicon and germanium.

At the Youngwood plant, Westinghouse manufactured a broad line of silicon diodes, transistors, rectifiers, and rectifier assemblies for commercial, industrial and military uses. The plant was also active in the development of thermoelectric materials and the production of thermoelectric devices. Other plant products include silicon Trinistor NPNP switches, Hall generators, infrared detectors, and Thermistors.

A three year extension of the contract for Westinghouse's operation of the Bettis atomic power laboratory was announced in August. The contract, which calls for an estimated annual cost of about $50,000,000, emphasizes continued advancement of nuclear power for naval propulsion and electric power generation. The work will include research and development on new and improved reactor plants for naval vessels, longer life fuel cores, advanced nuclear fuel elements, special materials and components and basic reactor technology.

The contract also covers operation of related research and development facilities at the AEC's National Reactor Testing Station in Idaho. Westinghouse developed and operates the submarine and surface ship prototype reactor plants and the expended core facility located at the test station.

A multi-million dollar expansion of the laboratory's research and development facilities was completed during the past year. These facilities include an expanded "hot lab" for studying irradiated materials, a high temperature test facility for conducting experiments on full scale nuclear mock-ups under high temperature and pressure and a high speed, high capacity digital computer.

Westinghouse has operated Bettis for the AEC since the laboratory was established in 1949. Starting with the land-based prototype reactor plant for the first nuclear powered submarine Nautilus and the USS Nautilus herself, the laboratory has developed reactors for the attack submarines of the USS Skate and the USS Skipjack classes and the land-based prototype nuclear plant for large surface vessels.

The submarine USS George Washington, the first ballistic missile submarine to successfully fire the missile Polaris while submerged, also is powered by a Bettis-developed reactor plant. The aircraft carrier Enterprise, to be powered by eight Bettis-developed reactors, is being built by the Newport News Shipbuilding and Drydock Company and the cruiser Long Beach, to be powered with two reactors, is being built by the Bethlehem Steel Company shipbuilding division at its Quincy, Mass., yard.

All of the design and development projects conducted at Bettis are under the direction of and in technical cooperation with the Naval Reactors Branch of the AEC.

In another field, the Company was active in 1960 in developing new methods for the generation of power. Among the Company's accomplishments was the successful development, for the Navy's Bureau of Ships, of the most powerful thermoelectric generator built so far, a generator which delivers five kilowatts of electric power by directly converting heat into electricity. It is about 50 times more powerful than any previously described thermoelectric power plant.

The Company completed a feasibility study and is now building equipment for a portable nuclear power plant being developed by the Nuclear Division of The Martin Company for the Atomic Energy Commission. The feasibility study involved the plant's steam generator and secondary loop. Equipment now being built includes a steam generator, a turbine-generator, switchgear, and a unique condenser for the prototype model of the plant.

The station being developed by Martin will have a net output of 1000 kw. In addition, the reactor and steam generator will provide seven million Btu per hour for space heating.

As a portable nuclear power plant, the equipment has potential application in remote military installations and is therefore designed for operation in a wide variety of climates.

Scientists of the company also unveiled a major step in achievement of new, direct methods of electric power generation when they demonstrated the first magnetohydrodynamic (MHD) generator to produce a substantial quantity of electric power continuously from combustion of a conventional fuel.

The MHD generator produces electric power by passing a super-hot, electrically conducting gas—a plasma—between the poles of a powerful magnet. This ionized gas passes through a ceramic-lined tube at 1800 miles an hour, cuts across the magnetic field of the magnets and produces electric power.

Operating at about one-fourth its full power rating, the new generator has produced 2½ kilowatts of power and has run continuously for four minutes. Previously reported MHD generators had operating cycles no longer than about five seconds.

Three amplifiers were built by the company's X-ray and industrial electronics division to accelerate ions in a research version of an ion space engine at the National Aeronautics and Space Administration's Lewis Research Center. Although the ion engine now being developed will produce relatively low thrust—in the order of 0.001g—this thrust will be adequate to drive a space ship at speeds up to 216,000 miles an hour in a weightless, frictionless atmosphere.

As a result of its work in solid-state technology, thermoelectric cooling devices built by the Company's semiconductor department were used to control the temperature of crystal filters in a successful space probe by an Aerobee-Hi rocket. The flight, conducted by the Naval Research Laboratory, reached an altitude of 130 miles.

The thermoelectric units controlled the temperature, within 0.5 degrees Centigrade, of the crystal filter in an infrared detection system that was also involved in the test. Although primarily designed for cooling, the thermoelectric devices also provide heating as required.

The first transistor capable of operating above 650 degrees Fahrenheit was also a solid-state development in 1960. The new transistor is made from silicon carbide, a hard crystalline material which in impure form is familiar because of its use as an abrasive in grinding wheels. The device was developed in cooperation with the Electronics Research Directorate of the Air Force Cambridge Research Laboratories.

Produced by a new process developed at the Company's semiconductor department, tunnel diodes became available for applications in logic, switching and computer circuitry which require faster switching times than are possible with transistors. In this process, tunnel diodes are made of germanium grown by the dendritic crystal process that produces uniform strips of material in the exact form in which it is to be used. This process permits greater utilization of high-cost semiconductor crystal.

Another semiconductor device introduced in 1960 was the Trinistor controlled rectifier, a three-terminal silicon device that controls large blocks of power. With characteristics similar to those of a thyratron the device will block voltage in the forward direction below a critical breakover voltage. However, by exceeding the critical breakover voltage or applying a proper gate signal, the device will rapidly switch to the conducting state.

The units are best suited for high power applications at up to 300 volts and currents up to 50 amperes. They have a switching time of 600 millimicroseconds with peak reverse voltages of 60 to 360 volts. These characteristics provide improved performance in a wide range of control and switching applications including: converters, variable frequency generators, motor control, voltage regulation, replacement of magnetic amplifiers, high power modulation, inverters, replacement of thyratrons, and many others.

Perhaps most significant of the Company's accomplishments in semiconductor electronics in the year was the development and applica-

BOW OF the nuclear-powered carrier Enterprise.

stage amplifier with output current of 1 to 2 amperes, a current gain of 500, and a power gain of approximately 45 db; a high-level, three-stage amplifier with output current of 1 to 2 amperes and current gain up to 10,000; a cross-coupled, bistable multivibrator operating at frequencies to 500 kilocycles; a ten-position, multiple three-terminal PNPN switch, with voltage level of 100 volts and above and current level of approximately 50 milliamperes; and a pulse generator operating in the 100-kilocycle frequency range with pulse widths less than one microsecond.

tion of a new concept in molecular electronics to produce a number of functional electronic blocks. Sponsored by the Electronic Technology Laboratory of the USAF's Wright Air Development Division, this work was carried out under a contract that prescribed these specific objectives: to determine the extent to which molecular electronics can be used to perform complex functions in several of the USAF's basic electronic systems; to develop prototype systems for inclusion in those systems; and to develop new materials needed to advance the usefulness of the concept.

As the result of the program, eight classes of functional electronic blocks demonstrated the feasibility of the concept at frequencies ranging from direct current to infrared. Demonstrated in early 1960, these function blocks were of the following types: (1) a 5-watt directly cascaded audio amplifier; (2) a two-stage video amplifier; (3) a frequency selective amplifier with notch filter in a feedback loop around the amplifier structure; (4) a variety of multivibrators—bistable, monostable and astable; (5) a variable potentiometer based on logarithmic addition of two inputs; (6) a variety of multiposition switches (including an "OR" switch, a multiple NPNP Dynistor switch, and a multiple NPNP Trinistor switch with firing electrode); (7) an analog-to-digital converter employing an NPNP relaxation oscillator; and (8) a two-stage cooler, employing the Peltier effect, covering frequencies from 1 cycle or less to 3 megacycles, for cooling infrared detectors to proper operating temperatures.

Later in the year, the company announced plans to produce 18 functional electronic blocks in quantities adequate for evaluation by systems designers. In early fall, five of these 18 were announced. They are: a high-level, two-

In addition to work with the 13 functional blocks yet to come, the company was also proceeding with other developments. Outstanding among these is the development of a 270-megacycle communications receiver now under development in the second phase of development work for Wright Air Development Division.

Developments in electronic tubes were numerous in 1960. Westinghouse began production of its Astracon image amplifier tubes in September at its electronic tube division, with most production intended for experimental work by astronomers and nuclear physicists.

Developed at the Company's research laboratories in Pittsburgh, the new image amplifier displays a near-perfect ability to amplify light. Single photons acting on the tubes' input surface are sufficient to trigger the release of electrons within the tube. Accelerated away from the input surface by a high-voltage field, each electron then liberates a number of electrons as it strikes the first of a series of films spaced along the tube-axis. Through a geometric increase in the flow of electrons, four such electron-multiplying stages enable one electron emitted from the input surface to stimulate about 600 electrons to produce visible light when they strike the phosphor-coated output screen. In total effect, more than 10,000 photons are emitted from the output screen as the result of the input of a single photon.

The new tube is expected to be signficant to astronomy because of its ability to increase the light sensitivity of any telescope system many times over. A second promising area is in nuclear physics where the tube has permitted researchers to see and photograph the tracks of cosmic rays and other high-energy particles produced when certain crystals are penetrated by such particles. Previous techniques had not been powerful enough to permit the feebly glowing track to be studied effectively.

A new photomissive material discovered at the Westinghouse electronic tube division in 1960 maintains a high level of sensitivity over many hours of operation at 250 degrees Fahrenheit. Developed under a research contract with the Bureau of Ships, the new material is expected to be most useful in such devices as imaging and photomultiplier tubes, in which photosurfaces convert radiant energy into electrical energy.

A new direct-view storage tube developed by the Company's electronic tube division incorporates two writing guns and a viewing gun system producing a bright, nonflickering, uniform display over a four-inch-diameter viewing area. Two electrostatically focussed and deflected writing guns permit independent, simultaneous writing of two signals. The new tube is particularly promising for such applications as airborne fire control radar, weather radar, transient studies, data transmission including half-tone storage, telemetering facsimile, and visual displays requiring steady, narrow-bandwidth transmission over telephone lines. Designed to operate in military environments, the WL-7268 tube can be operated unpressurized at high altitudes. The entire tube is potted within a magnetic shield in a synthetic silicone-rubber material.

A new airborne digital data processor developed in 1960 is thought to be the fastest military data processor known to have operated successfully. Designed as a general-purpose computer for purposes such as fire control, space guidance, navigation, and electronic countermeasures (jamming), its first application has been service in a track-while-scan radar detection system. Its function in this system is to keep track of multiple target information and to display the tactical situation.

The new DP-167 computer adds or subtracts at 167,000 operations per second, multiplies at an average rate of 24,000 operations per second, and divides at an average rate of 16,000 operations per second.

A new infrared system sensitive enough to see moving objects near room temperature solely by means of their emitted heat was announced by the Westinghouse research laboratories in Pittsburgh, Pa. Known as the photothermionic image converter, the all-electric device changes the infrared radiation emitted by an object into a visible picture on a television screen. The speed with which it responds to infrared is roughly equal to that of the human eye to visible light. The development, first in a series of such devices, was sponsored mainly by the Wright Air Development Center of the U. S. Air Force.

The first thermoelectric cooling devices to become commercially available for industrial and military applications were announced by Westinghouse in 1960.

The series of "thermoelectric modules" is intended for use as electronic component coolers and in other applications where compactness, silent operation with no moving parts, and a controlled cooling rate is desired.

A one-cubic-foot thermoelectric refrigerator designed and built by the Westinghouse new products laboratories was one of the key components of a manned capsule that housed an Air Force scientist on a simulated weeklong mission into space.

Brig. General Don Flickinger, Surgeon and Assistant for Bio Astronautics, Air Research and Development Command, announced the successful completion of the test of the equipment man must have to live in space. The test was conducted at ARDC's Wright Air Development Division Aerospace Medical Laboratory.

Designed to operate in the weightless environment of orbital flight, the Westinghouse refrigerator is a complete food storage system. One of six life-sustaining devices sealed in an airtight nine-foot capsule resembling an Atlas (ICBM) missile nose cone, the equipment permitted Courtney A. Metzger, ARDC laboratory engineer and project coordinator, to remain inside the capsule during the week-long test.

When the Robert E. Lee successfully completed its sea trials on August 2, as the nation's third Polaris missile-firing nuclear submarine, it was powered by a nuclear reactor designed at the Atomic Energy Commission's Bettis atomic power laboratory, operated by Westinghouse for the AEC. The nuclear reactors for the Robert E. Lee and her "sister" ships (the George Washington and Patrick Henry, commissioned in December, 1959, and April, 1960) were designed and developed by the Bettis atomic power laboratory under the direction of and in technical cooperation with the Naval Reactors Branch, U. S. Atomic Energy Commission.

Launching and handling equipment for the Polaris missiles was designed and built at the Company's manufacturing division in Sunnyvale, California.

At East Springfield, Massachusetts, the Company began manufacturing launching equipment for the air-to-surface guided missile Bullpup under terms of a contract for the Navy involving some 2400 launchers. Launched outside the effective range of enemy ground fire, the Bullpup is operational in the Sixth and Seventh Fleets of the Navy.

In addition to launching and handling equipment for these vessels, an additional $5,250,000 order was awarded Westinghouse under a Navy contract for initial work on launching systems for four nuclear-powered submarines to fire the ballistic missile Polaris.

These four craft, belonging to the Navy's second generation of Polaris submarines, are the Ethan Allen, Sam Houston, Thomas A. Edison and John Marshall.

A new weapon system—named Typhon after a fierce hundred-headed monster from Greek mythology—was announced in April by the Navy and by Westinghouse as the prime development contractor for the weapon control subsystem.

Typhon is designed to provide the fleet with a greatly improved anti-air warfare capability, and an offensive capability for engaging enemy fleet units and conducting long-range shore bombardment. The system will fire missiles from launchers mounted on fast moving warships in strategic fleet locations around the world. It will contain a new, advanced long-range, search, track, and guidance radar. High speed computers will provide near instantaneous target selection and designation. Display and monitoring equipment will complete the weapon control subsystem.

Announced at the same time was the award of a $38.5 million contract to Westinghouse for the development, design, and production of a prototype model of the long-range radar portion of the system. The new radar concept, originated by scientists at the Applied Physics Laboratory of the Johns Hopkins University at Silver Spring, Maryland, incorporates high data rate and high power features far in excess of present designs.

Subsequently, a new weapon control department was organized by the company to centralize responsibility for all aspects of the weapon control subsystem.

Later in the year a $947,000 subcontract for specialized microwave tubes to be used in the U.S. Navy's new "Typhon" weapon system was awarded the company's electronic tube division.

The work will be done at the division's plant in Elmira, New York, as a part of the over-all $38,500,000 contract awarded earlier to Westinghouse, the prime development contractor. Following competitive bidding, the subcontract was awarded to the electronic tube division by the Westinghouse electronics division in Baltimore. The electronic tube division will have responsibility for final design of the microwave amplifier tubes that will serve as power output elements in this system.

A contract award of $19.2 million for new high-powered long-range search radar systems for the continental air defense network was announced in July by Rome Air Material Area Headquarters of the Air Force. The new systems afford frequency diversity capability.

A Navy Bureau of Ships contract for over $12,000,000 for long-range shipboard radio communications equipment was also awarded to the electronics division, as the second production contract for this equipment to be placed with Westinghouse. The first amounted to $11,000,000. Delivery was scheduled to start late in 1960, with production to continue into 1962.

The AN/WRT-1 system provides radio telephone and teletype service, operating at frequencies of from 0.3 to 1.5 megacycles. It is an amplitude modulated, frequency shift keying, continuous wave transmitter.

The AN/WRT-2, specifically designed for submarine service, operates at frequencies from 2 to 30 megacycles. It is an independent sideband transmitter, also amplitude modulated, frequency shift keying, and continuous wave.

Radar systems capable of providing three-dimensional warning information six hours after air delivery to their sites were being built for the Air Force by Westinghouse Electric Corporation's electronics division. The equipment is being manufactured under a $15,000,000 contract with Rome Air Material Area.

The first prototype components of the electrical system for the Boeing B52-H missile bomber were shipped in 1960 from the Company's aircraft equipment department. The units comprise four 120-kva a-c generators; voltage regulator; control panel; current transformer package; current control package and associated electrical equipment. Rated at 480 kva, they are part of the largest a-c aircraft electrical system ever built.

They are part of a $5 million contract received from Boeing's Wichita Division for development of the electrical system and completion of a number of production systems for the B52-H. The final units under this contract will be shipped from the company's aircraft equipment department at Lima, Ohio, in September, 1961.

Twelve of the tracking stations that will monitor the course of the first United States astronaut in space are being equipped with air conditioning systems manufactured by Westinghouse. The installations, strung out in a pattern that encircles the globe, are being built for the National Aeronautics and Space Administration's "Project Mercury."

Many of the stations will be linked by point-to-point communications. Others will be able to talk directly with the astronaut over ground-to-air equipment. Complex telemetering systems will send hundreds of messages to the network's headquarters at Goddard Space Flight Center, Greenbelt, Maryland, recording the performance of the sealed space capsule and the personal observations and reactions of the astronaut as he sails through space.

The aircraft carrier Enterprise, christened at Newport News on September 24, will have a nuclear propulsion plant capable of driving this largest ship ever built at a speed of over 25 knots. The Enterprise's propulsion system will use eight reactors to supply the power to drive four propellers. Each is as high as a two-story house.

The atomic reactors were developed and designed by Westinghouse Electric Corporation under the direction of and in technical co-operation with the Naval Reactors Branch of the Atomic Energy Commission. The work was done at the Bettis atomic power laboratory, Pittsburgh, Pennsylvania, which Westinghouse operates for the AEC.

The eight reactors will run the Enterprise for years without refueling. It is estimated that nuclear power will multiply by some 20 times the distance the Enterprise can travel at full speed without refueling as compared with conventional oil-fired carriers. Dependance on distant bases and auxiliary ships is thus minimized.

The propulsion units were manufactured by Westinghouse at its steam division at Lester, Pennsylvania. Each of the carrier's engine rooms has giant turbines, reduction gears, condensers and associated machinery.

Heavy jet bombers and fighters aboard the Enterprise will be ferried to the flight decks by elevators supplied by the Westinghouse elevator division, Jersey City, New Jersey. Hydraulically-powered, the elevator platforms weigh about 210,000 pounds each and have an area of almost 4000 square feet. Each of the four giant deck-edge elevators will be capable of lifting a 45-ton bomber from hangar to flight deck in 15 seconds. Thus, the four elevators combined can ferry four planes every minute to the flight deck. Pilots aboard the carrier will also be speeded to their planes by two Westinghouse passenger elevators.

Westinghouse was also supplying the Enterprise with auxiliary generators and switchgear from its East Pittsburgh division; motors and control equipment from Buffalo, New York; standard control equipment from Beaver, Pennsylvania; transformers from Sharon, Pennsylvania; and ventilator fans from the Sturtevant division, Hyde Park, Massachusetts.

An electric arc heater able to supply a stream of gas at temperatures as high as 20,000 degrees Fahrenheit and at pressures as great as 15,000 psi, was developed in 1960 by Westinghouse. It can operate for sustained periods of time and at an extremely low level of gas contamination.

The arc heater has immediate application in a wind tunnel for missile testing. Also, it holds promise as a chemical synthesizer and as a furnace for processing metals with ultrahigh melting points. A prototype model of the machine was operated at a power input of 1700 kilowatts but a high of 30,000 kilowatts was planned.

An energy storage system to power a hyper-velocity impulse wind tunnel—called a "hot-shot" type wind tunnel by the aerospace industry—was ordered from Westinghouse early in 1960, by the McDonnell Aircraft Corporation. This facility will allow McDonnell engineers to investigate the thermal and aerodynamic properties of missiles and aircraft at speeds from 9 to 24 times the speed of sound, and at simulated altitudes above 100,000 feet.

Drive equipment valued at approximately $200,000 was being constructed by Westinghouse to power new compressors for the "blow-down" wind tunnel at Lockheed's California Division Research Center in Castaic, California.

The Westinghouse equipment, ordered for the Lockheed tunnel by the Clark Brothers Company, one of the Dresser Industries, will be supplied as a complete drive system. Components of the system will include a 7000-hp synchronous motor, a 7800-hp gear unit, switchgear and control.

SYSTEMS AND COMPONENTS MANUFACTURERS

AERONCA MANUFACTURING CORPORATION

DURING 1960 Aeronca Manufacturing Corporation acquired through merger two commercial companies—Buensod-Stacey, Inc., 45 West 18th Street, New York, New York, whose major activities are the installation of industrial air conditioning systems, and the United Welding Company, Middletown, Ohio, producers of extremely large weldments for the paper and steel industries. As a result of these mergers, major re-organization became necessary. Segregation of the corporate operations into two major groups—the Defense Products Group and the Commercial Products Group, each having its headquarters in Middletown, Ohio—was implemented.

Under the Defense Products Group is the Aerospace Division, Baltimore, Maryland; the Aerocal Division, Torrance, California; and the Middletown Division, Middletown, Ohio. To more efficiently handle sales for the Defense Products Group, five regional offices were established in the concentrated areas of major Defense procurement activities.

The Aerospace Division continued to expand its research and development with the addition of doctorate level scientific personnel. Major programs, funded by both the company and the Defense Department, included studies in space systems and related projects. The Division also developed, for manufacture, electromechanical sub-systems and components for the Department of Defense which include RVR signal data converters, ultraviolet miss-distance indicators for drone application, voltage comparators for data loggers, theodolite code storage panels, IF tracking discriminators, ground telemetry systems and video amplifiers.

The Middletown Division continues as a major producer of stainless steel honeycomb airframe and missiles structures. Among the programs currently in production are the B-58, the A2F and B-70 Systems.

During 1960 this division broadened its activities in the field of antenna systems and produced for MIT, Lincoln Laboratory, two 60 foot parabolic antennas. Erection of the antennas was completed at Groton, Massachusetts and Camp Parks, California by Aeronca personnel. The basic structure consists of aluminum bonded honeycomb panels making it possible to maintain tolerances suitable for operation in the ultra-high frequency radio ranges employed in space tracking and lunar observation projects.

The development of an electric blanket method of brazing was accomplished by this division during 1960 resulting in a substantial reduction of the brazing cycle, thereby reducing the cost of stainless steel honeycomb components. This system is being used to produce major B-70 structures.

Several breakthroughs in the development of extremely high temperature missile and space systems vehicle structures were accomplished. "Thermantic Structures," a proprietary development which is a combination of exotic metals and ceramics, are capable of operating in temperature environments up to 4000 degrees for extended periods of time. Aeronca was continuing to develop this system with both company and Department of Defense funding.

Under a research and development contract with WADD, considerable progress was made in the development of techniques for the fabrication of beryllium. The company perfected such techniques to the point where this material can be incorporated in missile and space systems vehicles. Concurrently, research continued in the field of ceramic adhesives. Significant progress was made in overcoming the brittle characteristics of ceramics when used as a bonding agent for honeycomb structures.

Full-scale production was inaugurated in 1960 for the Hawk ground support and maintenance shelters. Several significant design developments were realized in this program resulting in improved manufacturing methods that have achieved lighter and stronger units.

Aeronca was awarded a contract by White Sands Missile Range to design, develop and produce the Advanced Pogo-Hi Target Training Missile. First deliveries of these systems were to begin in early 1961.

Production continued on major airframe assemblies for the B-52H and KC-135 and 707 aircraft for Boeing Airplane Company.

The Aerocal Division continued the production of B-52G and H fuel tanks and pylons. KC-135 and 707 structural members were also produced during 1960. The Aerocal Division continued research and development in production methods for the use of molybdenum, Rene 40, vasco-jet and other exotic materials.

AIRCRAFT RADIO CORPORATION

AIRCRAFT Radio Corporation made several significant achievements during the year 1960. The most noteworthy of these was the continued growth in commercial sales. Another postwar high was achieved with a 24% increase over the previous high in 1959. This growth in commercial sales enabled ARC for the first time in its history to surpass military sales. Commercial sales in 1960 were slightly over 50% of the total sales volume.

This sales growth was achieved through continued acceptance of ARC's Type 21A ADF and Type 210 digitally-tuned VHF communications equipment. In addition, commercial sales of the TYPE 15F VOR/LOC System exceeded the original estimates.

ARC broadened its product line to include complete new local-controlled lines of navigation-communication systems. Equipment available from ARC in the past has been mostly restricted to the large multi-engine airplanes which make up a small percentage of the total number of commercial aircraft. With three distinct product lines, ARC is now in a position to provide high reliability nav/com equipment for a wide range of aircraft from light single engine models to large jet engine aircraft.

To identify the three lines of equipment, ARC introduced the name STARFLITE. STARFLITE I is ARC's line of high quality remote control nav/com equipment and components which were designed specifically for multi-engine aircraft. In 1960, ARC added to this line two new course director systems, the CD-3 and CD-4 Course Directors. In addition, the B-18A RMI Converter, miscellaneous antennas and other equipment were made available during the year.

ARC's STARFLITE II line is an all new local-controlled nav/com system designed primarily for light twin and heavy single engine aircraft. The initial equipment in this line is ARC's new Model 318A ADF system. Additional products required to complete this line will be introduced in 1961.

The ARC STARFLITE III line is designed for the budget minded aircraft owner and makes available for the first time to this category the precise engineering and reliability of ARC's prestige line. The initial equipment in this line is the ARC 501A ADF system. Additional equipment to complete this line will be available in late 1961 and 1962.

ALUMINUM COMPANY OF AMERICA

ALUMINUM COMPANY of America, during 1960, announced: production of the world's longest closed die forging for North American Aviation's Sabreliner—a new jet utility plane; supplying high-strength aluminum sheet as a structural material for a super-booster designed for project Saturn; plans to expand and modernize two major sheet mills; start-up of its ultra-modern $80-million Warrick (Ind.) smelter; cooperation with a major propellant producer in successful test-firing of all aluminum solid propellant rocket motor case; supplying material in a new high-strength, heat-defying alloy for Boeing Airplane Company's Bomarc B defense missile; production of the world's largest aluminum hand forging to serve as a mandrel in forming jet nozzles for industry's first major hypersonic wind tunnel; acquiring a fourth major source of bauxite, the ore of aluminum; supplying high-strength aluminum sheet that forms the landing surface of portable airstrips assembled by joining all-aluminum panels; development of an impact extrusion process to fabricate aluminum powder metallurgy (Alcoa APM) impacts for high temperature service; increases in guaranteed tensile and yield strengths for extruded shapes in aircraft and missile alloy 7178-T6; operation of a newly designed silicon rectifier that converts alternating current into direct current more efficiently than any large rectifier, thus permitting greater production of primary aluminum per unit of electricity; supplying alumina—the white powder from which aluminum is made—for ceramic nose cones used on guided missiles; production of the largest diameter seamless aluminum pipe achieved in this country for an underground fueling system for jet aircraft; supplying aluminum extrusions and plate for the plane-carrying elevators installed in the USS ENTERPRISE, first nuclear-powered aircraft carrier; development of a new tempering process that increases both strength and reliability of two aluminum alloys used in ballistic missiles.

A closed die forging, believed to be the longest ever produced, was fabricated by Alcoa for North American Aviation, Inc. Forged from an Alcoa alloy 7079 billet, the giant part extended nearly 23 feet in length and weighed approximately 320 pounds. To produce it, a 272-inch record-length die was sunk at Alcoa's Cleveland works die shop. The part, a wing spar, was shaped in the huge die by the tremendous pressure of a 50,000-ton press, operated by Alcoa under the Air Force Heavy Press Program. The record-size forging will be used in the T-39 Sabreliner, a twin-jet utility plane developed by North American.

A colossal rocket engine that will make possible manned flights to the moon and electronic exploration of planets deep in space has been assembled by the National Aeronautics and Space Administration. Aluminum sheet, supplied by Aluminum Company of America, forms the walls of the tanks that carry fuel and liquid oxygen. It also is the booster outer skin and constitutes an integral part of the Saturn structure. The alloy chosen for the rigorous application was 5456, developed by Alcoa and recognized as the strongest of the highly weldable aluminum-magnesium series. When test-fired, the super rocket engine functioned perfectly generating 1.3-million pounds of thrust, four times as much as America's giant intercontinental ballistic missiles. The booster actually is a cluster of eight highly reliable liquid propulsion units, produced by Rocketdyne division of North American Aviation, Inc., linked to fire simultaneously. Approximately 11-tons of lightweight, high-strength Alcoa aluminum sheet are used as structural material in the engine.

Plans to expand and modernize two major sheet mills at Davenport, Iowa, and Alcoa, Tenn., at a cost in excess of $18-million, were announced by Alcoa during 1960. The investment was being made in anticipation of a sharp rise in demand for aluminum sheet products predicted by company marketing experts. This newest phase of Alcoa's continuing capital improvement program was launched with the dual purpose of achieving greater rolling capacity, and improved production methods through the utilization of recent technological advances. The program will center on the huge North Plant mill at Alcoa works, world's largest aluminum sheet rolling operation, and at the equally impressive Davenport works. The North Plant has been operating since World War II, when it was rushed to completion to supply sheet for aircraft for the U.S. and its allies. Davenport began operation in 1948. Both mills have been expanded and revamped several times, and the 1960-62 program is designed to make them the most efficient producers of high-quality sheet and plate in existence.

In the field of solid propellant rocket motor cases, one-piece units produced by Alcoa were loaded and test-fired successfully. The cases were fabricated from alloy 7178-T6, the highest strength commercial aluminum alloy through a combination of forging, extruding, sizing, and machining. Aluminum's strength to weight ratio makes it an ideal material for motor cases. The monolithic test pieces were 12 inches in diameter and 45 inches long, with a wall thickness of 0.210 inch. Burst tests reached 3160 psi, a steel equivalent stress of 246,000 psi. One case developed a bursting stress of 94,000 psi, or a steel equivalent stress of 264,000 psi. Alcoa now is developing more sophisticated case designs to be used with new, higher strength alloys. Advanced fabrication techniques that will extend size limits also are being explored.

The nation's newest source of primary aluminum began operations in 1960 when Alcoa started up one of five potlines at its ultra-modern $80-million Warrick (Ind.) smelter. The unit has a capacity to produce 35,000 tons of metal a year, with total capacity of the facility set at 175,000 tons of aluminum annually. Electric power was being produced by one of three generating units at Alcoa's new 375,000 kilowatt steam plant, fired by coal, and adjacent to the smelter. The power plant was being operated by the Southern Indiana Gas and Electric Company.

ALCOA produced world's largest forging for Douglas Aircraft.

A strong, heat-defying alloy, developed by Alcoa was being used for a major structural part in new defense missiles built by Boeing Aircraft Company. The high-strength composition—alloy 2219—forms a combination fuselage section and fuel tank in an advanced version of Bomarc long range defenders against enemy jets and airborne missiles. Boeing engineers required a lightweight tank material, able to afford both the high strength needed to carry fuel under pressure, and to serve as a load-bearing structure for missile wings and power plants. Fuel tank walls also form the Bomarc's skin along a portion of the fuselage. An evaluation program conducted by Boeing demonstrated that Alcoa alloy 2219 possessed good weldability, and would maintain high strength under expected operating conditions. Boeing fabricates each $35\frac{1}{2}$-inch-diameter, 72-inch long tank by welding alloy 2219 sheet, rolled at Alcoa's Davenport (Iowa) works, to seven alloy 2219 rings roll forged at the company's Cleveland works. The units are welded with Alcoa filler wire 2319, a product of the company's Massena (N.Y.) works. The new "bird" has twice the range, greater speed, and improved "hair-trigger" reaction time over the earlier Bomarc A.

Fantastic speeds essential to test materials and designs for missiles and space craft, will be generated in industry's first major hypersonic wind tunnel. To simulate rocket-powered flight, Douglas Aircraft Company will blast air through a trio of jet nozzles into a testing chamber at speeds ranging from 4,500 miles per hour (Mach 6) to 7,600 miles per hour (Mach 10). Manufacture of the first of three precisely shaped nickel shells used as heat-resistant liners to protect nozzles projecting the tremendous air blast, was achieved by an unusual method requiring a massive aluminum hand forging. Believed to be the world's largest, the giant 8,230 pound Alcoa-produced forgings served as a core—or mandrel—for a coating of nickel that ultimately became the largest nickel liner ever made. The aluminum part was forged at Alcoa's Cleveland works, in alloy 2014, on an 8,000 ton hydraulic press. Douglas finished machined the 12-foot-long mandrel. Critical dimension was the diameter, which tapered from 24 inches at one end to 3 inches at the other. Tolerance was .001-inch, and had to be met at 1,440 measuring stations along the mandrel length. A cut was made to sever the small end of the mandrel. It was rejoined by running a bolt through the smaller section, and threading it tightly into an insert placed in the larger part. An electroforming operation deposited nickel on the mandrel surface, and the mandrel-nickel coating assembly then was exposed to sub-zero temperatures. Since aluminum shrinks more than nickel at the same low temperature, the mandrel sections were withdrawn, leaving the perfectly formed nickel liner ready for installation in Douglas' Mach 6 wind tunnel nozzle. Two similar liners were made employing reusable aluminum mandrels machined from even larger hand forgings produced by Alcoa.

In 1960, Alcoa acquired a fourth major source of bauxite by exercising an option covering mining rights on 30,000 acres of bauxite-bearing lands in Jamaica. The site, which Alcoa will develop over the 1961-63 period, is in Clarendon Parish, west of Kingston and 15 miles from Jamaica's south coast. Production was to begin by June 1, 1963, with ore being shipped to Alcoa's Point Comfort (Tex.) refining plant for the extraction of alumina.

Light, tough aluminum panels were converting rough, open country into smooth safe landing fields for high speed tactical jets operated by the Marine Corps. Developed and produced by Fenestra, Inc., the welded all-aluminum panels can be transported by helicopter, or unloaded across a beach, and assembled quickly to form a solid landing strip. The airstrip surface—high strength aluminum sheet supplied by Alcoa in alloy 5456—resists scorching jet blasts and punishing carrier-type landings essential to the Marines short airfield concept.

Alcoa unlocked the door to a new world of precision aluminum parts for high temperature service. Aluminum powder metallurgy impact extrusions were made by a new process. The parts—called Alcoa APM impacts—can be made with close-tolerance precision for applications in the atomic energy, aircraft, and missile fields. Contrasted with the powder metallurgy technique applied to other metals, which sinters the metal powder into the finished form, the Alcoa aluminum powder metallurgy impact employs a slug from which the final form is impacted. Result is to elevate the upper operating temperature limits for high-strength parts fabricated from these APM slugs. Alcoa carried the new process well beyond the experimental stage, and a prototype part was being evaluated for an atomic energy application.

Alcoa increased the minimum guaranteed tensile and yield strengths for extruded shapes in aircraft and missile alloy 7178-T6. The advances for shapes up to one-half-inch thick resulted from Alcoa's product surveillance program, which insures attainment of the highest possible guaranteed strengths for all alloys. Chief advantage is to aircraft and missile designers who now can take advantage of higher strength without increased weight in extruded shapes.

Three years of pioneering effort between Alcoa and Westinghouse Electric Corporation resulted in operation of what is believed to be the world's most powerful silicon rectifier unit, located at Alcoa's Badin works. The new rectifier can convert alternating current into direct current with greater efficiency than any large rectifier designed to date. Its use would permit the production of up to more than four per cent more primary aluminum per unit of electricity consumed.

Guided missile nose cones constituted a dramatic new market for ceramics made of alumina—the white powder from which aluminum is made. Alcoa, world's largest producer of chemical grade aluminas, supplies the white oxide to Gladding McBean & Co., for fabrication of nose cones used on the Navy's Sparrow III guided missile. Alumina's ability to offer exceptionally high strength, resistance to the shock of rapid temperature changes, and to the accelerated erosion experienced by nose cones as they rip through rain clouds at supersonic speeds were compelling factors in this application.

An underground fueling system for jet aircraft, utilizing the largest diameter seamless aluminum pipe produced in this country, was completed at Lemoore Naval Air Station, California. More than a mile of 16-inch diameter pipe, supplied by Alcoa, was installed to help service sleek, swift Navy jets. The king-size Alcoa pipe receives fuel that has passed through a large filter-separator unit. The separation process, using aluminum-lined tanks and aluminum pipe, removes contaminants formed in the fuel during storage and transfer in materials other than aluminum. Jet fuel is pumped directly from the 16-inch line to high speed service locations on runway aprons, through an 800-foot network of smaller diameter Alcoa aluminum pipelines.

The USS ENTERPRISE, first nuclear-powered aircraft carrier and largest ship in the world, used more than 3-million pounds of aluminum in her construction. Built to a colossal scale, the 1100-foot ENTERPRISE will be armed with the hottest, most modern fighting aircraft ever designed for carrier service. To handle these advanced jets, all plane-carrying elevators spotted along the giant warship's 252-foot-wide flight deck, are fabricated of aluminum extrusions and plate in Alcoa alloy 5456. Newport News Shipbuilding and Dry Dock Company personnel designed the elevators and originated the fabricating techniques to meet strict weight and strength requirements. Each is 52 feet wide and 85 feet long, and weighs 105 tons—a 30-ton saving over high tensile steel.

Alcoa developed a new tempering process during 1960 that increased both the strength and reliability of the strongest aluminum magnesium alloys—5456 and 5083. Both are used in ballistic missiles. Alloy 5456 exhibits a four per cent increase in minimum tensile strength over any previously available.

BENDIX AVIATION CORPORATION

CINCINNATI DIVISION

DURING 1960, the division continued a rapid growth of its scientific, process control and nuclear instruments.

Development work was initiated on a miniaturized model of the Bendix Time-of-Flight Mass Spectrometer which will be capable of analyzing the solid surface and subsurface of the moon. This instrument is unique in that it will show the presence of any isotopes present on the moon that are not on the earth. It will be remotely controlled and will transmit data back to earth via telemetering equipment.

This project was being done in conjunction with Bendix Research Laboratories and under a contract with Jet Propulsion Laboratories.

ECLIPSE-PIONEER DIVISION

For Eclipse-Pioneer Division of The Bendix Corporation, 1960 was characterized by the introduction of a number of new products for military and commercial aviation, and a vigorous production program that was chiefly responsible for swelling the company's employment level to the 10,000 mark, largest in the division's peacetime history.

Among the new products introduced during the year was a group of aids designed to relieve many of the problems created by the jet age and associated particularly with high-density terminal traffic. One of these, a Holding Pattern Programmer, was developed for use with automatic flight control (AFCS) and flight director systems to automatically fly the FAA defined racetrack holding pattern. It corrected for cross- and tailwinds, and, in conjunction with "altitude hold" and pitch control of the AFCS, it maintained the pattern in both lateral and vertical planes including during planned ascent and descent.

Another of the new aids was an Alternate Track Vortac Computer which was used to establish phantom Vortac stations from a true station. The airborne device made it possible to create an infinite number of stations as needed. These in turn were used to make additional arrival and departure tracks available for the relief of traffic bottlenecks.

Vernav, a vertical navigation system, was also introduced during 1960. Designed for compatibility with existing automatic approach and landing systems, it computed optimum approach angle according to individual aircraft characteristics. It also supplied positional information to the pilot with respect to a preset aimpoint and by allowing him to descend from cruise altitude to approach altitude safely and with minimum effort, it provided a significant increase in all weather capability.

The division, in 1960, also developed a magnetic Flight Data Recording system. Called the Multicorder, it weighed less than ten pounds and was designed to record a large number of functions, including time, heading, airspeed, altitude and vertical acceleration required by FAA for commercial operation, as well as others desired for airline operational analyses.

Other developments included a series of comparators for monitoring duplicate cockpit instruments of pilot and co-pilot, and a "To-From" Beeper that produced an electronic tone which dipped and rose as the equipped plane passed over the VOR "cone."

During 1960, the Boeing 720 jetliner was introduced to commercial passenger service by United Airlines. This new service brought to 35 the number of foreign and domestic airlines using Eclipse-Pioneer's PB-20 Automatic Flight Control System. Since its introduction into commercial service the system had, by end of 1960, logged over 1.5 million commercial flying hours and more than half a billion commercial airmiles. This was in addition to an indeterminate number of flight miles and hours in service of both the U.S. and Canadian Air Forces and Navies. During this period, the system established an enviable record of reliability and many of its components had earned approval of an 8500-hour overhaul schedule.

In the field of air data computers, a new compact model was developed. It was one-third the size of the unit originally built for and in operation on such aircraft as the F101, F105, F106 and B58 aircraft. It also made extensive use of solid-state techniques.

Highlight of new contract awards to the division during the year was one for the development of a hot gas flight stabilization and control system. The assignment was to develop, build and test a system that would steer or stabilize an aerospace probe, space ship, missile or similar vehicle. The contract was unusual in that it marked the first time an award involving a complete hot gas system had been made.

The year also saw Eclipse-Pioneer awarded the contract for air data computers and vertical scale instruments for the reinstated XB-70 Mach 3 Air Force "Valkyrie" bomber.

An integrated airborne digital computer system, combining special and general purpose digital and analog techniques in a single high-

BENDIX FILTER worked on hydrogen peroxide filters for the X-15 special research airplane.

speed, parallel, expandable computing system, was moved into the breadboard phase during the year. With its components arranged in "satellite" fashion around a central arithmetic unit, the system was capable of being enlarged to accomplish a wide range of diverse functions with little or no modification to the basic complex.

At year's end, considerable progress had been made toward perfecting the division's automatic landing and flare-out system, which held promise of being the final link to establishing practical automatic flight from take-off to touchdown.

Eclipse-Pioneer's Advanced Systems and Design Engineering Group, in conjunction with the Air Force's Wright Air Development Division, was responsible for the development of an energy management system for use in suborbital flight vehicles such as the Dyna Soar. The same group had also proposed a complete flight control and navigation system for the futuristic Mach 3 commercial transport.

The year also brought much activity in the field of cost reduction. Continuing with programs established in previous years that had shaved significant dollars from the cost of its aerospace systems, the division initiated a series of symposiums which shared important cost-reducing techniques with its vendors. Two programs worthy of special mention were those involving the division's Automatic Flight Control System for the B-58 Hustler, and the air data computer system for the F-105 airplane.

Highlight of the division's production activities was the increased pace of manufacturing inertial guidance systems for the Army's two-stage, solid propellant, surface-to-surface ballistic missile.

To meet the increasing demands of industry for qualified support equipment design and manufacturing capability, that section of Eclipse-Pioneer Division which had had responsibility for this function was broken away and given recognition as Bendix Support Equipment—Teterboro. Shortly after the new organization was established, it won the highly competitive contract for the AN/GJQ-9 Universal Tester for the air-launched Douglas Sky Bolt hypersonic missile.

FILTER DIVISION

At Bendix Filter Division, the year 1960 was marked by a number of outstanding events. Product development and facilities expansion moved forward in all areas involved in the manufacture of filters for handling aircraft piston engines, jet engine, and missile fuels; filters for hydraulic fluids and lubrication oils used in aircraft and missiles; air filters for carburetor fuel systems, fuel injection systems, and aircraft cabin air conditioning systems; and filter-water separators and related equipment.

During the year, Bendix Filter Division increased the floor space for manufacturing by over 20 percent. In addition to this area, a new fuel test laboratory building was completed on the 27 acre plant site. Outstanding in the industry, the division's combined fuel test facilities at year-end included 25,000 gallon fuel storage capacity and over 4700 square feet devoted exclusively to testing of filter-water separators and related equipment with full scale flow to 1000 gallons per minute.

Bendix clean room facilities, one of the most modern in the industry, were being up-dated on a continuous basis to meet the complex demands of the space industry. The newest addition was a complete section for liquid oxygen cleaning operations.

One of the major new products introduced during 1960 was the Bendix Go-No-Go Gage. It is the first practical and economical tool developed to check contamination in fuel under service conditions. It is called the Go-No-Go Gage because it permits acceptable fuel to pass through but acts as a positive cutoff device if the fuel is contaminated above a predetermined level with water and/or solids. An important feature of the Gage is that all fuel being transferred flows through the Gage and is checked.

Other noteworthy products manufactured during the year included: mass-produced resin-impregnated cellulose filter elements for use with Skydrol 500 (Boeing 707); 5000 gpm LOX filter assembly (Martin); 2-micron filter combinations for hydraulic ground service and test equipment; hydrogen peroxide filters for the X-15 (North American Aviation); and all metal-to-metal mechanical-assembly filter elements using no bonding material. Continued development work is proving the feasibility of wound-wire (Poroloy) porous metal gas turbine blades utilizing transpiration cooling.

HAMILTON DIVISION

The name of the Hamilton Division was formally changed to the Bendix Hamilton Division June 1, 1960 concurrent with the change in the Corporation's name from the Bendix Aviation Corporation to The Bendix Corporation.

During 1960 changes in product activity at Bendix Hamilton included the discontinuance of bellows manufacture, the transfer of missile and aircraft heat exchanger activity to Bendix Products Division, South Bend, Indiana and the initiation of a new program to manufacture microwave assemblies, thus utilizing the precision machining capabilities and the aluminum dip braze facilities of Bendix Hamilton.

The product effort of Bendix Hamilton was concentrated in the area of aircraft and missile hydraulic pumps and motors, hydraulic components and integrated sub-systems, as well as industrial hydraulic servo valves and hydraulic servo motors. Production programs included turbine engine fuel controls, both original equipment and overhaul, fuel pumps and subcontract manufacturing of precision components and sub-systems, including aluminum dip brazed microwave assemblies.

MONTROSE DIVISION

The Montrose Division continued the expansion of its principal product lines, which included: dynamotors; DC motors (1/4 h.p. and smaller); Ordnance-type synchros; aircraft autosyn pressure and position transmitters and indicators; servoed angle-of-attack indicators; aircraft pressure switches; tachometer generators and indicators; and Ordnance lighting and degasser switches.

This division developed and was in production on a line of high-quality Size 11 DC governor controlled motors. These motors are available with interchangeable planetary gearheads, with speed ratios varying from 5-to-1 to 1600-to-1. The motors meet the following environmental requirements: acceleration to 50 g's, shock to 30 g's, and vibration from 10 to 2000 cps at 16 g's, and can be supplied with temperatures ranging to 200°C.

The Montrose Division line of integrally-lighted indicators was expanded to include both "aviation red" and "white" lighting in several sizes. This line of indicators is being furnished both to the Government services and directly to manufacturers. Dual concentric 1″ integrally-lighted autosyn indicators have been added to the product line during the past year. These instruments have been well received by the aircraft industry since they serve to combine function presentations on overcrowded instrument panels.

A servoed 2″ torquemeter indicator was also added to the line during the year. This indicator contains a transistorized integral amplifier within the same case size as the previous servoed indicator which required an external amplifier. Sixty-cycle and 400-cycle synchro indicators have been made available for military ground support equipment and shipboard installations as well as for commercial applications. These indicators fill the needs of those companies which in the past have found it necessary to buy synchros and manufacture their own indicators.

The Montrose Division successfully qualified and was supplying an engine-mounted oil pressure transmitter. This instrument will withstand temperatures up to 450°F. and vibration from 50 to 2000 cps with a maximum acceleration of 20 g's. This instrument can also be supplied to meet higher temperatures and higher vibration frequencies if required.

A complete line of Size 15 synchros was in production at the Montrose Division. Many Size 15 synchros are being used in sophisticated weapon systems. Size 11 and Size 18 synchros are currently being produced capable of withstanding radiation-resistant environments as well as temperatures to 450°F. and higher. A complete line of Ordnance-type synchros from Size 11 through Size 37 is available at the Montrose Division.

PIONEER CENTRAL DIVISION

The Pioneer Central Division of Bendix added a new "twist" to its continuing expansion in the Aerospace Field. The "twist" involved the organization of an advanced engineering group whose primary duty is to keep abreast of, and coordinate, total engineering effort toward military and commercial Aerospace requirements. Included in the advanced engineering group are known, leading, contributors to the fields of Cryogenics, Fluid Dynamics, Chemistry, Physics and Aerospace Instrumentation. The application of this group to the standard Pioneer Central product line (liquid and gaseous oxygen equipment instrumentation and fuel measurement equipment) created a fresh approach to new and old problems. For example, the field of propellant utilization is just as old as the first propellant or fuel. This field was being thoroughly examined from the new standpoint of making large and critically controlled orbital, translunar and deep space payload placements. Another old field of endeavor is that of environmental control. Pioneer Central was involved in developing semi-closed and closed circuit breathing systems, as well as a closed Ecology System.

"Activities in 1960 resulted in a number of new products from Pioneer Central: one-hundred man regulators weighing less than a pound, liquid oxygen converters which are lighter and smaller with quick-disconnect design, a rate of descent indicator and a personnel purger and ventilator for Project Mercury, a partial pressure sensor which will detect a change in oxygen partial pressure within five seconds, and either personnel portable or aircraft integrated pressure suit ventilators."

PRODUCTS DIVISION

Bendix Products Division continued to supply landing gear and fuel control systems to many of the major airframe, aircraft engine and missile manufacturers. Concurrently, research and development programs were continued in these fields, as well as in missiles and other new product areas.

Development effort continued on a lightweight fuel control system for shaft turbine engines up to 1,000 h.p., and on a Universal Engine Control for turbojet engines from 1,000 pounds thrust upward. Significant running time was accumulated on engines of several manufacturers of turboshaft units for aircraft, industrial and ground vehicle applications.

Liquid rocket engine controls of the hydro-mechanical type, operated directly with rocket fluids, were qualified and available on a production basis.

Fuel injection for light aircraft became a reality. Development was continued and certification received on injection systems for engines up to 600 h.p. At year-end, these were in production for several applications.

Production and product improvement continued on all types of fuel metering systems for large gas turbine engines for both commercial and military aircraft.

Bendix Support Equipment, South Bend, was established to complement the Teterboro, N.J. activity. Studies were completed in the field of mechanical and electromechanical ground support equipment. This included missile transporters and emplacement equipment, hydraulic ground power units, hydraulic and pneumatic test equipment, fluid handling equipment and systems management. Emphasis was placed on high reliability ground support equipment having characteristics of air transportability and low cost.

Designs of movable nozzles for solid rocket motors were successfully test fired on motors using the latest high energy propellants, planned for use in new high performance missiles. A swivel joint that will withstand the high temperatures and highly abrasive rocket exhaust gases was also successfully tested. These components use novel sealing methods requiring minimum power and weight for actuation and control.

Solid propellant rocket cases, using a unique method of wrapping a wire tape around a collapsible mandrel, were also designed, developed and tested. This new method of fabrication enabled Bendix to produce wire-wrapped rocket cases with very high hoop stress and lower cost than those being produced by other methods. Additional applications of this same manufacturing technique were being considered for several types of pressure vessels.

Development and testing was continued by the High Temperature Materials scientists in the field of cermets for rocket throats, leading edges, jetvanes and insulating liners for use with the latest high energy propellants. Rocket nozzle throats for the latest missiles were successfully tested and qualified.

A new chromium base cermet called Chrome Cerametalix* was developed. This new material exhibits good strength in the 2000°F. to 3000°F. range with excellent oxidation resistance. Protective coatings applied with flame-and plasma-spraying techniques are also available.

In 1960, Bendix wheels and brakes continued their outstanding service record on the Boeing 707 and Douglas DC-8, improving considerably over the operationg costs predicted for them. Bendix equipment was also specified for the Convair 880-M and 990 which will go into service in 1961.

Research and development was continued on liquid-cooled aircraft brakes to provide greatly increased safety and reliability during "hot stops."

Further improvements were made in the Bendix line of hydroelectrical and hydromechanical aircraft steering systems. Also in production were landing gear shock struts for a variety of military and commercial aircraft.

Development continued on the adaptation of hydraulic shock absorbing principles to the protection of railroad freight. First production units of a large shock absorber were shipped for assembly into freight cars. Similar equipment, for use on special missile-carrying cars, was also under development.

RADIO DIVISION

The Air Force and the Advanced Research Projects Agency took another step in sponsorship of development the Bendix Radio Division was doing on a new type of radar by authorizing construction of a demonstration model of its ESAR equipment. The structure housing this scaled-down model of "the radar of the future" is the size of a five-story building, located on the premises of the division at Towson, Maryland. A full scale version of ESAR will detect and keep accurate track of hundreds of ballistic targets and satellites far out in space. ESAR (Electronically Steerable Array Radar) derives its name from the manner in which its radar beams are electronically steered through space and positioned on a target. Conventional radars have large mechanically rotated antennas and can perform only one function at a time. ESAR has no moving parts and can perform search and tracking functions simultaneously. By using a high speed computer, the beams can be shifted from target to target in an infinitesimal part of a second, enabling ESAR to track many objects at the same time. Rockets sent aloft from NASA's launching site at Wallops Island, Virginia, and air traffic in the Baltimore-Washington area were serving as targets for the experimental demonstration model.

Ultimately, ESAR type radars may be used to keep tabs on thousands of earth-circling satellites, for tracking of and communications with space vehicles launched on deep space probes to the moon and other planets, and as a ballistic missile detection and tracking radar in the space-age defense system of the United States.

WIDE-ANGLE, two-axis hydraulic antenna.

The Navy, with the problem of protecting its fleets against missile attacks, turned to Bendix Radio for investigation and development of electronically steerable array radar techniques for shipborne use.

Conventional radar for Air Defense and Air Traffic Control remained an important element of the Bendix Radio activity. During 1960, the division delivered new radars to the Air Force for installation on an extension of the DEW-Line. They must operate in the severe weather conditions that prevail on the Ice Cap of Greenland. The division also delivered its AN/FPN-34 Air Traffic Control Radar to the Air Force. It incorporates many new features and has application both in military and civil aviation because of the improved performance it provides in control of jet aircraft. The Federal Aviation Agency obtained one of the radars from the Air Force to evaluate it at its National Aviation Facility Experimental Center at Atlantic City, New Jersey.

Air Defense radars produced by the Radio Division ring this country, but some of this equipment is now more than ten years old. Several years ago the division began an engineering effort aimed at product improvement to keep these radars up to date with fast moving technical developments. The Air Force welcomed the effort, and during the year awarded Bendix Radio sizeable production contracts for modification equipment.

Ancillary to its radar work, Radio made use of a unique distance measuring device it developed in an advanced system to measure antenna patterns. The system was proposed to the Air Force, and a contract for its design and construction was awarded. This AN/ASM-13 Pattern Analyzer proved extremely effective, and was being operated by division personnel for the Air Force to measure the antenna radiation patterns of the newest radars in the military inventory.

Space projects continued to receive major emphasis at Bendix Radio Division through participation in MERCURY, MINITRACK, SPASUR, ADVENT, the Pacific Missile Range, and the Goldstone Deep Space Instrumentation facility. The division was acting as corporate manager for the global ground tracking, communication, and telemetry network for the NASA's MERCURY project. The Bendix Pacific, Cincinnati and York divisions were also contributing to the Bendix portion of the ground environment which is being supplied by an association of companies headed by Western Electric. Installation of equipment by Bendix field engineers was well under way at sites in the United States and the Atlantic.

New equipment was ordered by NASA from the Radio Division for the MINITRACK satellite tracking network that extends from the United States down through South America. The division also assisted NASA in converting the stations from van mounted installations to permanent installations. Bendix Radio personnel continued to operate, maintain and supply MINITRACK for NASA. A companion system was being operated and maintained for the Naval Research Laboratory. This is the SPASUR network which is used to detect and track satellites which are not emitting signals from their transmitters. A third satellite tracking facility, MICROLOCK, used to monitor missile launchings also was turned over to Bendix Radio by NASA for operation and maintenance.

The Radio Division's contract with the Navy for down range operation and operational maintenance on the Pacific Missile Range was renewed during 1960 and services were expanded. A primary responsibility of the Bendix personnel is to operate the equipment with which missiles and nose cones are located for recovery operations after re-entry.

Important additions to the Bendix Radio list of space programs were ADVENT and field engineering services for the Goldstone Deep Space Instrumentation facility.

The Bendix Radio Division was the major associate of the Bendix Systems Division in the ADVENT satellite communications program. ADVENT is the Army Signal Corps project to use active satellite relays for long range communications. Bendix Radio was responsible for design of the ground terminals (exclusive of antennas), and for production of the satellite communications sub-system.

Under contract from NASA, the Jet Propulsion Laboratory of California Institute of Technology is responsible for the scientific program carried out at the Goldstone Deep Space Instrumentation facility in California. The facility is used to transmit commands to and receive signals from deep space probes to carry out space experiments. Bendix Radio's field engineering department won an award for operation, maintenance and supply of this facility in support of the JPL program.

In other areas of Field Engineering activity, Bendix Radio opened an overhaul depot in Rome, New York in support of Rome Air Materiel Area equipment repair requirements. In Europe, the division was operating two major overhaul depots—one at Alzenau, Germany and one at Madrid, Spain. In addition, it maintained supply depots at Wymeswold, England and Ankara, Turkey. Electronic and communications equipments used at air defense installations throughout Europe and the Near East are sent to these depots by the Air Force for periodic overhaul. Another depot was being operated in Iceland in support of air defense installations there.

In cooperation with Pan-American World Airways, Bendix Radio engineers conducted an extended series of tests with new equipment to prove the feasibility of effecting reliable air-ground communications at much greater distances with very high frequency radio than has generally been believed practical. Standard theory holds that reliable air-ground range at these frequencies is limited to line-of-sight (about 150 miles) as in television. However, by exploiting a radio energy atmospheric scattering or ducting phenomenon, it now appears that good communications between an aircraft and ground can be obtained over at least 600 miles (on several occasions usable signals were received between San Francisco and Hawaii).

During 1960, the Radio Division demonstrated through flight tests that the basic techniques it developed for an aircraft collision avoidance system are practical. The Federal Aeronautics Agency was sponsoring development of the Bendix system.

A $4.4 million contract award for ground communications equipment was made by the Army Signal Corps to the Radio Division. Under this contract, the division was supplying and installing automatic teletype relay equipment as part of a unified global communication network that is being engineered for the Department of Defense for use by all of the military services. The Signal Corps also placed with Bendix a $1 million production order for a lightweight AN/ARC-45 airborne radio, which the division previously had manufactured for the West German Government.

The year 1960 found the new Bendix Doppler Radar Navigation System going into airline service. Because Doppler navigation requires no cooperating ground stations, it is particularly well adapted to over-water flights. It was appropriate, therefore, that the first commercial airline installations should be aboard California-to-Hawaii DC-8 flights by United Air Lines.

Another interesting use in which the new Doppler was being tested is an Air Force program to determine the feasibility of employing Doppler in parachute drops of men and material. On board a C-130 Hercules transport several Doppler systems, the Bendix DRA-12 included, were under evaluation by the Tactical Air Command.

As the jet age in commercial aviation became a reality, Bendix avionics product planning for the new airplanes began to pay dividends, with one after another of the major airlines selecting Bendix electronics equipment for their new jet aircraft. Aboard the new Boeing, Douglas, Lockheed, and Convair jets Bendix equipment was selected by dozens of airlines, including American, United, Pan American, Braniff, Eastern, Panagra, National, TWA, Northwest, Lufthansa, KLM, Alitalia, Varig, Ansett-ANA, and Air France.

Engineering research and development was almost completed on a new aircraft automatic direction finder, the Bendix DFA-72.

Full transistorization of the new equipment makes possible dramatic reductions in size, weight, and power consumption. The control panel and most of the receiving system may be mounted right in the instrument panel. Thus the DFA-72 makes available to small aircraft the same performance, the same sensitivity and selectivity, that until now has been available only in airline equipment. This improvement is particularly noteworthy under adverse weather conditions.

The antenna for the new direction finder is also a significant improvement. It is a new magnetic type that greatly reduces precipitation static. Its fixed loop goniometer eliminates entirely all external moving parts.

As research and development funds for certain military equipments become scarce, military agencies were looking more and more to "off the shelf" commercial products to fill their needs. In 1960 this movement was exemplified by the Navy's order for $1.5 million for VHF radio transmitters and receivers and by the RCAF's order for flight path deviation indicators to round out Bendix VHF navigation systems ordered earlier. In addition, the West German Air Force adopted the Bendix DRA-12 Doppler Navigation System. Over a million dollars in VHF navigation equipment was also sold to the West German Air Force for installation on the Hamburg-built Noratlas troop and cargo carrier. Off-the-shelf orders for VHF radio receivers were also placed by the Royal Swedish Air Force for use on Percival Pembroke twin engine transports.

Sales of Bendix RDR-1 airborne weather radars in 1960 continued at a high rate. Over 2000 systems have been sold to airlines and business aircraft owners.

Product research yielded a new bright display radar indicator for the Bendix weather radar. The radar trace can be seen equally well in light or darkness and the viewing hood formerly required is eliminated.

RED BANK DIVISION

During 1960, the Red Bank Division continued to expand its facilities and products in the three different product groups contained in the divisional structure, namely the Electrical Power Generating Group, the Electron Tube Group and the Semiconductor Group.

The Electrical Power Generating Group expanded its line of AC brushless generators to cover a range from 10 KW to 80 KW. Simultaneously modern transistorized, control and fault detecting devices were put into production so that all the necessary building blocks were readily available for complete complex aircraft and missile electric power systems. This group further developed and introduced extremely reliable 30, 100, 200 and 400 ampere starter generators for the turbine-driven aircraft market. Further accomplishments of this group included the development and fabrication of highly dependable 250 and 1500 VA static inverters. The long sought after dependable performance for this type product was successfully demonstrated to major aircraft and missile manufacturers throughout the industry. This group also successfully designed, developed and fabricated demonstrating models of both thermionic and thermoelectric power generating systems. Lastly, this group designed and fabricated a special motor for the finite positioning of the control rods of a nuclear reactor.

The Electron Tube Group continued to expand its range of klystrons so that they now cover a range of from 5 Kmc to 35 Kmc. Further, a line of traveling wave devices covering a range of 40 to 150 Kmc was designed and certain sizes fabricated and demonstrated for customer requirements. This group undertook to design a reliable replacement for the 3D21 beam power amplifier for use on the TACAN equipment. This new replacement serves to eliminate a multitude of field service difficulties. Another item of considerable importance developed and manufactured during 1960 was a miniature tube that serves as a time totalizer. With proper application in any electric or electronic system, this device is calibrated so that by taking a resistance reading of the elements within the tube at any given time a determination is made as to how long a given electric or electronic device was in actual service. The Electron Tube group also devoted a great deal of its effort to the production development of a complete family of ferrite devices including attenuators, phase shifters and circulators. At the close of the year this group had finalized the designs on a new product called cerameterm which is a ceramic insulated terminal for use in high temperature devices, such as transistors, relays, capacitors, transformers, etc. It was anticipated during the 1961 year that these devices will be available in large production quantities to meet industry requirements.

The Semiconductor Group during 1960 took possession of a new plant located at Holmdel, New Jersey, which expanded its facilities approximately 4 times. The new and modern facility is designed for the high speed production of power transistors, silicon diodes and rectifiers. This group further improved upon and enlarged the range of the DAP transistors for which they have gained industry recognition. The new engineering facilities included in the above plant will enable Red Bank Semiconductor engineers to rapidly finalize the design of a multitude of semiconductor products, such as 50 and 100 ampere DAP transistors, 5 ampere silicon transistors, 10 ampere PNPN switches, post alloyed diffused transistors, germanium mesa transistors, RF alloy transistors, RF drift transistors, mixer diodes, varactor diodes, tunnel diodes, gallium-arsenide diodes, stud package high power transistors and automotive rectifiers. Perhaps one of the most significant accomplishments of 1960 was the development and introduction of our 25 ampere DAP power transistor which won immediate industry approval.

RESEARCH LABORATORIES DIVISION

The Research Laboratories Division of The Bendix Corporation completed several notable development programs during 1960 in the space technology and aeronautical fields.

A unique mobile-type TV satellite tracking system, developed by the Research Laboratories, employs a closed circuit television system used in conjunction with three turret-mounted telescopic lenses. The system is capable of amplifying existing light up to 50,000 times so that faint stars of the 8th and 10th magnitude—far too weak to be seen by the unaided eye—are clearly discernible on the TV screen. The tracking system was developed as part of "Project Space Track" for the National Space and Surveillance Control Center under a program sponsored by the Advanced Research Projects Agency, Department of Defense.

In the microwave field, a series of new miniature and ultraminiature components were developed for use with printed circuitry and in various types of aircraft, missile and satellite systems. These advanced concepts in ferrite devices led to new applications in electronically scanned antenna systems and in precision-measuring microwave devices. Included among these new components were Y-circulators, eletrically variable attenuators and phase shifters, coaxial connectors, directional couplers and R-F switches.

Experimental and analytical studies of microwave plasma were also conducted during 1960 to determine the feasibility and application of such electro-magnetic ionization and its discharge in low-pressure air.

The phenomenon of creating glowing microwave plasma was achieved by directing pulsed x-band microwave energy against a parabolic reflector to focus it at a point in an evacuated glass vessel. Since this electrodeless discharge stands completely isolated from the power generating source, many possible applications are suggested, such as providing a source of continuous or pulsed light, as a localized source of heat for crystal growing in the solid state field, applications in thermo-nuclear power production, for the wireless transmission of power, and as possible use in future weapon systems.

The Research Laboratories developed advanced memory and logic digital computer circuitry based on the tunnel diode, a promising new semiconductor component. Memory-circuit development includes experimental random-access memories based on coincident-selection and on word-selection techniques. Logic-circuit development includes special-purpose storage and shift-register circuits, various auxiliary circuits, and general-purpose gating circuits which can perform all of the basic logic functions required for a typical computer. Experimental work to date indicates that computers using tunnel-diode circuits will be capable of operating much faster and over a wider range of environmental conditions than computers now in use. These advantages, together with the possibility of compact packaging and low power consumption, make tunnel-diode computers particularly attractive for use in all types of aircraft, missiles, and space vehicles.

For application in advanced radar missile guidance systems, a high-performance hydraulically controlled antenna was developed during the year. With a look angle of $\pm 70°$, which is believed to be greater than any other known missile antenna, the development represents a significant advancement over current designs. Similarly, extremely limited space allocation for the antenna required development of new miniature hydraulic components, which also contributed to the state-of-the-art.

Developed initially for the missile radar antenna described in the above paragraph, a miniature hydraulic motor was available on the market for applications where power, weight and size are extremely critical. Believed to be the smallest motor of its type in existence, the unit weighs only four ounces, is less than one cubic inch in volume and develops 1/3 HP at 1500 psi and 6000 RPM.

In other accomplishments in the miniaturization field, the Research Laboratories also developed the smallest known 1-GPM servo valve for hydraulic systems with ratings up to 4000 psi. The unit is approximately 1.5 cu. in. in volume and weighs only 4 oz. The servo valve has high response characteristics and was designed with emphasis on reliability. It was being manufactured by the Bendix Pacific Division. When integrated with the miniature hydraulic motor, the combination constitutes the smallest and lightest servo package for its power capability known today. These components are ideally suited as drives for missile radar antennas, missile control surfaces, rocket engine nozzle controls, submarine controls and applications in other precision control systems.

In the field of high temperature environment, the Laboratories developed a torque motor for fluid power servo applications that will operate satisfactorily with a fluid temperature of 1000° F. and an ambient temperature of 1200°F. Although initially developed without nuclear radiation effects as a consideration, it proved to be a high-temperature, radiation-resistant torque motor. With these capabilities was possible to mount servo control mechanisms in close proximity to jet, chemical rocket, or nuclear rocket engines with a very significant simplification of circuitry and linkages. The high-temperature torque motor was developed for Republic Aviation Corporation under sponsorship of the Air Force; it was being manufactured by Bendix Pacific Division.

A new building—an "Advanced Power Laboratory"—was completed and placed in operation in October, 1960. This modern high-pressure, high-temperature facility expanded the Research Laboratories' capability for test and evaluation of the many key control subsystems and components under development for advanced satellites, rockets and missiles. Typical of the items tested are small rocket engines as reaction controllers, small gas generators for auxiliary power sources on space vehicles, complete control systems operating on high-temperature and high-pressure gases, nuclear radiation resistant controls, and components for the fields of thermionics and thermo-electric power.

SCINTILLA DIVISION

During 1960, Scintilla Division placed on the market two new ignition systems for single and twin engine business aircraft. These systems were identified as the S-200 high tension ignition system and the S-600 low tension ignition system. Both employ the retard breaker and starting vibrator system to provide positive ignition at all cranking speeds.

Scintilla Division also developed a complete series of high temperature capacitors operational at 200°C. These capacitors are supplied in hermetically sealed cans of both tubular and rectangular construction and offer the maximum in environmental resistance, exceptional stability, no voltage derating, and radiation resistance.

A new 30,000 square foot plant to house engineering and manufacturing facilities for Bendix cabling and electrical connectors was opened in October, 1960, at Santa Ana, California. This plant will specialize in manufacture of cabling for ground based electronics equipment.

The latest development in multiple conductor cable connectors, the Bendix QWLD "Hus-Key" was specially designed to meet the rugged environmental conditions of missile launching equipment, ground radar, or power and control circuits. Some outstanding advantages are five keyways to provide positive polarization, closed entry socket contacts, self-ejecting coupling action, and improved waterproofing.

THE SHEFFIELD CORPORATION
A Subsidiary of The Bendix Corporation

The ability to measure holes up to 0.250 inch in diameter to the accuracy required by today's missiles, aircraft and space vehicles is industry's gravest measurement problem.

In order to provide the measuring tools and techniques necessary to solve these problems, metrology engineers of The Sheffield Corporation, Dayton, Ohio, a major developer and manufacturer of precision inspection instruments and systems, announced two top developments during 1960. The company is a subsidiary of The Bendix Corporation.

To measure holes with diameters as small as 0.020 inch—a size approximately equal to one-half the diameter of a typewritten period—Sheffield introduced a new type electronic inspection instrument that measures the size of a hole with a single gaging stylus. The gage is capable of attaining a measurement accuracy to within 5 millionths of an inch.

Following the development of the revolutionary Unipoint Hole Inspection Gage, Sheffield manufactured three Master Setting Rings of these sizes .43840 (Mean), .43842 (Max.) and .43838 (Min.). The rings were calibrated and certified to an accuracy of plus or minus three millionths of an inch by the company's Eli Whitney Metrology Laboratory and then sent to the National Bureau of Standards, Washington, D.C., which also certified them as being accurate within plus or minus three millionths.

This agreement marked the first time the National Bureau of Standards had certified internal measurement to this accuracy. As a result, the Bureau will now measure and certify internal diameters of this size to plus or minus five millionths in place of previous Bureau certification of internal diameters of this size to plus or minus 10 millionths.

SYSTEMS DIVISION

A contract was awarded to Bendix Systems Division during 1960 by the Signal Corps for the ADVENT Microwave Satellite Communications System. The ADVENT satellite, which will hover in a 24-hour synchronous equatorial orbit some 22,300 statute miles from the earth's surface, will vastly extend the present line-of-sight global communications links. The half-ton satellite will receive and amplify the signals, re-transmitting them between ground stations located in the vicinity of Camp Roberts, California, and Fort Dix, New Jersey.

The Bendix Systems Division will be responsible for the communication system engineering on Project ADVENT and for the design of the satellite repeater and special purpose ground equipment. The Bendix Radio Division will design and build the ground terminal equipment, as well as install and operate this equipment.

Project ADVENT is a follow-on program to the STEER Program for which Bendix Systems Division served as UHF Communication Contractor. Bendix initiated engineering activities on Air Force Project STEER in 1959, as a part of the NOTUS Program of the Advanced Research Projects Agency to develop a global satellite communications system. The Steer program was being phased out during 1960.

A $26 million contract for continued development and evaluation of the EAGLE Missile System was also awarded to Bendix in November, for management by Systems Division as prime contractor. A $21 million follow-on contract for EAGLE was awarded to Bendix earlier in the year.

The EAGLE will be a long-range, air-to-air, high performance guided missile for destroying any enemy aircraft or aerodynamic guided missile expected in the foreseeable future. It was designed to attack enemy targets at all operating altitudes, at greatly increased ranges and under all tactical conditions.

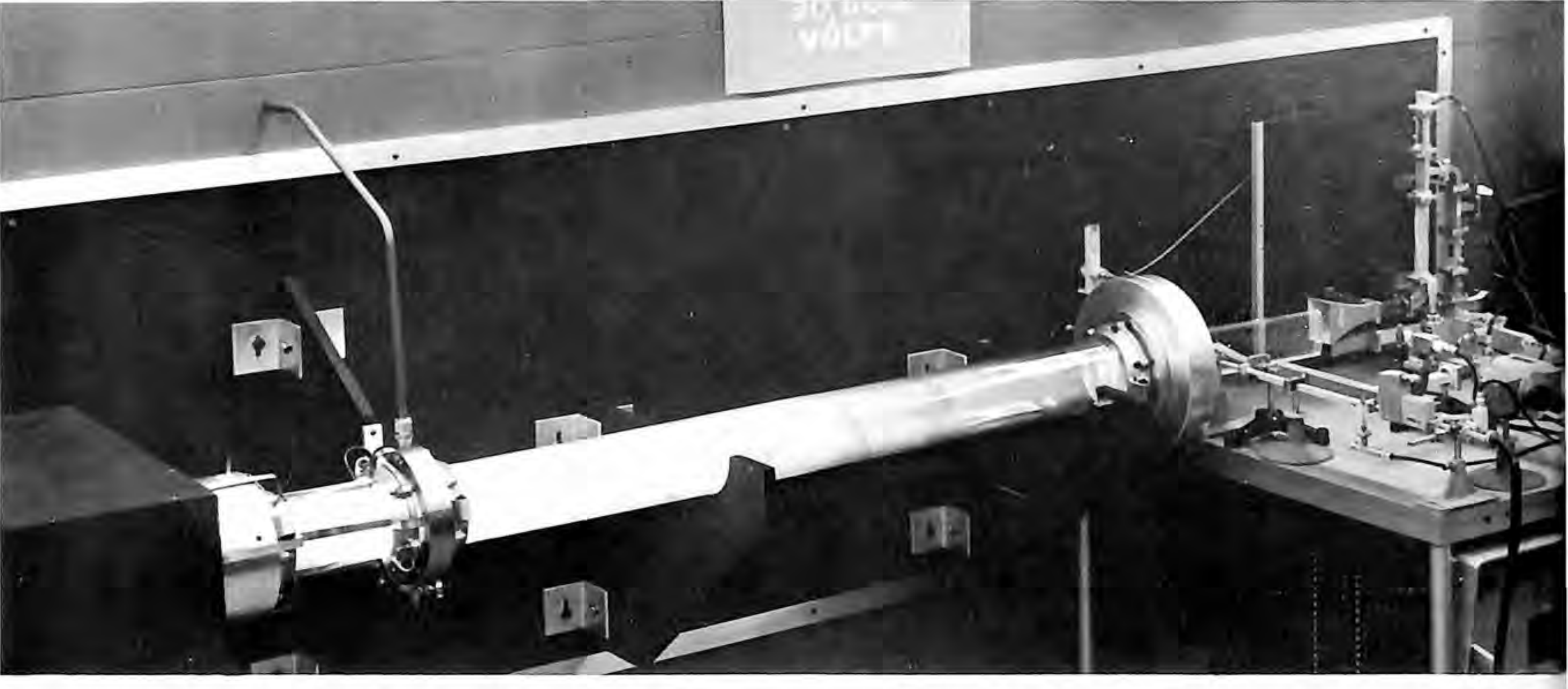
In the EAGLE System, high performance is being built into the missile rather than the launching aircraft. This philosophy permits design of a highly efficient launching aircraft with increased endurance, fire power, and versatility. It also makes possible the development of an airborne weapon system that is complementary to, and compatible with, surface-to-air guided missiles.

The Computer-Operated Electronic Display (COED) facility was a major hardware development by Systems Division during 1960. COED is a systems design tool, unparalleled in the industry, which is capable not only of simulating

The COMPACT Display.

both manned and automated functions of actual complex systems, but of visually depicting the effect of human responses to operational situations as they occur. This device, initially designed for the EAGLE Missile System, has great potential for application in management and war-gaming; system efficiency study; process analysis; training; industrial on-line control; and intellectronics experimentation.

Combined with a high-speed computer, COED provides a dynamic and flexible research tool which uses advanced digital data handling techniques complemented by the intelligence of the human operator. It is a step-



ping stone in the Bendix program of intellectronics where the ultimate goal is the machine synthesis of man's unique perceptual and intellectual faculties.

A coordinated transfer of information between the man and the machine is effected by an ultra-versatile group of general-purpose displays and controls which communicate directly with the computer installation. By programming the COED computer combination to accurately simulate a system, Bendix engineers are able to determine, through actual experience, the optimum allocation of functions between man and machine. Engineering psychologists observe the simulated system in action, and re-adjust the original distribution of functions until the man and machine are working together smoothly.

The COMPACT Display was another laboratory facility designed by Systems Division specifically for the evaluation of machine-aided, manual data reduction and interpretation operations. This facility considerably extends the usefulness of the Bendix G-15 computer in applications requiring the dynamic display of graphical or pictorial data. The COMPACT unit is particularly useful in instances where the significance of computer results must be assessed on the basis of changes in data pattern or form, rather than by actual numerical changes. It has been used extensively in the study and synthesis of counter counter-measures techniques, and in the areas of logistics simulation and reliability analysis. The Bendix Systems Division's COED/COMPACT laboratory comprises one of the finest facilities in the country devoted specifically to the analysis and synthesis of man-machine systems.

During 1960, Systems Division continued its program for the Air Force Wright Air Development Division, to develop electronic equipment capable of successful operation in extreme environments, particularly nuclear radiation. Subassembly tests have been carried out in The University of Michigan's Ford Nuclear Reactor, and equipments are being modified for complete unit testing. A significant result of this program was the successful operation of modified equipment subjected to an equivalent of 1,000 hours in an intense nuclear radiation environment. Increased emphasis was being placed on combined environments, adding humidity, temperature, altitude, and vibration environments to the nuclear test chamber.

Company-sponsored research at Bendix Systems Division during 1960 resulted in important developments which may prove to be the keys to space systems of the future.

For instance, the Bendix Shock Tube is a new research tool designed and fabricated by Bendix Systems Division for the study of hypersonic and magnetogasdynamic phenomena. The shock tube is essentially a miniature wind tunnel in which extremely high speed and high temperature flow conditions can be generated in the laboratory. Typical shock tube experiments include studies of the flow around missile nose cones and manned satellites during their re-entry into the upper atmosphere. A problem of major interest is the communication "blackout" caused by a sheath of ionized gas which surrounds any vehicle operating at extremely high speeds in the atmosphere; the shock tube is a convenient experimental device for investigating various methods for alleviation of this "blackout."

SHOCK TUBE, designed by Bendix Systems.

Suitable condition-monitoring equipment was also developed by Systems Division to correlate existing theories with the results obtained in shock tube experiments. Two diagnostic techniques, one of which was invented at Bendix Systems Division, are implemented by the apparatus set up to the right of the shock tube.

One company-sponsored basic research and development program at Systems Division resulted in a new Bendix invention which holds great promise for future applications: the Free Reaction Sphere Satellite Attitude Control System. With increasing demand for more precise attitude control of orbiting scientific and military vehicles, the free reaction sphere was cited as one of the most significant technological steps to date in providing the ultimate answer to this important problem.

In the near vacuum environment of space beyond the earth's atmosphere, where there are no aerodynamic forces with which to control the vehicles, the angular velocity of the satellite will remain unchanged unless torque is applied. A conventional mode for providing torque is to mount three reaction wheels on orthogonal axes to control the satellite's angular velocity around these axes. A single free reaction sphere can replace all three conventional reaction wheels and, in addition, overcome many of their major limitations.

The system requires no bearings and, therefore, no friction, wear, or lubrication problems are encountered resulting in a high degree of reliability; since there is no mechanical contact between moving parts, much higher relative speeds may also be obtained. Secondly, there is no cross-coupling such as occurs in a conventional reaction wheel, where a wheel spinning along one axis will attempt to precess when torques are applied about another axis. Thirdly, it is possible to balance the spherical shell, both statically and dynamically, to much closer tolerances than the conventional flywheel. This advantage results from the characteristics of the suspension system and the fact that the rotating member is a spherical shell.

A satellite simulator was fabricated by Bendix Systems Division for use as a test bed in developing the Free Reaction Sphere Satellite Attitude Control System. Mounted on a spherical air bearing pad, the platform is instrumented with reaction jets for initial stabilization and the reaction sphere for fine attitude control; a sun sensor provides attitude error information. Large spheres have been suspended and tested at high spin rates on this simulator. The ultimate capabilities of this space vehicle control device are under current development and evaluation.

UTICA DIVISION

Utica Division of The Bendix Corporation, Utica, New York, completed development of another "first" in aircraft starting systems in 1960. Designed for engines of the 12,000 pounds thrust class, the unit consists of an air turbine starter with an integral accessory drive pad. After operating as an air turbine starter to bring the engine up to cut off speed, the starter portion is automatically disengaged and the accessory drive is rotated by the engine through the gear box of the unit. The first production unit has a gear reduction of approximately 1.66 to 1 from the engine mounting pad to the accessory drive pad on the starter and is intended to drive a hydraulic pump.

Further development and tests on a solid propellant/pneumatic starter progressed through the year and as a result a greatly improved version of this starter was expected to be ready for production early in 1961. This unit has the capability of operating as an air turbine starter using either bleed air or a G.T.C. as the source of energy for normal starts. When a self contained starting system is desired the same unit may be operated as a cartridge starter using energy produced by a solid propellant charge.

Modifications to a production flexible drive shaft used on the Grumman S2F and WF2 resulted in a line of these shafts suitable for aircraft such as the Boeing 707 and KC-135, Fairchild F-27, Convair F-102 and F-106, Lockheed P2V and Douglas C-124. One of the unique features of these shafts is their capability of operating at high speed, with no lubrication required for the torque carrying members. The forged steel diaphragms, machined to a hyperbolic curve to give even distribution of stresses, assure a truly constant ratio transmission between the input and output of the shaft. Because the torque carrying members require no lubrication, these shafts can be operated at considerably wider temperature ranges than other similar units.

An accessory disconnect designed to meet the latest requirements of H1AD was developed and tested during this year. This disconnect is intended primarily for emergency use and can be designed as an integral part of many accessories or can be designed as a "sandwich" to be mounted between the drive and the accessory. The Bendix disconnect embodies curvic tooth design using force from driving torque to provide self-energized disengagement, and short travel of driving member to avoid risk of spline damage.

The Bendix Flexural Pivot, developed and tested during 1960, provides a practical and convenient crossed spring assembly for mounting of sub assemblies or components for friction free movement. These pivots are practical for most applications where a limited rotary motion is required. They are insensitive to dirt, and require no lubrication.

YORK DIVISION

During 1960, the York Division announced the advanced research and development of proximity fuzes. These fuzes are compact, high frequency, radar systems and are utilized on many missiles in the defense program. In addition, some of these developments resulted in releases for production where many advanced techniques for manufacture were also developed, particularly in the microwave field.

Also, the York Division, through engineering programs, continued to improve and produce the tactical test equipment for the Talos missile. The equipment for this purpose was designated as TATTE and provided rapid go-no-go indications and fault isolation. These tests were performed aboard Navy missile ships and the equipment was operational.

During the course of the year the division entered into an advanced program to develop a system for use in checking out helicopters and light aircraft for one of the major defense agencies. It was anticipated that this development will result in reduction of maintenance time and through this means greatly enhance the usability of the aircraft.

Utilizing advanced development techniques employed in radar fuzes, the Division entered the field of space technology. Among possible applications was the determination of spin-rate and spin-axis of various planets. It was anticipated that an immediate system would be installed in an Aerobee-150 rocket to obtain pulse returns from the earth from an altitude of 250 kilometers. This will be done to obtain correlation with data obtained through use of ground radar systems and to prove the use of radar for ultimate application to space satellites.

The Division participated in many missile programs, including Sparrow I, Honest John, Little John, Lacrosse, Bomarc, Redstone, Sage, Pershing and Talos.

CHANDLER EVANS CORPORATION

DURING 1960, the most notable new developments at Chandler Evans came in the field of hot gas actuation and reaction control systems for an ever growing missile and spacecraft industry.

While the company's principal production activity continued to be centered about various types of fuel pumps and control systems for many of the country's leading producers of jet aircraft powerplants, its research and development activities, targeted toward the space-age market, were productive of experimental contracts that gave promise for future volume production.

In addition, Chandler Evans' engineering and precision manufacturing capabilities resulted in its being selected in 1960 to receive a prototype order for the development and production of an atomic reactor control valve and system. In this project, the company was working closely with Kaiser Engineers, Inc. and the Hanford Atomic Products division of General Electric Company.

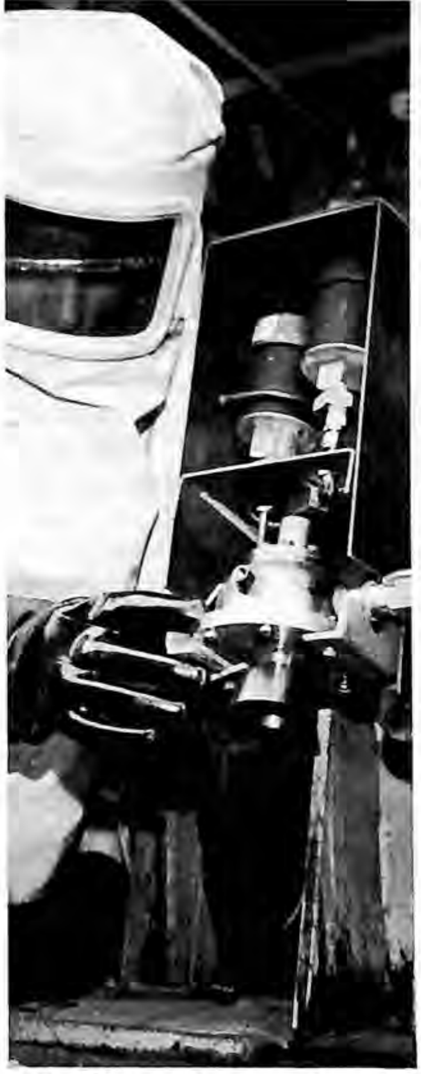
Though production volume was off slightly from its peak in 1959, the company continued to produce fuel pumps and afterburner fuel controls for Pratt & Whitney J52, J57 and J75 engines which power many of the country's most advanced military jet aircraft. Fuel pumps for the commercial equivalents of these engines were also manufactured.

One of Chandler Evans' principal production items during the year continued to be the unitized fuel control and pumping system for Lycoming T53 gas turbine engines—a powerplant used extensively for helicopters. These engines and fuel systems contributed much to the establishment of eight new world's records for altitude, speed and distance achieved during the last twelve months by Kaman and Bell helicopters.

Chandler Evans' experimental test facilities were augmented early in the year by the completion of a new Hot Gas Laboratory where many of the company's latest designs for bistable hot gas actuation systems using solid propellants have been proved.

One of the company's newest developments was a reaction control system which performs the steering function for a missile. Its principle can be adapted also to attitude control of spacecraft. The operation of this system is based on the use of a hypergolic combination of storable fluid propellants: hydrazine and nitrogen tetroxide.

At year end, Chandler Evans was placing great emphasis on the continuation of its research and development programs which embrace a variety of systems, sub-systems and components in the field of high pressure pneumatics for the new era of missiles and spacecraft.



TECHNICIANS ready new missile reaction control unit.

COOK ELECTRIC COMPANY

DURING 1960 Cook Electric Company's activities included several new developments in the aero-space and ground support fields.

The Air Mod division along with sister divisions Nucledyne and Cinefonics developed a new type barrier hook for F-102 aircraft. Air Mod division also established a new IRAN facility at Rome, New York, to repair and modify electronic aircraft equipment and is staffing the Travis, California, AF Base C-124 Maintenance Program.

The Diaphlex division developed a new lightweight, high torque Polarized Motor. A D.C. Motor without commutation, (known as the Andrews Motor) this unit has a high starting and running torque for a given watt input, and the current consumption of this motor is nearly constant, even with locked rotor or load variations. This desirable feature is useful in areas where there is a limited source of power (ie: solar cell or battery) or where the current availability is limited. In addition, this arc free operating motor is activated by synchronized impulses and the sealed circuit may be remote from the motor. Another important feature of this new polarized motor is that as the load increases there is a negligible current change. This characteristic is extremely useful in missile and space applications where it is necessary to know how much current all the components will need for a given period.

Data Stor division continued development and manufacture of digital data handling equipment. The products under manufacture perform such vital functions as the loading of target information into Atlas, Titan and Minuteman ICBM Missiles and perform other information data functions in our more exotic programs such as "Project Echo," "BMEWS" and future moon landings.

Advanced Communications Engineering division was chosen to develop and engineer the intersite communications systems for three Titan and Atlas missile complexes located in the northwest portion of the United States. The work includes all phases of the communication systems, including engineering construction, instrumentation, check-out and maintenance.

Nucledyne division continued its activities in the environmental equipment field including the design and construction of the most advanced facilities for aerospace environmental simulation relative to missile, satellite and orbital reconnaissance of special interest. Nucledyne developed and delivered to Missile Ranges mobile environmental conditioning units for preconditioning missile components prior to firing missiles and has also recently delivered pylon type rocket motor test stands for use in rocket motor test and development programs.

The Cook Technological Center continued to provide the highly successful Cook Recovery

NEW TYPE barrier hook for F-102 aircraft.

Packages for Missile Nose Cone Recovery. Latest use was to bring back from outer space the three mice, Amy, Moe and Sally. During 1960, Cook Technological Center continued in research and development in new areas. Included in these fields are: Project Saturn, aircraft safe landing studies, NASA Solar Beam Experiments, nickel cadmium battery studies, direction finding and homing systems for missiles, micrometeorological systems.

Cinefonics' technical and briefing film reports included classified productions on communication satellites, missile defense systems, air weather reconnaissance and nuclear weapon safety.

THE DOW METAL PRODUCTS COMPANY

THE SUPPLY of products to the aerospace industry continued to be a major factor in the 1960 operations of The Dow Metal Products Company, Division of The Dow Chemical Company. Big aluminum integrally stiffened skin panels for the Titan missile and wing panels for the B-52 were extruded on Dow's 13,200-ton extrusion press. The company also supplied magnesium-thorium extrusions and rolled products for several missile and space programs requiring materials with good elevated-temperature properties; these included the Talos, Titan, Polaris, Agena and Bomarc. Magnesium sheet, plate and extrusions were supplied for the canisters used to carry Project Echo inflatable satellites into space.

Dow facilities supplied castings and fabrications for missile and aircraft electronic equipment, both airborne and ground based. These included lightweight, close-tolerance housings for the Arma inertial guidance system for the Atlas and a series of very large castings, with individual weights up to 1,450 pounds, for the Nike ground guidance system. Production continued on castings for several types of turbojet engines.

FLIGHT REFUELING, INCORPORATED

THE COMPANY'S year was marked by additional diversification of its activities in the production of missile and cryogenic fuel handling equipment. New products, techniques and systems included positive sealing booster disconnects, fuel fill and drain disconnects, retro rocket chambers, fuel flow regulator valves and depot and shipboard missile handling systems, all of which were either being studied or manufactured at FRI during the year. In addition, research and development programs involving space refueling, controlling airborne nuclear reactors and ground support equipment for nuclear aircraft and missiles were being conducted by FRI's Missiles and Nuclear Group. Commercial product development included the Model QD-16 Quick Release Coupling, Magnetic Liquid Level Indicator, and a Bottom Loading System.

THE HALLICRAFTERS COMPANY

AVIATION AND MISSILE equipment business at The Hallicrafters Company rose sharply during 1960, sparked by increased QRC contract activity, including a $19,000,000 Air Force contract to produce electronic countermeasure equipment for B-52 bombers.

At the end of the fiscal year August 31, the company had a military sales backlog of $25,000,000, an increase of 212 per cent over the $8,000,000 in existence 12 months before. Sales of military electronic products were up 15 per cent over the previous year.

More than 30 QRC (Quick Reaction Capability) projects were handled during the 18 months through December, 1960, covering equipment for missiles and SAGE (semi-automatic ground environment) in addition to countermeasures and counter-countermeasures. A total of 143 scientists, engineers and related personnel were added to the research and development staff during 1960.

Hallicrafters data transmission systems were widely used in industry as well as throughout the Atlantic Missile Range, including Cape Canaveral. There they scramble and unscramble coded messages from Bomarc and Atlas missiles and feed the information into central computers.

To meet growing requirements for facilities to simulate conditions of extreme heat, cold, moisture and altitude as well as vibration-load situations, the company installed the largest environmental test chamber of its type in the Midwest. It now has 11 such test chambers in operation.

Hallicrafters also instituted a "Blue Streak Program," which serves the Armed Forces by supplying technical personnel to help maintain complex electronic equipment at bases throughout the world.

HARVEY ALUMINUM

THE YEAR 1960 saw Harvey Aluminum, Torrance, California, strengthen its position as a leading producer of aluminum, titanium, zirconium, and other metals for aircraft, missile, space, and nuclear programs.

Harvey continued to produce large heavy press structural aluminum extrusions for aircraft, missile, and ground handling equipment. A significant accomplishment was the extruding of large diameter hard alloy aluminum tubing with special external configuration for missile bodies. In steel, Harvey was extruding super alloys on a production basis for missile and space applications. Titanium tubing in a wide range of sizes as well as complex shapes also were being extruded for jet engine, air frame, and missile use. New techniques for extruding columbium proved successful, enabling the company to produce columbium tubing for high temperature, high strength use in nuclear propulsion systems for aircraft.

In 1960, the company went into volume production on long zirconium tubing for nuclear reactors. These tubes are extended and drawn to 53½ feet. Seamless and unwelded, they are the most efficient for pressure tubes. Zirconium tubes are being produced by Harvey in a wide range of sizes from ⅜ to 8 inch O.D. and larger for leading reactor manufacturers. Other zirconium mill products also are available from Harvey in Zircaloy–2, 3, or 4; unalloyed zirconium; and developmental alloys with special properties.

At the Wright Air Development Center, the Materials Laboratory contracted with Harvey Aluminum to explore the basic parameters for the fabricability of refractory alloys, i.e., molybdenum, tungsten, niobium, and tantalum. To solve the high temperature problems concerned with propulsion and re-entry, a shift to materials having a high melting point and increased high temperature capability is necessary. Before materials specifications can be established, environmental conditions must be defined and design criteria and fabrication methods established. The metals processing facility was established to accelerate the Air Force refractory alloy development program.

A new Research and Development Center was completed during the year. Located adjacent to the Torrance, California facility, the new building will be used for research and development activities concerning space, missiles, ordnance, electronics and materials.

During the year, the company was awarded a contract by the Army Ordnance Ammunition Command for the continued operation of Milan Arsenal, Milan, Tennessee.

Construction was started to increase capacity 25% at the company's primary aluminum plant at The Dalles, Oregon. When completed, the reduction facility will have a capacity of 75,000 tons annually. The company signed a 20 year contract with the Bonneville Power Administration for the supply of electrical power for an aluminum reduction plant to be built in the Northwest. The proposed plant will have a capacity of 75,000 tons per year. As part of its expansion program, Harvey announced plans for an aluminum sheet, plate, and strip rolling mill.

HUCK MANUFACTURING CO.

EMPHASIS on research and development in the field of fastener design and application was again evident during 1960 at Huck Manufacturing Company.

Broader inroads were made in metals research for application in high quality fastener production. The fasteners themselves were refined and improved in configuration and physical and mechanical properties.

Newer designs and specifications, some of them still on drawing boards and many of them undergoing laboratory and field tests were aimed at meeting higher strength and temperature requirements in aircraft and missile production. Standard materials, already accepted and widely used in fasteners, were also being studied in high temperature applications. The goal was establishment of more realistic time at temperature limits for conventional designs and materials.

Huck engineers and metallurgists were working with both government and industry research and development programs involving high-strength, high temperature studies.

Among significant developments for aircraft and missile use were 1) a new line of precision ground self broaching Huckbolt fasteners, 2) an expansion of the Huck line of mechanical lock pindle blind rivets, and 3) a new line of close tolerance shank "exotic metal" Huckbolt fasteners.

An outstanding Huck development was the precision ground selfbroaching Huckbolt fastener, available in alloy steel and A286. Pins for these fasteners are first rool formed to shape; the shank and broaching sections are then centerless ground to final size. Grinding produces three basic advantages: 1) a better, sharper broach, 2) better concentricity between broach and shank, and 3) elimination of any out of round condition which might exist. Huck found good acceptance of the self broaching fastener among missile producers, especially for use in LOX areas.

JACK & HEINTZ, INCORPORATED

MAJOR J&H ACHIEVEMENTS during 1960 were: (1) significant progress on the all-electric VSCF generating system, (2) acquisition and expansion of a quick-connect coupling line, (3) production of a new, lightweight motor for hydraulic pumps used in missiles, (4) production of a new 100-amp generator for executive aircraft, (5) production of a new lightweight engine starter for executive aircraft.

The VSCF, an all-electric variable-speed constant-frequency generating system which eliminates the need for a conventional constant-speed drive moved along rapidly.

During 1960, J&H made two significant gains: development of the "full-rated frequency changer" scheme and demonstration of the engine-starting capabilities of the system. The full-rated system employs a brushless generator that connects directly to the engine accessory pad. The entire variable-frequency output of this generator is fed into a static frequency changer which converts the variable input into a constant-frequency output. During 1960, major aviation representatives attended special demonstrations and "short technical courses" and termed the new a-c generating system as "inevitable" for transport use. The reasons are these: design is completely static (compared to the hydromechanical CSD not employed) and therefore inherently more reliable; service life between overhauls is placed at a minimum of 2500 hours (a ratio of 2½:1 compared to the present CSD-Generator arrangement); the operating cost is placed at approximately 20¢ per hour, a drastic reduction compared to conventional systems.

Further, the system's demonstrated engine-starting capabilities offer the additional economies attendant to the elimination of air-start carts currently employed for turning over jet engines.

Jack & Heintz entered the quick-connect coupling market in 1960 with the acquisition of Roto-Lock. The Roto-Lock is a specially designed quick-connect coupling employing locking pins in lieu of the more conventional ball bearing. This feature, together with simplified sealing mechanisms and "star poppets" make it exceptional from these standpoints: higher pressure capability with the aluminum coupling (others are of steel, brass and plastic) rated at 3000 psi proof; low pressure drop with the 1″ coupling rated at less than 3.1″ of water at 6 gpm; long service life attributed to the locking pins which eliminate "brinneling," the common cause coupling failure.

The Roto-Lock has extensive application in the aero-space industry. It is designed to handle all fluids from air thru the exotic fuels.

In addition to Roto-Lock, J&H developed Trigger Lock. The latter is a no-air inclusion quick-connect coupling aimed specifically at a growing number of applications which dictate minimum loss of liquid on disconnect and minimum entrapment of a foreign matter on connect. This is particularly true of applications handling corrosive, explosive or toxic fluids and also of hydraulic systems feeding controls.

Another coupling line introduced by J&H at the close of 1960 was a special air-start design. Because of its locking and swivel mechanisms, this coupling has already gained considerable interest in air transport, military and non-military.

J&H missile activity centered around its VSCF system, its SECSYN (brushless generators) and handling systems. Certain electromechanical erector-actuator designs effected during 1960 helped gain wider acceptance of the fact that electromechanical approach is simpler, lighter and more reliable than comparable hydraulic and hydromechanical systems. Altho still classified, the systems were serving missiles in the ICBM classification.

A special component of note in the missile area was a new J&H lightweight motor for missile hydraulic pump applications. Rated 6 hp intermittent, the d-c machine weighs only 18 pounds. The motor delivers its rated capacity for more than 30 minutes under conditions of no cooling. This thermal lag capability derives from a special lamination construction and an "air slinger" configuration. This motor was in production for the Douglas Nike Hercules.

Reflecting its accelerated and expanded service to the executive aircraft market, J&H completed two significant projects during 1960. The first of these is a lightweight d-c starter designed for engines of displacements up to 1000 cubic inches. Featuring ease of assembly, adjustment and replacement, the starter operates on 13.5 to 24 volts.

An important development in terms of executive aircraft need was the 100-amp d-c generator introduced by J&H during 1960. This machine delivers a full 100-amps at all engine speeds ranging down to idle. It is the only machine with this capability. It has received the TSO seal of approval by FAA. Its ability to deliver full 100-amps at all speeds means that the pilot has full use of instrumentation thru all flight regimes, day or night. It is expected that the machine will help executive aircraft owners to expand instrumentation aboard current ships, and will certainly assist in equipping new ships with the latest in electronic gear. An outstanding example of the new aircraft incorporating the new J&H Model 30059 are the AeroCommander 560F's and 680F's.

In addition to the 100-amp machine, J&H announced that other electric power systems and component designs exclusively for executive aircraft were nearing completion.

J&H sales in 1960 were approximately $22,-000,000. Employment remained steady at about 1400.

KOLLSMAN INSTRUMENT CORPORATION

DURING 1960, Kollsman Instrument Corporation strengthened its position in the industry through a management reorganization program. David B. Nichinson, who had been responsible for the company's development of advanced navigation and weapon systems, was named president. Kollsman's research and engineering activities were realigned with the formation of a new Research Department, under the direction of Dr. Arthur S. Robinson, to conduct investigations in pure and applied fields of science. The revised engineering department was placed under the guidance of Raymond A. Rugge as Director of Engineering and Dr. Nathan Kaplan as Engineering Manager. Concurrently, the sales activities of Kollsman were centralized under a new Vice President for Marketing, Edward C. Leeson.

A major portion of the 1960 sales resulted from the quantity production of the company's family of astronavigation instruments and systems for the military. Included in this product group was the MD-1 Automatic Astro Compass System for the Air Force's Boeing B-52 jet bombers. This precision system, employing a six-pound tracking telescope, measures the relative bearing of a star and automatically combines this with computed azimuth. The result is a precise aircraft heading with an accuracy of six minutes of arc. Advanced versions of this system were being produced for the Convair B-58 supersonic bomber to provide true heading and position data for Bomb/Nav system use. Another version was being used on the B-52 for prelaunch true heading orientation of the GAM-77 "Hound Dog" missile.

The latest celestial navigational device designed and developed by Kollsman during 1960 was a satellite-borne star tracker. This star tracker is capable of locating and tracking automatically any star within a 30 degree cone. Moreover, it can be commanded to ignore all stars whose brightness differs from that which has been selected. The star tracker is designed with the necessary reliability and environmental qualifications to make it suitable for space vehicle and satellite applications.

By year-end, Kollsman had produced and shipped more than 1,000 astro tracking systems.

Other important production activities at Kollsman during 1960 evolved around such items as air data computers for the B-52 and the B-66, master air data computers for the B-66, central air data computers for the F-105 and F-106, photoelectric sextants for Navy submarines, ballonet fullness computers for Navy dirigibles, integrated flight instrument systems for the Boeing 707, Douglas DC-8 and Convair 880 and 990 jet transports, and radar barometric altimeters and command Mach-airspeed indicators for the A2F.

Increased impetus was placed during the latter half of 1960 on the company's research and development activities. Spearheaded by the new

Research Division, the company instituted a number of highly important feasibility studies.

One of the studies involved the application of TV camera tubes to astro tracking. Such tubes provide a high-speed electronic scan capable of supplying information from several stars in a given field of view. Kollsman had a Vidicon Tracker in operation and was investigating problem areas such as the reduction of sensitivity due to motion of the image on the photosensitive surface and the determination of star positions to higher orders of accuracy.

Another investigation was concerned with the application of solid state photodetectors. Techniques are being developed which will make possible the smallest, most reliable star tracker.

Other feasibility studies under way ranged from the broad category of space navigation to the more specialized fields of solid state photosensors, circuit packaging, hi-accuracy optics and switching servo amplifiers.

The delivery in 1960 of increased numbers of large jet transports brought about a broadening of Kollsman's commercial airline business. At the end of the year, Kollsman listed the majority of U.S. and international air carriers among its customers. To meet the increasing requirements from these customers for factory training of customer technicians, Kollsman revamped and expanded its training school facilities through the addition of increased floor space and specialized equipment for training purposes.

LEAR, INCORPORATED

DURING 1960 LEAR, Incorporated celebrated its Thirtieth Anniversary in a recently completed executive office building in the Lear complex adjacent to the Santa Monica, California, airport. Entering its fourth decade of operation, Lear, as of December 1960, reported estimated sales of approximately $91 million.

In keeping with its growth philosophy, Lear initiated a number of major moves in 1960 to strengthen its position in the aerospace industry. A full scale service organization attained divisional stature with a staff and facilities expanded to provide unified service to Lear customers of all military, commercial and industrial products. The Service Division, to augment its existing facilities, acquired a 33,000 square foot customer service center in Harrisburg, Pennsylvania and signed factory-level service agreements with three flight equipment service stations.

Increased emphasis on international operation was stressed with the planned establishment of an International Division. This division will be instrumental in effecting sales and licensing the products of all Lear divisions and facilities in this country and abroad to foreign customers, with the exception of Canada, and to engage in the importing and sales of foreign products in the United States.

Continued expansion of overseas operation caused Lear to augment its operations with additions to the staff of the company's European headquarters in Geneva, Switzerland, and the establishment of a Far Eastern sales office in Tokyo, Japan.

In January of 1960, Lear sold the LearCal division, and those products applicable to transport and military markets were transferred to other divisions. This was in line with the decision to focus Lear's resources on design and manufacture of highly sophisticated military, airline and industrial products and increase space and consolidate facilities of Lear Astronics Division and Solid State Physics Laboratory.

Lear Instrument Division, operating in a new 172,000 square foot facility at Grand Rapids, Michigan, continued to expand its work in design, development and production of precision components and systems for manned and unmanned flight vehicles. Major products included: flight indicators; gyro-stabilized platforms and compasses; automatic bombing systems; displacement and rate gyros; synchros and ground support equipment; resolvers.

Continuing its leadership in gyroscopics, the Instrument Division introduced two remarkable entries in 1960. The "genie," is a gas-driven displacement gyro with only four moving parts. The "Talisman," Series 7601 gyro is the first sub-miniature rate gyro introduced by Lear. Electrically driven, the six and one-half ounce Talisman incorporates three major design improvements; greatly improved damping, reduced power requirements and the elimination of external choke.

In the areas of data display, the Instrument Division made such contributions as: the development of a combined absolute altitude and instantaneous vertical speed indicator which displays absolute altitude from zero to 200 feet and instantaneously indicates vertical speeds from zero to 40,000 feet per minute. This in-

LEAR'S new executive office building.

strument will provide valuable "second source" information to ILS or programmed landing information and is currently being evaluated for inclusion in an all-weather landing program being jointly conducted by WADD and the FAA. Instrument Division also began work in the research and development of an airborne data insertion unit (ADIU) which will be the cockpit display portion of the FAA's Automatic Ground-Air Communications System. Transmitting messages digitally, this system will permit ground-air, air-ground communications with 500 aircraft every two minutes through a single frequency.

The Electro-Mechanical Division, also located in Grand Rapids, designed, manufactured and marketed electric fractional horsepower motors; clutches; electrical, hydraulic and pneumatic actuators; control systems and precision servo equipment.

In the missile and military aircraft markets, the Electro-Mechanical Division continued production of servo actuators and air inlet and landing flap systems.

E-M's remote fuel trimmer system, widely used for commercial jet transports as well as military jets, was adapted for use with turbofan engines. The trimmer allows one man in the cockpit to complete the engine trimming operation with greater accuracy than manual adjustment.

Production of industrial servos for Robodyne and remotely operated automatic control systems for nuclear reactors strengthened Electro-Mechanical Division's position in the industrial market.

The Astronics Division at Santa Monica, California, designed and produced automatic flight control and stabilization systems, communication equipment and other electronic devices. MILLIMIN, Astronics' modular, high density, electronic packaging technique was advanced to provide maximum flexibility in design. Production continued through 1960 on contracts for: two axis stability augmenter systems for Northrop; transistorized, modular command manuevering control systems for the Ryan Q2C drone target missile; and stability augmentation systems for the Nato G.91 fighter.

Evaluation tests were started in the latter part of the year on the remote control and stabilization system for the Gyrodyne, DSN drone helicopter for the Navy's Dash program.

Astronics, under contract to the FAA, extended its work in areas of automatic landing and navigational systems. Airborne equipment was produced for use with the Range and Elevation Guidance for Approach and Landing (REGAL) ground installation design by Gilfillan; delivery of Minimum Air Navigation (MAN) system, a dead reckoning navigator, was made to the FAA's Experimental Center for flight test.

The delivery of Astronics' first prototype North-seeking gyro for the Minuteman Air Force ICBM was made in the last quarter of 1960, as was Astronics' first 5 KMC Automatic Tracking Telemetry Receiving System for another high priority missile program.

1960 marked Lear's first order for automatic flight control equipment by a major American airline, with a contract from United Air Lines for its fleet of Sud Caravelles which were scheduled for service early in 1961.

Lear-Romec Division at Elyria, Ohio, near Cleveland, Ohio, continued development of its and development programs involving high-strength, high temperature studies.

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MAJOR J&H ACHIEVEMENTS during 1960 were: (1) significant progress on the all-electric VSCF generating system, (2) acquisition and expansion of a quick-connect coupling line, (3) production of a new, lightweight motor for hydraulic pumps used in missiles, (4) production of a new 100-amp generator for executive aircraft, (5) production of a new lightweight engine starter for executive aircraft.

The VSCF, an all-electric variable-speed constant-frequency generating system which eliminates the need for a conventional constant-speed drive moved along rapidly.

During 1960, J&H made two significant gains: development of the "full-rated frequency changer" scheme and demonstration of the engine-starting capabilities of the system. The full-rated system employs a brushless generator that connects directly to the engine accessory pad. The entire variable-frequency output of this generator is fed into a static frequency changer which converts the variable input into a constant-frequency output. During 1960, major aviation representatives attended special demonstrations and "short technical courses" and termed the new a-c generating system as "inevitable" for transport use. The reasons are these: design is completely static (compared to the hydromechanical CSD not employed) and therefore inherently more reliable; service life between overhauls is placed at a minimum of 2500 hours (a ratio of 2½:1 compared to the present CSD-Generator arrangement); the operating cost is placed at approximately 20¢ per hour, a drastic reduction compared to conventional systems.

Further, the system's demonstrated engine-starting capabilities offer the additional economies attendant to the elimination of air-start carts currently employed for turning over jet engines.

Jack & Heintz entered the quick-connect coupling market in 1960 with the acquisition of Roto-Lock. The Roto-Lock is a specially designed quick-connect coupling employing locking pins in lieu of the more conventional ball bearing. This feature, together with simplified sealing mechanisms and "star poppets" make it exceptional from these standpoints: higher pressure capability with the aluminum coupling (others are of steel, brass and plastic) rated at 3000 psi proof; low pressure drop with the 1″ coupling rated at less than 3.1″ of water at 6 gpm; long service life attributed to the locking pins which eliminate "brinneling," the common cause coupling failure.

The Roto-Lock has extensive application in the aero-space industry. It is designed to handle all fluids from air thru the exotic fuels.

In addition to Roto-Lock, J&H developed Trigger Lock. The latter is a no-air inclusion quick-connect coupling aimed specifically at a growing number of applications which dictate minimum loss of liquid on disconnect and minimum entrapment of a foreign matter on connect. This is particularly true of applications handling corrosive, explosive or toxic fluids and also of hydraulic systems feeding controls.

Another coupling line introduced by J&H at the close of 1960 was a special air-start design. Because of its locking and swivel mechanisms, this coupling has already gained considerable interest in air transport, military and non-military.

J&H missile activity centered around its VSCF system, its SECSYN (brushless generators) and handling systems. Certain electromechanical erector-actuator designs effected during 1960 helped gain wider acceptance of the fact that electromechanical approach is simpler, lighter and more reliable than comparable hydraulic and hydromechanical systems. Altho still classified, the systems were serving missiles in the ICBM classification.

A special component of note in the missile area was a new J&H lightweight motor for missile hydraulic pump applications. Rated 6 hp intermittent, the d-c machine weighs only 18 pounds. The motor delivers its rated capacity for more than 30 minutes under conditions of no cooling. This thermal lag capability derives from a special lamination construction and an "air slinger" configuration. This motor was in production for the Douglas Nike Hercules.

Reflecting its accelerated and expanded service to the executive aircraft market, J&H completed two significant projects during 1960. The first of these is a lightweight d-c starter designed for engines of displacements up to 1000 cubic inches. Featuring ease of assembly, adjustment and replacement, the starter operates on 13.5 to 24 volts.

An important development in terms of executive aircraft need was the 100-amp d-c generator introduced by J&H during 1960. This machine delivers a full 100-amps at all engine speeds ranging down to idle. It is the only machine with this capability. It has received the TSO seal of approval by FAA. Its ability to deliver full 100-amps at all speeds means that the pilot has full use of instrumentation thru all flight regimes, day or night. It is expected that the machine will help executive aircraft owners to expand instrumentation aboard current ships, and will certainly assist in equipping new ships with the latest in electronic gear. An outstanding example of the new aircraft incorporating the new J&H Model 30059 are the AeroCommander 560F's and 680F's.

In addition to the 100-amp machine, J&H announced that other electric power systems and component designs exclusively for executive aircraft were nearing completion.

J&H sales in 1960 were approximately $22,-000,000. Employment remained steady at about 1400.

KOLLSMAN INSTRUMENT CORPORATION

DURING 1960, Kollsman Instrument Corporation strengthened its position in the industry through a management reorganization program. David B. Nichinson, who had been responsible for the company's development of advanced navigation and weapon systems, was named president. Kollsman's research and engineering activities were realigned with the formation of a new Research Department, under the direction of Dr. Arthur S. Robinson, to conduct investigations in pure and applied fields of science. The revised engineering department was placed under the guidance of Raymond A. Rugge as Director of Engineering and Dr. Nathan Kaplan as Engineering Manager. Concurrently, the sales activities of Kollsman were centralized under a new Vice President for Marketing, Edward C. Leeson.

A major portion of the 1960 sales resulted from the quantity production of the company's family of astronavigation instruments and systems for the military. Included in this product group was the MD-1 Automatic Astro Compass System for the Air Force's Boeing B-52 jet bombers. This precision system, employing a six-pound tracking telescope, measures the relative bearing of a star and automatically combines this with computed azimuth. The result is a precise aircraft heading with an accuracy of six minutes of arc. Advanced versions of this system were being produced for the Convair B-58 supersonic bomber to provide true heading and position data for Bomb/Nav system use. Another version was being used on the B-52 for prelaunch true heading orientation of the GAM-77 "Hound Dog" missile.

The latest celestial navigational device designed and developed by Kollsman during 1960 was a satellite-borne star tracker. This star tracker is capable of locating and tracking automatically any star within a 30 degree cone. Moreover, it can be commanded to ignore all stars whose brightness differs from that which has been selected. The star tracker is designed with the necessary reliability and environmental qualifications to make it suitable for space vehicle and satellite applications.

By year-end, Kollsman had produced and shipped more than 1,000 astro tracking systems.

Other important production activities at Kollsman during 1960 evolved around such items as air data computers for the B-52 and the B-66, master air data computers for the B-66, central air data computers for the F-105 and F-106, photoelectric sextants for Navy submarines, ballonet fullness computers for Navy dirigibles, integrated flight instrument systems for the Boeing 707, Douglas DC-8 and Convair 880 and 990 jet transports, and radar barometric altimeters and command Mach-airspeed indicators for the A2F.

Increased impetus was placed during the latter half of 1960 on the company's research and development activities. Spearheaded by the new standard product lines, including centrifugal fuel booster pumps, lube/scavenger pumps for jet engines, pressurization and desiccator assemblies for radar units, servo valves for missile hydraulic guidance, and cooling units for airborne and ground support equipment applications.

During 1960, Lear-Romec developed a heatless, reactivating dehydrator which provides up to 25 SFCM of air so dry that it contains less than 1/10 part per million water vapor by volume.

Under Lear's global concept, Lear-Romec entered into sales and licensing agreements with two foreign manufacturers: Lucas-Rotax, Limited, of Canada and Plannair, Limited, of England. The Plannair Agreement granted Lear exclusive sales and manufacturing option rights to market the English firm's cooling units for communication and electronic equipment. Under the Canadian agreement, Lucas-Rotax will manufacture pumps and check valves developed by Lear.

The Lear Solid State Physics Laboratory was started in Santa Monica with research underway in electroluminscence, metallic oxide films, infrared detection, plasma technology, semiconductors, ultrasonics, photo-conductors, thermoelectricity and gyromagnetics. The laboratory was specializing in fields of microminiaturization and molecular electronics.

MB ELECTRONICS, A DIVISION OF TEXTRON ELECTRONICS, INC.

TECHNICAL ADVANCES in vibration testing equipment and techniques characterized 1960 at MB Electronics. MB's integrated vibration test systems were being used by major missile, aircraft and electronics firms as well as by an increasing number of non space age companies. Technical advances in the science of vibration testing further solidified it as a major factor in improving system reliability while cutting research and development time and expense.

In 1960, MB built the industry's first fully automatic spectrum equalizer for random motion vibration test systems. Automatic spectrum equalizers are geared to equalize vibration shaker systems within seconds. The device increased testing accuracy while providing substantial savings in test time and money. MB's automatic unit utilizes a multi-band compensation approach. The spectrum is divided into 25 cps increments. Continuous automatic equalization is achieved by using solid state magnetostrictive filters with correct phase properties plus servo regulators on each of 80 channels in the 15 to 2,000 cps spectrum.

Increased emphasis was placed on electro-hydraulic shaker systems in 1960. These shakers, designed to complement electro-dynamic units and not to replace them, are compact systems which deliver extremely high vibratory forces and long strokes in the low to intermediate frequency range. They are expected to enlarge the scope of vibration, shock and fatigue testing through their special capabilities. In 1960, MB, using experience gained on prototype units, introduced a complete line providing vibratory forces from 1,000 to 100,000 pounds, strokes as long as nine inches and practical test capacity from 5 pounds to 15 tons over a low to intermediate frequency range.

In this same general field, MB undertook the design and development of one of the world's largest single-unit underwater transducers to be hydraulically driven for the Bureau of Ships, U. S. Navy. The unit is for the Navy's Underwater Sound Laboratory in New London, Connecticut. Underwater sound is a field in which much is expected in the near future. MB's activity in this area is part of its policy of applying the technical skills gained in pioneering vibration testing to new fields.

Technical product improvements in MB's line of electronic power supplies and vibration meters and pickups were also recorded in 1960. The N503 vibration meter, geared to accept signals from both velocity pickups and accelerometers and to provide readings of displacement, velocity and acceleration for each signal, represented a major step forward in vibration measurement.

In addition to improving product performance and launching product innovations, MB continued its program of vibration seminars designed to disseminate current technical information on vibration testing. The program, an industry first, was planned to last as long as the demand. In mid 1960, the program entered its second year. More than 250 engineers and technicians from most of the major users of vibration test equipment attended the two-week course given in New Haven. Special courses were also held at the Polytechnic Institute of Brooklyn and on the West Coast.

Sales to aircraft and missile manufacturers abroad increased markedly in 1960. This was particularly true in France where MB vibration test systems were purchased for a comprehensive environmental laboratory by Sud Aviation, Cannes. Activity increased on other foreign fronts including Germany and England.

PTF Engineering, an environmental engineering firm, and another division of Textron Electronics, Inc., also was active in Europe. One of the company's chief U. S. contracts involved designing laboratory facilities to simulate outer space and atmospheric reentry conditions for NASA's new $18-million Goddard Space Flight Center at Greenbelt, Maryland.

MINNEAPOLIS-HONEYWELL REGULATOR COMPANY MILITARY PRODUCTS GROUP

PUBLIC ANNOUNCEMENT of the Asroc anti-submarine missile system and development of a super-accurate miniature ceramic gas bearing gyroscope highlighted the news from Minneapolis-Honeywell's Military Products Group during 1960.

Honeywell's Ordnance Division was prime contractor on Asroc. In June, Honeywell and the Navy announced the successful shipboard evaluation of the system which was described by the Navy as "a significant advance in the Navy's antisubmarine warfare program."

Asroc is capable of delivering either an acustic homing torpedo or a depth charge to an enemy submarine while the launching ship is thousands of yards away. It is an integrated weapon system consisting of four major parts: an underwater sonar detection device, an electronic digital fire-control computer, an eight-missile launcher, and the Asroc missiles.

In a matter of seconds after sonar detection of a submarine has been made, a computer charts course, range, and speed of the sub and the missile launcher whirls into firing position. The ship commander can then fire either a rocket-propelled torpedo or a depth charge.

The missile follows a ballistic trajectory, shedding its rocket motor at a predetermined signal and its airframe shortly before water entry. When the payload is a torpedo, a parachute blossoms in flight to slow its plunge into the water in the target area.

The Asroc torpedo is activated by the energizing of a seawater battery after hitting the water and begins acoustical homing search from which it locks onto its target and pursues it to destruction. The Asroc depth charge sinks to a predetermined depth where it detonates with a large effective kill area.

BOW VIEW of ASROC missile firing from U.S.S. Norfolk.

Asroc is approximately 15 feet long and one foot in diameter. It is solid fueled and weighs approximately 1,000 pounds. Development cost of the weapon system was about $65,000,000.

In addition to the development cost, Honeywell announced in August that it had been awarded a $2.9 million contract for production of Asroc missiles, bringing to $4.9 million the total funding for missile production.

The Navy had plans to equip some 150 destroyers and cruisers with Asroc over the next few years.

In June, Honeywell's Aeronautical Division unveiled a new eight-ounce ceramic gyroscope for missile and space guidance, described as being so accurate it could measure motion 7,500 times slower than the hour hand on a watch.

Secret of the gyro's super accuracy is that it is made of a new ceramic material as hard as sapphire and uses gas bearings for its key moving part. The ceramic material avoids problems associated with metal, such as expansion and wear. Gas bearings virtually eliminate friction, a major cause of gyro errors.

The new gyro was developed after four and a half years of research. It is intended to help make possible more precise electronic guidance systems needed for future long-range missile flights and for deep space missions. Precision gyroscopes are the most sensitive and critical elements in such systems.

In February, the company disclosed plans for a strange new machine to duplicate on earth most of the conditions and phenomena of space. The elaborate device will be built for the Air Force's Wright Air Development Division to speed the testing and evaluation of space reconnaissance equipment. Called a dynamic analyzer, it will be an important adjunct to space technology.

The dynamic analyzer will simultaneously create the searing heat, bitter cold, rarified atmosphere and rugged vibrations encountered by space vehicles as they orbit far above the earth. It thus will take the guesswork out of designing space reconnaissance equipment and reduce testing time now necessary in advance of space explorations. The space machine will be a cylindrical steel chamber fifteen feet long and 9 feet in diameter. It will be supported on angular legs that move violently to give the chamber the rolling, pitching and yawing motions found in space.

Early in the year, the Aeronautical Division announced plans to increase engineering employment by 20 per cent. The division had an immediate need for approximately 200 graduate engineers.

Ground was broken for a $1 million expansion of the division's facility in Minneapolis. A three-story, 64,000-square-foot addition will be built to provide added engineering and research space and to house a $1 million Honeywell 800 computer for both business and scientific use.

In April, Honeywell announced receipt of a significant contract in connection with the Polaris program. Under subcontract to Hughes Aircraft Company, Honeywell will produce precision inertial guidance platform gimbal assemblies, a key element in the guidance system of the Polaris missile.

Another Navy contract was announced a month later. The company's Ordnance Division was awarded a $3.6 million contract to develop and build a sophisticated submarine training facility which will electronically simulate a full-scale naval battle. Utilizing a giant computer and advanced electronic techniques, the facility will provide a startling degree of realism in waging of mock sea battles to train the crews of Polaris-armed and other nuclear submarines in the complex tactics of modern underseas warfare. The trainer will occupy an entire wing of a three story building at the Navy's Submarine School at New London, Connecticut.

During the year the Scout space vehicle, on which Honeywell was contractor to NASA for guidance and control, was successfully fired twice. The test firings proved the effectiveness of the vehicle's simplified, low-cost guidance and control systems.

A variation of the Scout guidance and control system was being built by Honeywell for the Air Force's 609A space vehicle. A similar gyro package is also used in the Thor Delta space vehicle to guide the Delta stage and inject the payload into orbit.

Also in the guidance field, the company disclosed details of the guidance reference system which provides a major portion of the electric brainwork for the first two minutes of flight of the Air Force's Titan Intercontinental ballistic missile. The Titan system is an advanced version of the "strapped down" concept in which gyroscopes are fastened rigidly to the frame of the missile and react according to preset time signals and external guidance commands.

Other important projects which continued during the year at Honeywell include:

Development of the flight control system and the attitude stabilization and control system for the Project Mercury man-in-space capsule. The sophisticated system will control the critical position of the Mercury capsule as it orbits the earth at 17,500 miles per hour and re-enters the atmosphere with the first U.S. space traveler.

Development of a unique instrument for Project Mercury called an Earth Path Indicator. The shoe-box-sized device contains a revolving globe-like replica of earth which shows the orbiting astronaut his position over earth and where he will land if he ejects his capsule from orbit.

Development of inertial guidance systems for Centaur, a space vehicle which will be capable of placing a payload on the moon, or placing instrumented space research and communication satellites in precise orbits ranging from 300 to 22,000 miles. The Honeywell Centaur guidance will be the first all-inertial system developed for space missions.

Development of super sophisticated inertial navigation systems for two complex pilotless surveillance aircraft being built for the Army Signal Corps.

Development of a super-accurate shipboard inertial navigation system for Polaris missile-firing submarines, based on Honeywell's new electrically suspended gyroscope. The only moving part in the new gyro is a beryllium sphere machined to accuracies better than five millionths of an inch.

Development of a new adaptive flight control system for future manned space vehicles. This system is keyed to the complex transition from the use of aerodynamic surfaces in the atmosphere to pure reaction control in space and will be tested on the X-15 aerospace vehicle under the auspices of the Air Force's Wright Air Development Division.

THE NEW YORK AIR BRAKE COMPANY, WATERTOWN DIVISION

THE WATERTOWN Division of The New York Air Brake Company made important strides in the development of hydraulic starter systems for gas turbine engines during 1960. This was a major contributing factor in the expansion of the Company's Stratopower hydraulic pump and motor line.

Hydraulic starting systems offer material advantages in weight, space, cost and reliability in many applications. This is particularly true where the aircraft or missile design incorporates a single hydraulic system arranged to perform the engine starting function as well as supply prime hydraulic power.

The New York Air Brake Stratopower Over-center hydraulic pump design was particularly suited for starter applications, and more specifically, for starter/pump units. The company had these units in limited production in 1960.

The hydraulic starting systems available at year-end were capable of covering the entire range of jet engines. The combination of pump and/or motor characteristics which can be obtained will meet almost any engine requirement.

PACIFIC AIRMOTIVE CORPORATION

DURING 1960 Pacific Airmotive Corporation became the first company authorized by the Federal Aviation Agency to overhaul all commercial turbojet, turboprop and piston engines. Following more than $2.5 million investment in engine, accessory and propeller overhaul facilities, the company's monthly overhaul capablity was 25 JT3-JT4 engines, 25 Rolls-Royce Dart engines, and 100 piston engines ranging from 145-horsepower Lycomings and Continentals up through 3,500-horsepower R4360s.

New turbine engine overhaul contracts were signed during 1960 with Continental Air Lines, Western Air Lines, Qantas, Aloha, West Coast and Northern Consolidated Airlines, accompanied by a comparable increase in piston engine overhaul volume. In addition, The Flying Tiger Line, Inc., awarded PAC the first overhaul contract for Rolls-Royce Tyne engines. This contract, which is expected to exceed $6 million, covers powerplants for the Canadair CL-44 airfreighters to be operated by this carrier. The contract runs for four years from the anticipated receipt of the first Tyne engine by PAC in mid-1961.

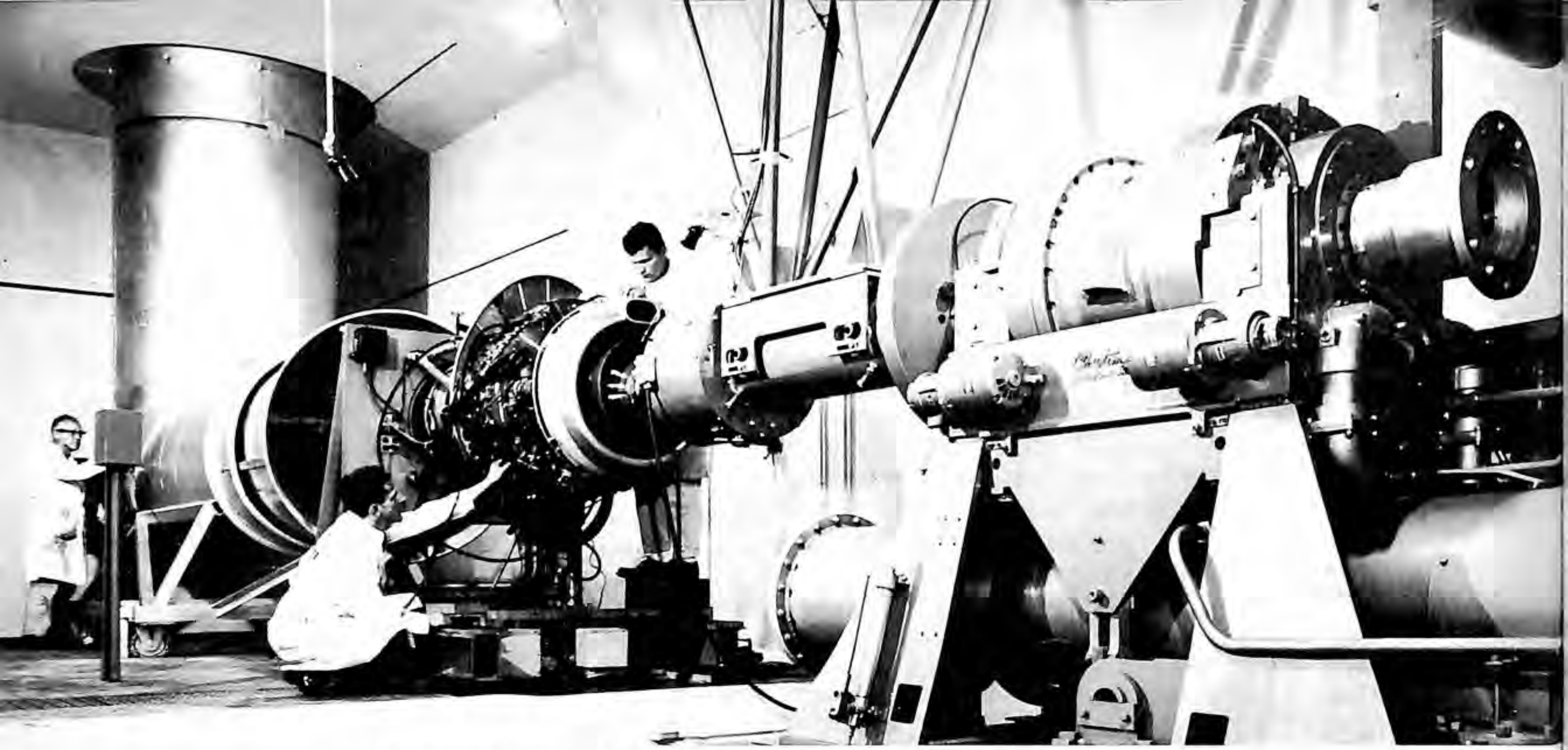
The company's new turboprop test facility that was placed in operation in April to test the Rolls-Royce Dart engine will also handle the Tyne engine as well as American turboprop engines of opposite rotation. Additional tooling and fixtures required to overhaul a minimum quantity of 15 Tyne engines a month will be installed prior to receipt of the first engine from Flying Tigers. Tooling and equipment are also being acquired for the overhaul of the Pratt & Whitney JT3-D series fan engines.

First production Allison propjet-powered Convair conversion was test flown at PAC's Santa Monica plant in January, 1960, representing an important milestone in a joint program with the Allison Division of General Motors to upgrade Convair 340s and 440s to high performance propjet aircraft. FAA certification of the Allison Convair followed three months later, after PAC pilots had completed more than 345 hours of flight testing of the YC-131C military prototype airplane.

The conversion of the twin-engine Convair transport to Allison 501-D13 propjet engines adds 80 miles an hour to the airplane's cruising speed and increases block speeds 25 to 30 percent. Rate of climb at sea level is over 4,000 feet per minute. Twelve Allison Convair conversions were completed for corporate customers during 1960.

Twenty Gruman Gulfstreams were sold by PAC, one of three U.S. distributors of this turboprop-powered business aircraft. Of this total, 13 airplanes received custom interiors and installation of electronic gear at the company's Burbank or Santa Monica plant.

The company's aviation products sales volume, which encompasses the distribution of aircraft replacement parts and rotable spares to



PACIFIC Airmotive Corporation's new turboprop engine test facility.

the commercial aviation market in the western and central United States, increased over 20 percent in 1960. This growth in volume resulted primarily from PAC's earlier efforts to expand its product lines to include new manufacturers furnishing original equipment on the turbojet and turboprop transport aircraft.

Expansion into the general aviation field was accelerated during 1960 with the company representing an increasing number of manufacturers supplying equipment for private, utility and business aircraft. Associate distributors are being appointed in key trading areas to service their local market with the many product lines handled by PAC.

In October, Mid Continent Airmotive Corp., wholly owned subsidiary of PAC, became the exclusive aircraft service operator on the new Jefferson County Airport located 15 miles northwest of Denver, Colo. Under the terms of a 10-year lease agreement, Mid Continent will supply complete aircraft overhaul and line maintenance service to private and business operators at the new airport.

All manufacturing of Spraymat ice protection systems and specialized test and ground support equipment was consolidated in the Flight Support Division at the company's new Culver City plant during 1960. Spraymat applications for the engine air inlet ducts of the NATO F-104s represented an increasing share of this division's production during the latter half of the year, with orders received from Canada, Germany, Belgium and Japan. Another major program covered installation of Spraymat on the wing root leading edges and dorsal air inlet ducts of the North American Sabreliner. Test equipment production included water injection pump test stands for the B-52 and the KC-135. Export shipments of test equipment included deliveries of rotating and nonrotating Skydrol test stands and submerged fuel boost pump test stands to Lufthansa in Germany.

REEVES INSTRUMENT CORPORATION

IN 1960, Reeves Instrument Corporation continued to expand and increase its activities in the missile field, with particular emphasis in the areas of instrumentation and ground tracking equipment.

In August, Reeves completed delivery on a number of air-transportable tracking radars contracted with the National Aeronautics and Space Administration for use in the MERCURY program. These Very Long Range Tracking Radars (VERLORT®), are capable of tracking to a range of 2500 miles. They were assigned to a world-wide net of NASA tracking stations and will follow the manned MERCURY capsules as they orbit the earth.

In 1960, Reeves continued delivery of the high precision three axis pedestals which were designed as mounts for tracking radars used in the DISCOVERER satellite program. The pedestals have an angular tracking accuracy of

0.015 milliradians, made possible through the use of direct drive d.c. torque motors on each axis. Complete servo instrumentation is supplied with the pedestals, which were produced for the Philco Corporation. Reeves was also manufacturing the associated radar electronics, and the entire system will undergo final testing.

Reeves was designing and producing a very large two axis mount for a missile tracking telescope, under contract with Lincoln Laboratory of the Massachusetts Institute of Technology. The telescope will be used to investigate the physical phenomena associated with the very high speed re-entry of nose cones into the earth's atmosphere. The pedestal will mount a 48 inch reflector telescope and spectrographic equipment for recording the energy spectrum of the heat generated during re-entry. A very high order of accuracy will be built into the system, which will have an elevation accuracy of five seconds, and azimuth accuracy of three seconds.

Reeves was also producing a bomb scoring system for evaluating simulated bombing runs of Navy bombers; fuzing systems and components; and subassemblies for a world-wide tropospheric scatter communications system.

In the missile component field, Reeves developed two highly accurate miniature floated gyros for inertial system applications. One of these gyros, identified as the ZERO ONE, has a trimmed drift rate of 0.01 degrees/per hour, and a wheel angular momentum of 300,000 c.g.s. units. Reeves also had in development an inertial gyro measuring only 1.2 inches in diameter, which will have a trimmed drift rate of 0.1 degrees/hour.

A pancake resolver designed for direct gimbal mounting was also produced in considerable quantities during 1960. The resolver has a functional accuracy of ten seconds.

In the computer field, Reeves marketed a full line of transistorized computing amplifiers for analog computer applications. A completely solid state diode electronic multiplier was also developed and produced during the year. The multiplier design is based on the quarter square law principle, and provides a static accuracy of 0.25 volts peak. Eight multiplier channels can be housed in a single 7″ x 19″ rack.

Reeves systems and components found application in a majority of the current missile programs, including Atlas, Titan, Polaris, Regulus, Discoverer, Thor-Able, Bomarc, Terrier, Falcon, Hawk, Sparrow III, La Crosse, Sergeant, and Tartar.

ROHR AIRCRAFT CORPORATION

ROHR'S OPERATIONS through 1960 showed greater emphasis upon research and development, new products and new processes. However, the company's order files continued to show a heavy volume of components of all kinds for both subsonic and high performance military and commercial aircraft.

As a subcontractor manufacturing a wide variety of aircraft, missile and rocket components, Rohr shipped its products to Boeing, Lockheed, Convair, McDonnell, North American, Atlantic Research Corporation, General Electric, U.S. Army arsenals and others.

During the year Rohr produced jet engine pods and power packs for a number of commercial airliners. These included the Boeing 707 series—both turbojets and turbofans—as well as the Convair 880 and the Lockheed Electra. For the Boeing airliners, Rohr also built sound suppressors and thrust reversers, aft fuselage sections, stabilizers and other components. Twin turbojet pods and thrust reversers were designed and built by Rohr for Lockheed's new JetStar executive-military transport.

Military production included manufacture of pods, struts, stabilizers and other components for the Boeing KC-135 jet tanker, pods and struts for the Boeing B-52G and the newer B-52H turbofan version, propjet power packs for the Lockheed C-130B Hercules and the Navy P3V, an ASW version of the Electra. Stainless steel honeycomb sandwich structures were manufactured for the Convair B-58 medium bomber and for the McDonnell F4H-II Navy fighter-interceptor, as well as for North American's Mach III B-70 bomber.

Rohr also manufactured components for the North American Hound Dog missile program, test fins for the Atlantic Research Corporation's Iris sounding rocket, test radiator-condenser assemblies for the Atomics International Division of North American to be used in the Systems for Nuclear Auxiliary Power program, nuclear reactor tubes for General Electric and gun components for the Army's Watervliet Arsenal, among others.

Late in the year Rohr entered a new field of manufacture with formation of an Antenna Systems Division. By adding a team of engineers trained and experienced in this growing field to the company's existing design and manufacturing facilities, Rohr developed capability for production of a variety of antenna structures. Work started under contract on one type

FRED H. ROHR, founder and chairman of the board, supervises operation of new stainless steel honeycomb core manufacturing machine.

of large antenna structure, while another proprietary structure was in the design stage. The new division will handle design, manufacture and installation of fixed detection antennas, as well as troposcatter and tracking antennas and wave guide assemblies.

The company developed and put into production a new machine for the manufacture of higher quality stainless steel honeycomb core material and experimented with a number of new stainless steel sandwich brazing techniques.

In the field of adhesive bonding, Rohr developed several new potential products, among them airborne radar reflectors and wave guide antennas, helicopter blades and rotors and rocket fins. Development work in filament wound pressure vessels also showed promising results.

Manufacturing research also made progress in the fields of high energy forming, developing an entirely new spark discharge forming apparatus now being groomed for production use, and in further utilization of numerically controlled machine tools in the milling of close tolerance, compound-contour parts and tools. Numerical control programming advanced to make possible programming service to other firms, with the addition of a Remington Rand Solid State 80 computer giving greater versatility to the programming facilities.

At the end of the fiscal year, Rohr's production facilities covered 2,081,570 square feet in manufacturing plants at Chula Vista and Riverside, California and assembly plants at Auburn, Washington and Winder, Georgia.

SOLAR AIRCRAFT COMPANY

EARLY IN 1960 Solar became a subsidiary of International Harvester Company. The two companies formed a team with wide ranging capabilities in the aerospace field—especially in ground support and turbomachinery. International Harvester and its associated companies combine experience in the design and manufacture of wheeled vehicle and engines with Solar's experience in the production of aircraft and missile ground support units and electronic systems.

During 1960 a new type of electronic checkout system for gas turbine-powered auxiliary power units went into production at Solar. It may be used in conjunction with a mobile test stand developed by Solar for checking out gas turbine driven auxiliary power and heating units. The testing device, which utilizes a logic computer, will check the complete circuitry of an airborne APU, including all switches, relays and controls, in approximately eight minutes. It will not only locate any source of malfunction, but will indicate how the malfunction may be corrected.

Previously, in the event of a malfunction, an APU had to be removed from an aircraft and replaced with another unit. This process required from 4½ hours to a full day.

In the fall of 1960 Solar's compact Titan gas turbine engine-powered APU's were being installed in the Army's new YHC-1B turboshaft cargo helicopter. The helicopter, produced by Vertol Division of Boeing Airplane Company, was scheduled for test flights late in the year.

A one-man helicopter powered by the Solar Titan engine was put through qualification tests for the Navy during September and October. The gas turbine engine develops up to 80 hp, is 12½ inches in diameter, 25 inches long and weighs 59 pounds.

In the ducting field, Solar designed and manufactured a boundary layer control system for the McDonnell F4H "Voodoo," which makes possible safe, efficient carrier landings. The boundary layer control is achieved by bleeding air from the propulsion engine and directing it at sonic speeds over wing control surfaces. In the case of the F4H, it reduces the landing speed by 10 knots. Made from high strength, heat treated Inconel X, the lightweight system weighs only 98 pounds. It is tested to 172 psig and operates at 778F. Ducting wall thickness is .012 in. A special design feature allows passage of the ducting system through folding wing joints.

In September, one year after it was begun, a new 62,000 square foot engineering and research building was occupied at Solar's San Diego bayfront plant. It was being used to house expanding projects in aerospace and turbomachinery programs.

SPERRY RAND CORPORATION

SPERRY RAND Corporation celebrated the 50th anniversary of a principal division, the Sperry Gyroscope Company, founded in 1910 by the late Elmer A. Sperry through the first practical application of a gyroscope.

The company partially observed the historic milestone by starting construction of an initial 67,000 square-foot facility for the Sperry Rand Research Center. Located on a 150-acre rural hillside, at Sudbury, Mass., just west of Boston, the center will be devoted to broad research in the basic sciences, as well as to the application of design and development advances.

SPERRY . . . LONG ISLAND

High on a long list of achievements during the year was the contribution Sperry's Ships Inertial Navigation System (SINS) made to the success of the Polaris ballistic missile program. Sixteen of these advanced navigation systems were delivered to the Navy by Sperry's Marine Division, 11 for use aboard nuclear subs and test ships.

Capable of precisely sensing and measuring the movement of a vessel, as well as that of the earth over which it is traveling, the Sperry equipment performed with great accuracy and reliability in test after test. In one of these, some 30 miles off the coast of Cape Canaveral, the course of ballistic missilery was advanced when from deep within a submerged U.S.S. George Washington a Polaris was fired successfully from undersea for the first time.

Three major subsystems which comprise the Sperry system are:

1. SINS
2. NAVDAC, a navigation data simulation computer, capable of some 1,000 computations per second.
3. A central control board which "ties" the preceding systems together.

Sperry's Surface Armament Division disclosed that it had been working for almost two years on development of a high-powered target tracking radar transmitter for the Nike-Zeus anti-missile missile system. The radar will be used for tracking the incoming hostile vehicle to obtain data needed for automatically directing the Nike-Zeus against the target.

Another significant achievement was acceptance by Air Force of the huge FPS-35 surveillance radar which Surface Armament developed and erected at Montauk Point, L.I., as part of the nation's SAGE system. Now in operation by the Air Force, the radar feeds position data on all air-breathing missiles and aircraft into high-speed computers which automatically calculate intercept data for air defense systems in the area. Antenna for the system measures 40 feet in height and weighs 80,000 pounds.

Air Armament Division was recipient of another highly-important contract calling for development and installation for the Air Force of a nuclear detonation evaluation system.

Loran-C, an experimental radio navigation system development, was operated successfully in year-long tests by the Coast Guard at ranges up to 2,300 miles with great accuracy. The Office of Naval Research, in an analysis of results obtained by using a Loran-C monitor station 550 miles from the closest and 900 miles from the farthest transmitters, showed that a ship in the area could expect 95 per cent of its "fixes" to be within 800 feet of its actual geographic position.

The Air Armament Division also received extensive new contracts for continued production of navigation-bombing systems for the third wing of Air Force B-58 Hustler bombers. The Sperry equipment enabled a Strategic Air Command Hustler aircrew with only six weeks operational experience to take first place in both high and low level bombing events while participating in the SAC Annual Combat Competition at Bergstrom Air Force Base.

An inertial flight data system designed to guide the X-15 rocket research aircraft through manned probes of the "edge of space" performed excellently in tests of the high-speed vehicle at altitudes up to 136,500 feet, where portions of flight involved "weightless" conditions.

The Sperry division also developed a line of miniature inertial components—floated and fluid-sphere gyros, integrating and direct-reading accelerometers and stable platforms—which are expected to advance performance and reliability standards in missile, space and aircraft systems to new, high levels.

Sperry announced development for Army of a new electronic amplifier to be among radar's most powerful microwave transmitter tubes. The new device, a super-powerful klystron, will increase the capability of the Nike-Zeus anti-missile systems and extend future radars into the new high levels of performance.

The company also announced factory testing of electron tubes capable of supplying 3,000,000 watts of precise radar power. Klystrons of the series—operating in frequency bands above four billion cycles per second—now are being used by all services in radars to control, guide and track supersonic missiles.

Sperry scientists developed a new "electron gun" that removes one of the basic obstacles to extension of radar power. The development, which can supply electron beams of more than 200 million watts power and 100 amperes current, is being used to increase the capability of large missile guidance radars and anti-missile systems.

Sperry scientists also successfully employed a "fourth state of matter," called "gyro-electric plasma," to form for the first time a practical electronic circuit. Plasma, which is neither liquid, gas nor solid, consists of electrically charged parts of atoms which can both create and inter-react with electric and magnetic forces.

Also announced were several electronic devices capable of handling information at a rate 30 million words per second. The development may make possible the transmission of a 30-word message in a millionth of a second, a complete message on a single radar pulse.

A means of greatly extending the speed and altitude limits of lightweight, inexpensive jet engines by combining them with pyrophoric fuel afterburning systems was announced by Sperry's Aeronautical Equipment Division. Successful tests of unique afterburner controls enabled engineers to employ these exotic fuels —a group of fast-burning liquids which ignite on contact with air—in the afterburner of a standard jet engine.

SPERRY ELECTRONIC TUBE DIVISION

Sperry Electronic Tube Division at Gainesville, Fla., developed a new variant of the reflex oscillator klystron which eliminates the need for expensive repeller-tracking potentiometer and linkage normally required for other designs. Development will permit great reductions in cost, weight and size while increasing reliability in airborne and missile applications.

SPERRY PHOENIX COMPANY

Sperry Phoenix Company at Phoenix, Arizona, considerably expanded its engineering and manufacturing capacity, in 1960.

The company passed a major milestone during the year with its announcement of a Microwave Aerospace Navigation (MAN) system, capable of taking automatic ground control of manned or unmanned spacecraft returning to earth and landing them by remote control. The MAN system, which grew out of pioneering Sperry activity in the fields of microwave command guidance of pilotless aircraft, is believed to be the first capable of acquiring control of returning spacecraft at great distances and guiding them precisely throughout the high speed earth-approach and landing.

Also significant were Sperry Phoenix programs to remotely control the largest unmanned bomber ever flown, the multi-jet B-47, and the fastest jet ever "droned," the F-104 fighter. Working jointly with Lockheed Aircraft Corporation in both instances, Sperry developed specialized equipment to stabilize, guide and control the high performance jets for a variety of missions, including realistic tests of the nation's air and missile defenses.

Unique automatic pilot systems—tailored to the special needs of a new generation of commercial transports, private and business planes —received Federal Aviation Agency approval and were placed in service during the year. Sperry's SP-30 system for jet transport began regular service on global routes of 18 major air carriers.

The company also began volume production of the SP-3 system for private and business aircraft—single engine planes and light-to-medium twins. The SP-3 equipment, which affords a unique "building-block" approach to automatic flight, may be installed in varying combinations to give users any desired degree of airborne automation.

Additionally, its new SP-40 system moved into production for upcoming series of piston and turbine-powered transports, including the Lockheed JetStar.

The Sperry concept of universality in automatic pilot equipment—the design of a single set of components for use in all types of aircraft—was solidly proven during the year during successful flight tests of the AN/ASW-12 (V) system for Army aircraft. The ASW-12 (V) system, known as the Universal Automatic Pilot, already has been employed in H-21 and S-55 helicopters and in L-23 and AO-1 fixed-wing craft.

Developmentally, Sperry Phoenix engineers pressed forward a series of programs to make possible fully automatic landings of transport-type aircraft, including jets, on a practical basis

—also newer, more accurate aircraft compass and gyro systems and specialized air data equipment required to meet continuously increasing demands of accuracy and reliability. The company also readied itself technically to supply self-adaptive, or self-optimizing, automatic controls of various types.

SPERRY UTAH ENGINEERING LABORATORY

A $2 million facilities expansion of 108,000 square feet of Sperry Utah Engineering Laboratory in Salt Lake City was major news as the Utah division geared for full-scale industrial production of the Army's Sergeant missile, scheduled to begin early in 1961. Production of the Sergeant during 1960 was primarily for test purposes.

Highlight of the year was an Army revelation that Sergeant has been 100% reliable in test firings to date. The Army disclosed that in about two score test firings of the Sergeant every missile fired successfully.

The solid-fueled Sergeant will replace the liquid-fueled Corporal, now deployed with American and NATO forces throughout the world. Highly mobile and easy to operate, the Sergeant approaches conventional artillery in speed of emplacement and displacement. It can be removed from its containers and assembled for firing on its transportable erector-launcher in a matter of minutes.

SPERRY SEMICONDUCTOR DIVISION

In its newly-built plant in Norwalk, Conn., the Sperry Semiconductor Division increased its production capabilities, incorporating the latest techniques in mechanized production and testing of semiconductors for missiles and ground support equipment. Two major semiconductor devices were introduced during 1960; germanium tunnel diodes and silicon mesa transistors.

FORD INSTRUMENT COMPANY

Following highly-successful production of inertial systems for both Redstone and Jupiter, Ford Instrument Company this year was deep in manufacture of control components for Project Mercury.

An Air Force contract was awarded to Ford Instrument to build and test an experimental model of a radically new airborne inertial navigation system. Designated the AN/AJN-7, the new system does away with the conventional "stable platform" of inertial navigation systems. Its computer, known as "Fordac," is an all-solid-state unit.

SPERRY's AN/FPS-35 surveillance radar.

A second computer, which was developed by Ford Instrument under a supplement to the original AN/AJN-7 contract, was a new solid state digital computer that combines incremental and DDA (Digital Differential Analysis) techniques. The computer—nicknamed "Poco" from "POsition COmputer"—will combine the output of "Fordac" with information from vehicle sensors to compute the position of the vehicle with respect to the earth.

Ford Instrument received a contract from Bulova to develop and produce a fuzing device for the Army's newest missile, the PERSHING.

Other completed activities in this field include safety, fuzing and arming devices for atomic weapons, and the fuzing device for the JUPITER missile.

The New York company also received additional orders in excess of $20 million from the Air Force for its latest development of the Automatic Navigation Computer AN/ASN-7.

Methods for airborne interpretation of information received from the most commonly used types of reconnaissance sensors—photographic, radar and infrared—also were being developed for Air Force. Engineers were devising methods for combining data from two, and possibly all three, of the sensors to provide a display which contains more information than any sensor alone provides and which can be interpreted rapidly and accurately.

Utilizing existing interrogator-responder-type beacon equipment, a system designed to augment present air traffic control facilities, both civilian and military, was evaluated in tests this year. In addition to offering speed and accuracy for air traffic control the system is readily adaptable to military IFF needs.

The year also marked field testing of the Ford's Flight Control System, Surveillance Aircraft AN/UPW-1. This is a new remote control system which can send Army surveillance drones on intelligence-gathering missions far behind enemy lines.

REMINGTON RAND UNIVAC

Remington Rand's Univac Military Division, in cooperation with Bell Telephone Laboratories and Western Electric Co., built the target intercept computer for ground guidance of the Army's Nike-Zeus anti-missile missile. TIC was undergoing tests at White Sands, N.M. and in 1961 was scheduled to guide a battery of Nike-Zeus missiles fired from Kwajalein Island in the South Pacific against Atlas missiles launched from Vandenberg Air Force Base in California.

The Division's initial partnership with Air Force resulted in the design, development and production of several Bomarc computers for command guidance of the Bomarc missile. Design features of the computer include special scanning equipment, analog-to-digital conversion abilities, and output equipment to feed directly into a data link transmitter.

The Univac Athena ground guidance computer never failed to function perfectly in more than 20 firings of the Titan ICBM following a series of guidance tests using Thor-Able missiles. Its reliability record of 99.99 established a new standard for digital computers of its type.

The same machine was programmed to place the Tiros weather satellite and the Echo passive communications satellite into the most nearly perfect circular orbits ever achieved by any satellite, Russian or American. These shots, an upcoming lunar probe, and subsequent space efforts were all under the supervision of the National Aeronautics and Space Administration.

VICKERS, INCORPORATED

At Vickers, Incorporated, additional emphasis was placed on the development and production of equipment for missiles and spacecraft. The company demonstrated its unusual capability by supplying new and improved auxiliary power systems (APS), servo systems and various cooling systems for most major U.S. missiles and rockets.

Various types of power systems, put in production or under development, covered a broad range of power requirements. Hot gas engines delivered to prime contractors covered such diverse applications as gun drives and nuclear warhead arming equipment. One hot gas servo system under development will be used for stabilization and orientation of the upper stages of light space vehicles. Over 100 hours of testing were completed on a hydrogen-oxygen engine demonstrating the lowest specific fuel consumption of any known chem-dynamic engine.

This engine was targeted for use in more advanced space vehicle auxiliary power systems. Vickers was selected to supply the APS for this country's newest air-to-ground ballistic missile, Skybolt, and also was producing power units that actuate the exhaust deflectors used for directional control of all three stages of Minuteman.

A new acceleration switching (time dwell) servo valve was released that permits tighter servo loop control than proportional valves, has unusual contamination tolerance, and is relatively insensitive to temperature change. To acompany this, Vickers developed a solid-state pulse synch generator needing no external power supply, that adapts the output of a normal servo amplifier to the acceleration switching valve. The first a-c servo valve for high temperature environment and with nuclear radiation tolerance is being developed under contract. Late in the year, a miniature version of Vickers "Spacemaster" servo valve was released. This is the smallest servo valve known to be available, and weighs 3.5 ounces.

Vickers also released during the year its contaminant-tolerant fuel pump. This was specified for seven light turbine engines manufactured by Pratt and Whitney, Continental, Boeing, Solar and General Electric.

SUNDSTRAND CORPORATION

IN AUGUST, 1960, Sundstrand integrated the operations of the Turbo division at Pacoima, California, into the Denver organization of the Aviation Division. The branch facilities at Phoenix, Arizona, were also relocated. Pacoima continues as the engineering test laboratory for the aerospace programs at Denver. With essentially the same or a slightly larger volume of advanced research programs compared to 1959, this consolidation provided increased efficiencies in operations.

SUNDSTRAND AVIATION-ROCKFORD

In May, 1960, Sundstrand Aviation announced its new starter drive at an Aircraft Electric Power Systems conference held in Rockford. A 40 kva mock-up system was demonstrated in the laboratory, typical of the 800 operations simulated on its inertia wheel test stand. This new concept in aircraft engine starting and electric power generation has been selected for use on the Boeing 727. It provides electrical starting of an aircraft jet engine with the same equipment used for in-flight power generation. New design concepts employed have more than doubled the time between overhaul, improved equipment reliability, and resulted in lower overhaul costs.

Through extensive record keeping and accurate determination of statistical reliability on 2,500,000 in-flight hours of airline drive operation, Sundstrand achieved the highest reliability yet attained for commercial constant speed drives, and thus increased the time between overhaul for these products too.

On the military side, Sundstrand was selected as the drive supplier for the Navy's P2V-7 electric power system retrofit program. This drive has an integrally mounted reservoir and cooler, and provides 400 cps over a 4:1 input speed range. A product development contract was received from the Air Force in 1960 for Sundstrand's new cartridge-pneumatic starter, first announced in 1959. Qualification testing has been completed for the B-52H, which included 400 cartridge and 800 pneumatic starts.

The reinstatement of the B-70 to a weapons system substantially stepped up the tempo of Sundstrand's activity in this program. Work was accelerated on the secondary power generating system constant speed drive and gearbox designs.

SUNDSTRAND AVIATION-DENVER

Several major awards from both the Air Force and the Navy made Sundstrand Aviation-Denver a major supplier of power generating systems and reaction control systems for missile and space vehicles. Among the Air Force contracts under development at Denver were a 15 kw solar mechanical engine, a solar regenative fuel cell, a low temperature cryogenic integrated thermal control system, a hydrozine APU, and an electrostatic generator. For the Navy, Denver was developing a torpedo propulsion system and a ram air turbine driven actuator system. These systems will find application on such aerospace projects as Apollo, Saint, a military test space station, DynaSoar, a recoverable booster, the Saturn S-4 stage, Polaris, and a soft lunar landing program.

Nonmilitary development programs included pumps for oil field production, petrochemical processing, and boosters.

THOMPSON RAMO WOOLDRIDGE INC.

THOMPSON Ramo Wooldridge Inc. continued to make significant progress as a major contributor of subsystems and components for the aircraft, missile and space fields during 1960.

About mid-year, reorientation of contractual relationships with the Air Force were concluded by Space Technology Laboratories, TRW's subsidiary. This established STL's status as that of any prime contractor to the Air Force.

Under the agreement, such in-house functions for the Air Force as advanced systems planning, technical staff assistance or administrative support were transferred from STL to the nonprofit Aerospace Corporation, which was formed under Air Force management.

STL continues to provide systems engineering and technical direction for the Atlas, Titan and Minuteman programs, and both STL and the parent company are free to compete for contracts related to new missile programs and space projects without being subject to special procedures which previously had applied.

In addition to the role that STL performed as a principal contractor in the Air Force program which brought into being United States operational intercontinental ballistic missiles in five and a half years since the beginning of the special ballistic missile program, the TRW subsidiary also had an important part in many of the space projects accomplished by the cooperative efforts of the military services and the National Aeronautics and Space Administration during the past two years.

A major space exploration milestone was achieved on March 11, 1960 with the successful launch of a satellite, Pioneer V, into solar orbit. A true interplanetary satellite, Pioneer V explored space and maintained communication with earth over a greater distance than any previous spacecraft. Now in permanent solar orbit, Pioneer V reached its perihelion of 74.9 million miles from the sun and 46 million miles from earth on August 10, 1960. Pioneer V sent back previously unknown data about the fundamental nature of the solar system and space itself, information essential to manned space flight.

In addition to assembling and testing the second, third and fourth stages of Pioneer V, STL built important instrumentation and guidance control subsystems for the second and third stages of the satellite. It also designed and built the fourth stage. STL directed and controlled the testing and launching of this satellite and operates the worldwide tracking network used to command and receive data from satellites.

After achieving its free competitive status, STL won a major competition and was selected as one of four companies to conduct a study leading to the "soft" landing of a space craft on the moon for the purpose of sampling lunar physical environment and transmitting data back to earth and was awarded a NASA contract in excess of $15,000,000 for 060 (orbiting Geophysical Laboratory).

October witnessed the 100th successful flight of the Thor ballistic missile, for which STL provided systems engineering and overall technical direction of the R&D phase. Thor had boosted 18 satellites into space.

Meantime the Tapco Group of TRW was consolidating its position in the aircraft components field and moving aggressively forward in engineered products and new concepts for missile and space applications.

The jet engine airfoils and components segment of TRW's manned aircraft business was at a higher level than at any time since the shift of procurement emphasis from aircraft to missiles. Improved manufacturing efficiencies enabled Tapco to move into a leading position in this area.

TRW continued as a supplier of fuel pumps to almost every major military and commercial aircraft flying today and had a contract to provide high-temperature booster pumps for North American's B-70 bomber program.

Under a separate contract Tapco's West Coast Engineering Laboratory built a simulator, the only one of its kind in the United States, for testing the complete B-70 fuel system.

A leader in the field of secondary power systems for missiles, during 1960 TRW produced electromechanical and hydraulic components for advanced versions of the Terrier and Tartar missiles, moved toward production phase on an auxiliary power system for the Bomarc missile and neared completion of the development program on the Tapco-designed "Miniaps" miniature turbo-generator.

Notable, too, were the development of a variety of subsystems under contracts with NASA, the Atomic Energy Commission, and Wright Air Development Center, for space applications.

Chief among these was a contract awarded by NASA for "Sunflower I," a solar auxiliary power system for space vehicles, designed to generate 3,000 watts of electrical power for a minimum of one year, using the sun's heat to boil and vaporize mercury which in turn will drive turbo-electric machinery to produce electrical power.

Others included Snap II, a power conversion system using a small nuclear reactor as the energy source, a "helionic" converter which will convert the sun's rays directly into electricity, regenerative fuel cells for space and ground applications, a unique approach to magnetohydrodynamic power generators, an oxygen regeneration system for manned space vehicles, and a radiation-cooled motor capable of operating in 1000 degrees Fahrenheit ambient temperature.

In the area of ground support equipment, TRW's Tapco Group made a contribution to the Army's Martin-built Pershing solid propellant missile. TRW designed and built the transporter-erector-launcher which gives Pershing maximum mobility and rapid reaction time. It operated successfully in all Pershing test launchings.

Pacific Semiconductors, Inc., another TRW subsidiary, continued production of high quality silicon semiconductor devices for missile and other military electronic systems. Specific component developments included a giant water-cooled silicon transistor. Developed under an Air Force contract in 10, 20, 50 and 100 ampere versions, the smallest units delivered in excess of 100 watts output at 10 megacycles. Another was the Psi Microdiode. With a packing density of 20,000,000 per cubic foot, it provided designers with a new concept of systems micro-miniaturization.

WYMAN-GORDON COMPANY

ENGINEERING PROGRAMS in the Eastern Division plants of Wyman-Gordon Co., that in Worcester, Massachusetts and the Air Force plant it operates in Grafton, Massachusetts, continued to develop forging capability with materials and configurations required for advanced propulsion systems, missiles and space vehicles.

A capability was being developed for a broad range of materials; beryllium, titanium alloys, nickel base alloys, refractory metals, and low alloy and stainless steels in addition to the light alloys.

Component requirements were anticipated in the following areas: *Re-entry and Space Vehicles:* Shields, shield supports, shells, structural components, leading edges, and landing gear components; *Missile Frames and Guidance Systems:* Structural components, pressure bottles and guidance components; *Solid Propellant Rocket Motors:* Domes and closures, cylinders and nozzle components; *Liquid Propellant Rocket Engines:* Turbopump components; *Nuclear Rocket Motors:* Reactor components and auxiliary components.

Nearly all beryllium components are produced starting with metal powder which is consolidated either by vacuum press sintering into a block or by press forging into a shape. The beryllium powder process used by Wyman-Gordon Company differs from most conventional powder-metallurgy processes in that (a) high compacting pressures are used simultaneously within the range of the sintering temperatures, (b) the cycle time is very short, and (c) plastic deformation or forging occurs during the latter part of the cycle.

Hollow conical frustums, domes, guidance components and pancakes have been successfully forged. Size of forgings has ranged from ½ lb. to 300 lbs., from 20 square inches to 1,000 square inches in projected area. Forging capability exists beyond 4,000 square inches.

Large extrusions, weighing over 150 lbs. have been made in development with limited success. More development is required. Parts have been forged successfully from press-sintered material contained in steel. Procedures have been developed for working beryllium, without being canned, below 1500°F where rapid oxidation occurs.

At Grafton, the company had a completely integrated in-house production capability for producing beryllium forgings from receipt of powder to delivery of completely tested, rough machined components.

At a yield strength of 180,000 psi, the all-beta B120VCA titanium alloy offers designers a material with a yield strength/density ratio of 1,000,000 inches. This strength level is equivalent to steel at 290,000 psi.

Two methods were being used to produce solid rocket motor casing domes and closures in B120VCA. In one method, a billet is upset into a pancake which is drawn through a draw ring to produce the dome. In a second method, the dome is close-die forged.

The forging designs provide material for integral igniter and thrust termination bosses and attachment skirts, eliminating or extending welds from highly stressed areas.

Continued development work with B120VCA in domes offers growth potential in yield strengths up to 200,000 psi with elongation of up to five per cent. Work was also being conducted in other areas to demonstrate property response in irregular shapes and in heavy sections. Another development was the extrusion of B120VCA into a 25 inch long x 5.8 inch diameter tube. Results of this effort indicate that scale-up to much larger diameters is feasible.

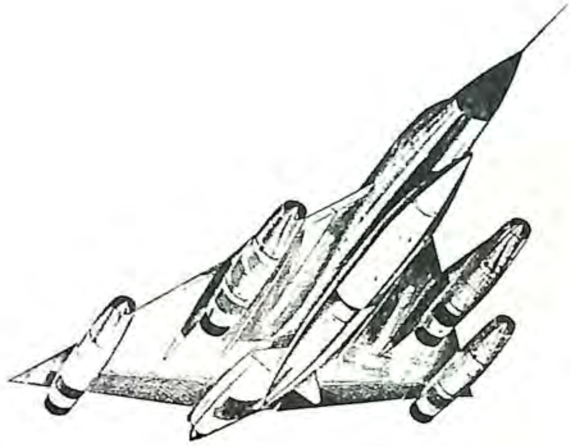
The nickel base superalloys are the ranking alloys between 1200°F and 1800°F for short time tensile strength and for long time creep-rupture strength. Astroloy forgings up to 1,000 lbs. and Waspaloy forgings up to 1,600 lbs. were produced to guaranteed properties.

The nickel base alloy forgings were developed as a group at Wyman-Gordon through a total effort involving induction vacuum melting, casting, forging and heat treatment studies. Continuing work is concerned with the forging of these alloys in structural shapes for use in manned aircraft and vehicles, and the design and forging development of advanced alloys. Forgings beyond the present 50″ diameter property guarantee limit are being proposed.

The refractory metal forgings: group includes tungsten, tantalum, molybdenum and columbium in order of melting points and therefore potential usefulness for temperature applications above 1800°F in advanced propulsion units and vehicles. Molybdenum forgings for solid rocket motor nozzles are in production. Tantalum and tantalum-tungsten alloys have been forged on a development basis.

Steel forgings offer high strength at relatively low cost, and great flexibility in heat treatment. The major use in missiles has been for solid rocket motor casings where strength/weight ratio, fracture toughness and fabricability are the primary criteria for materials selection. Closures were being forged in vacuum melted low alloy steels such as H-11, 300M and D6C. These forgings exceed the present specification requirements for minimum .2% yield strengths of 220,000 to 230,000 psi with 8% elongation. The design philosophy of integral bosses and attachment skirts originated with the steel casings.

Large structural steel forgings, such as frames and pylons were being made for advanced aircraft. The largest was SAE 4335, 98 inches long, 11 inches wide, weighing approximately 1100 pounds. A 17-4 PH semi-austenitic stainless steel "U" shaped frame 44 inches wide by 32 inches high is also being produced. Another type of forging experience is with components for the nuclear power industry. ■



MILITARY AVIATION

DEPARTMENT OF DEFENSE

IN THE WANING DAYS of 1960, President-elect John F. Kennedy started naming the men who will direct the activities of the Department of Defense under the new administration.

First to be named was the new Secretary of Defense, Robert S. McNamara. McNamara was previously president of Ford Motor Company.

Roswell L. Gilpatric, chairman of the board of Aerospace Corporation, was nominated to be Deputy Secretary of Defense.

Paul H. Nitze was named Assistant Secretary of Defense for International Security Affairs.

Other Kennedy appointments:

Secretary of the Navy: John B. Connally, former Naval officer and Texas attorney.

Secretary of the Army: Elvis J. Stahr, Jr., former president of University of West Virginia.

Secretary of the Air Force: Eugene M. Zuckert, Washington attorney and former member of the Atomic Energy Commission.

Director of Research and Engineering: Dr. Herbert H. York, who was appointed to the office on December 24, 1958, was asked to continue as director for an indefinite period under the Kennedy administration.

At the end of 1960, top members of the secretariat included:

Secretary of Defense: Thomas S. Gates, Jr.

Deputy Secretary of Defense: James H. Douglas

Secretary of the Navy: William B. Franke

Secretary of the Army: Wilber M. Brucker

Secretary of the Air Force: Dudley C. Sharp

In a major change of the military staff, General Nathan F. Twining, USAF, retired as Chairman of the Joint Chiefs of Staff. He was succeeded, on October 1, 1960, by General Lyman L. Lemnitzer, USA.

General George H. Decker succeeded Lemnitzer as Chief of Staff, U.S. Army. Admiral Arleigh A. Burke served throughout the year as Chief of Naval Operations and General Thomas D. White continued as Chief of Staff, U.S. Air Force.

Early in the year, General David M. Shoup succeeded General Randolph McC. Pate as Commandant of the Marine Corps.

Robert S. McNamara
Secretary of Defense

Roswell L. Gilpatric
Deputy Secretary of Defense

Paul H. Vitze
Assistant Secretary of Defense

Eugene M. Zuckert
Secretary of the Air Force

John B. Connally
Secretary of the Navy

Elvis J. Stahr, Jr.
Secretary of the Army

Gen. Lyman L. Lemnitzer
Chairman, Joint Chiefs of Staff

Gen. George H. Decker
Chief of Staff, U.S. Army

Gen. David M. Shoup
Commandant, U.S. Marine Corps

DEPARTMENT OF DEFENSE SUMMARY OF MAJOR MILITARY FORCES

DEPARTMENT OF THE ARMY

	June 30 1955	June 30 1956	June 30 1957	June 30 1958	June 30 1959	June 30 1960
Divisions	20	18	18	15	15	14
Regiments	12	10	9	5	5	5
Army Air Defense Battalions	122	133	118	90	85	80¼
Active Aircraft Inventory	3,539	3,573	4,447	5,027	5,199	5,493

DEPARTMENT OF THE NAVY

	June 30 1955	June 30 1956	June 30 1957	June 30 1958	June 30 1959	June 30 1960
Commissioned Ships	1,030	973	967	891	860	812
Warships	402	404	409	396	386	376
Other Ships	628	569	558	495	474	436
Fleet Carrier Air Groups	17	17	17	17	16	16
Other Fleet Combat Air Squadrons (Patrol, Mining, Continental Defense, etc., excluding carrier anti-submarine squadrons)	44	48	49	48	47	47
Carrier anti-submarine squadrons	19	19	20	22	22	31

MARINE CORPS

	June 30 1955	June 30 1956	June 30 1957	June 30 1958	June 30 1959	June 30 1960
Divisions	3	3	3	3	3	3
Marine Aircraft Wings	3	3	3	3	3	3
Active Aircraft Inventory (Navy & Marine Corps)	12,821	12,317	11,617	10,533	9,649	8,863

DEPARTMENT OF THE AIR FORCE

	June 30 1955	June 30 1956	June 30 1957	June 30 1958	June 30 1959	June 30 1960
Total Wings	121	131	137	117	105	96
Strategic	46	51	50	44	43	40
Air Defense	29	32	32	28	27	23
Tactical	46	48	55	45	35	33
Troop Carrier	13	13	15	13	11	11
Active Aircraft Inventory	23,694	26,760	25,969	22,578	20,890	18,712

The 1960 year in Defense was markedly similar to the preceding year, with a high level of activity in all areas and particularly in the field of research of development. Missile forces were considerably strengthened during the year as new types reached operational status and the de-emphasis in manned aircraft was slowed with a decision to continue with a major supersonic bomber program.

The Department's expenditures for the fiscal year 1961, which started July 1, 1960, were estimated at $41.5 billion, a slight increase over the previous fiscal year's expenditures, which amounted to $41.2 billion.

New obligational authority for fiscal 1961 was $41,385,000,000, compared with $41,058,000,000 in fiscal 1960.

As of June 30, 1960, military personnel on active duty totaled 2,476,435, broken down as follows: Army, 873,078; Navy, 617,984; Air Force, 814,752; Marine Corps, 170,621. The total was approximately 28,000 fewer than the previous year, with slight reductions in Navy, Air Force and Marine personnel and an increase of 11,000 in the Army total.

Civilian employes working for the Department of Defense totaled 1,047,120 as of June 30, a slight reduction from 1,078,178 the previous year. The 1960 total was broken down this way: Army, 390,046; Navy, 347,760; Air Force, 307,449; Office of the Secretary of Defense, 1,865.

To the left is a summary of the major military force levels, as of June 30, 1960, with comparison data for the preceding five years: ■

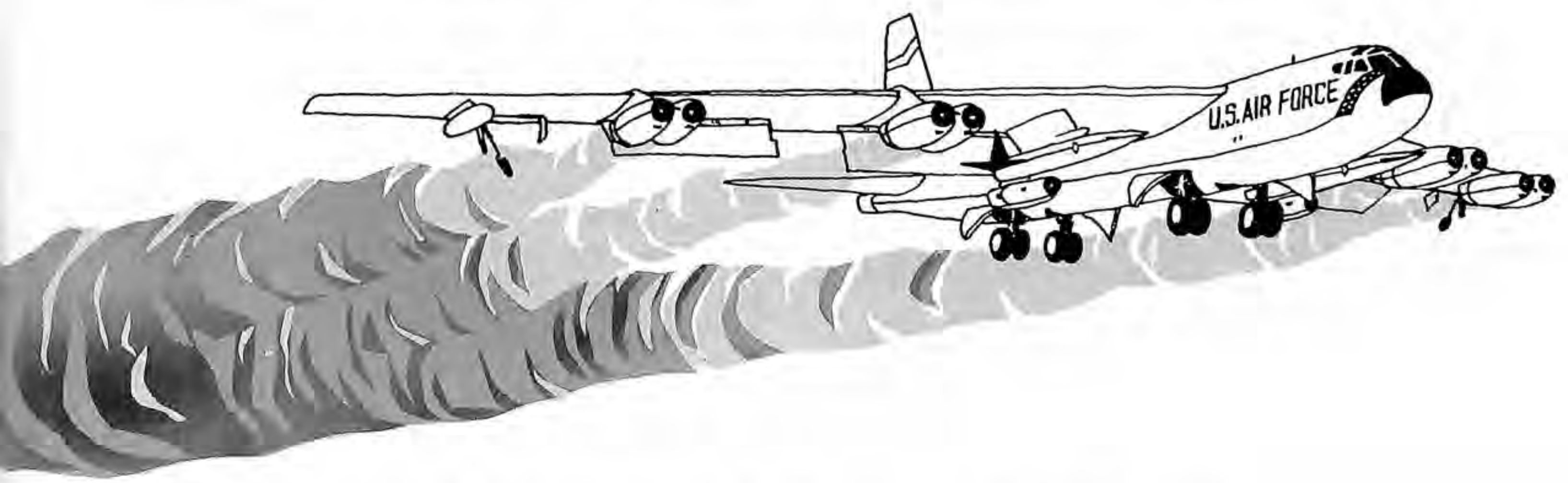
AIR FORCE

THROUGH 1960, the Air Force continued to advance rapidly in the related fields of space and missile technology. In November 1959, the Department of Defense transferred the Discoverer, Midas, and Samos projects from the Advanced Research Projects Agency to the Air Force. Again, in February 1960, it shifted a number of space studies to the Air Force.

A notable achievement in astronautics occurred on August 11, 1960 when the capsule of Discoverer XIII was successfully recovered after being ejected from outer space. On August 19, 1960, an Air Force plane recovered the capsule of Discoverer XIV in a spectacular midair catch over the Pacific near Hawaii. The data obtained from these capsules will aid greatly in the research on the Midas and Samos satellite programs.

In August 1960, the Echo II satellite was put into orbit by NASA and USAF. This satellite is a passive transmitter that reflects radio waves beamed at it, thus opening the threshold to better communication networks. Although there was some doubt as to the life expectancy of Echo II, it enabled broadcasts beamed from the east coast of the United States to be received in California.

On October 13, 1960, two mice successfully rode an Air Force Atlas 5,000 miles through space. In reaching an altitude of 650 miles the mice passed through the radiation belt before returning to Earth in good condition. Neither the cold of space nor the heat of reentry into the atmosphere harmed the space travelers in



SAC's B-52G missile platform bombers carry two Hound Dog missiles.

any way. This test opened the way for a new series of rocket tests with animals, initially monkeys.

In preparation for the effort to put a man in space, two USAF volunteers remained in a simulated space cabin for over 30 days. Although the tests were performed under the same physical conditions that future space travelers will face, the mental stress was not as severe. The tests turned out exceedingly well with no personality clashes.

On August 27, 1960, Capt. Joseph Kittinger of the Air Force made a spectacular parachute jump of 102,800 feet (19 miles) to test the effects of a high altitude jump. In proving that a bailout from high altitude aircraft is quite possible, Captain Kittinger suffered no ill effects from his long fall.

A nuclear aircraft about the size of a B-52, now on the drawing board, may be the forerunner of a whole new era in aviation. Powered by an atomic engine, it will be equipped with two jets for take-offs and landings. Although this first nuclear aircraft will be a test vehicle, it will be able to sustain independent flight for very long periods of time, but its speed will not measure up to the speeds of many of our present jet bombers.

In August 1960, the rocket-powered X-15, an experimental manned aircraft designed to reach the outer fringes of the earth's atmosphere, streaked across the Mojave Desert at a speed of 2160 miles per hour for a new speed record.

The Strategic Air Command reached the goal of one-third of its bomber-tanker force on 15-minute ground alert in May, 1960. Funds for an airborne alert of one-eighth of the force became available in August 1960. In addition, the dispersal of the striking force over a larger area proceeded on schedule. The B-47 is still the backbone of SAC although it is now being replaced with the B-58, which can attain speeds of Mach 2. In March 1960, the first B-58 wing was activated and deliveries to the wing began in August. In addition, new deliveries of the jet KC-135 tankers raised the number of these aircraft beyond 300.

SAC began a study in June, 1960, of the use of air bases of other commands and civilian airports for the periodic deployment of B-47's. These procedures would necessarily improve the survivability of the nation's deterrent air arm in the event of attack.

The Mach 3 intercontinental B-70 bomber,

which had been down-graded in priority by budget cutbacks in 1959, was given greater emphasis in September 1960 when additional funds were made available for its development. The Air Force hoped to invest $1.5 billion in the B-70 over the 1961-65 period. This will give it a weapon capable of delivering a bomb load at supersonic speed, yet subject to recall in case a change of situation should develop.

In the search for better weapons, SAC conducted operational tests of the GAM-77 Hound Dog and GAM-72 Quail missiles. These air-to-ground missiles will be carried by the B-52 and the B-58.

In addition to the Atlas ICBM base at Vandenberg AFB, Calif., in May, 1960, an Atlas base became operational at Francis E. Warren AFB, Wyoming. The total number of selected ICBM bases reached a total of 20, of which three were near completion. Every effort was being made to give these bases maximum protection by dispersal and hardening techniques, and, for the Minuteman, use of mobile railroad launchers.

IRBM's—Thors and Jupiters—were turned over to allies for mutual defense and were being based in England, Italy, and Turkey.

A new communication system helped improve the SAC control system. The new single-side-band ground-to-air radio system known as SHORT ORDER went into interim operation in March, 1960, and became fully operational in October, 1960. This system provides instant

THE AIR FORCE'S supersonic B-58 with two-component pod.

voice communication between the SAC command post and combat aircraft in flight.

Although tactical air components—Tactical Air Command, U.S. Air Forces in Europe, and Pacific Air Command—declined slightly in unit strength, the addition of new weapon systems promised to more than offset this. Deliveries began in February, 1960, of the new F-105 fighter that will eventually replace the F-100 Supersabre, TAC's first-line fighter.

TAC arranged for the use of SAC's KC-135 jet tankers in connection with emergency TAC deployments overseas. The use of jet tankers will permit speedier and safer refueling of TAC's planes, thereby reducing the reaction time of composite air strike forces in time of emergency.

TAC was converting its Matador missile groups to the TM-76 Mace, which has improved guidance and range. Two USAFE groups completed the conversion in March, 1960, and became fully operational. More groups were to be converted later.

In order to test and perfect the capabilities of the USAF tactical air forces, several large-scale test exercises were carried out. Operations Spearhead, Quick Span, Mobile Yoke, and Banyan Tree II were examinations of TAC's support, deployment, and combat capabilities that answered questions of military significance.

Air Defense Command reoriented its major programs in March, 1960, after a thorough review showed that many planned programs would be completed too late to be of adequate service. Accordingly, more emphasis was placed on the existing interceptor force and the development of ballistic missile warning systems. Programs were under way to improve and extend the communication system of the DEW Line as well as converting the circuits of U.S. Navy picket ships to a single side band. The BMEWS site at Thule was completed and placed in operation. The second BMEWS site at Clear, Alaska, was nearing completion, and agreement was reached with the United Kingdom for construction of the third site at Fylingdales, in Yorkshire.

Eight of the Air Defense Command's Bomarc sites were dropped. This reduction left eight Bomarc A and B sites in the United States and two Bomarc B sites in Canada.

ADC's fighter-interceptor force improved the quality of its equipment during 1960, all but a few of the squadrons having century-series aircraft—F-101's, F-102's, and F-106's. The F-106 and F-101B were operationally tested by ADC and ten new squadrons of each were activated. ADC also used B-57's, equipped with electronic countermeasure equipment, for training purposes in detection and interception.

The bulk of the MATS transport fleet was eight to ten years old. Because of this, MATS would have difficulty meeting requirements for strategic airlift. To alleviate this deficiency, Congress appropriated $40 million for the development of a high speed, turbine-powered cargo plane. Another $194 million was also authorized to provide for procurement of interim aircraft such as C-130E's and a cargo version of the KC-135.

In addition to modernizing the MATS fleet, the Air Force decided to further increase its airlift potential by making greater use of civilian carriers. This plan will not only help the military during peacetime, but it will also better prepare civilian carriers to be of service in time of emergency or war.

From March 14 to 28, 1960, MATS joined with the Continental Army Command in carrying out its largest peacetime strategic airlift—Operation Big Slam/Puerto Pine. This airlift proved that MATS could accelerate from peacetime to wartime utilization of aircraft in a short time and also demonstrated that the airlift of large quantities of troops and supplies could be conducted even under poor weather conditions. But it showed, too, the limitations of MATS planes—lack of speed, range, and carrying capacity.

F-100 FIGHTER-BOMBER launches Bullpup air-to-surface missile.

After the earthquakes in Chile in May, 1960, MATS flew in supplies and equipment to aid the victims of this disaster. Other mercy flights included aid to victims of a typhoon in Japan, a tidal wave in Hawaii, and earthquakes in Morocco. During the crisis in the Congo, MATS and USAFE provided most of the airlift for U.N. troops and supplies. Between July 15 and August 29, the Air Force lifted 9,093 troops and 4,531,000 lbs. of equipment and supplies to the Congo, returning to European bases with refugees from the troubled area.

The Air Force had to cope with many obstacles in performing this airlift—no weather stations, lack of navigation kits, unsatisfactory runways, poor communications, and marginal availability of crews. However, during the two weeks of maximum effort 322 missions were flown, and throughout the whole airlift there were no major accidents.

MATS also aided the missile and satellite programs in 1960 through its technical services—Air Rescue Service, Air Weather Service, Air Photographic and Charting Service, and Airways and Air Communications Service. The latter also had responsibility for technical control and transmission engineering for BMEWS circuits.

More important to the national defense than stockpiles of weapons are the men who operate, service, and maintain them. During fiscal year 1960 (July 1, 1959-June 30, 1960) the military manpower of the Air Force continued its downward trend, declining from 840,435 to 814,752. At the end of the year there were 129,689 officers and warrant officers and 685,063 airmen in the Air Force. Approximately 207,370 of the officers and airmen were on overseas duty. Civilian strength declined from 313,466 to 307,449 during the same period. The reduction in strength was most noticeable in operating forces, where the Air Force decreased from 105 to 96 wings, including 3 missile wings.

The AFROTC remained the major source of officer material for the Air Force. The Air Force Academy graduates entering the Air Force during 1960 numbered 218, while 107 graduates came from the other service academies. A total of 9,083 new officers were commissioned by the Air Force between July 1, 1959 and June 30 1960.

During 1960, a new plan was formulated for the management of the Air National Guard (ANG) and the Air Force Reserve (AFR). This plan was devised because of the need for a higher degree of combat readiness on the part of the reserve forces. Consequently, AFR and ANG units were transferred from Continental Air Command to the commands which will have operational control of them in a national emergency, chiefly TAC and ADC. This will provide closer integration between the reserve forces and the active forces.

Specific missions assigned to the reserve forces included strategic airlift, post-attack recovery, and base support. A test program planned for 1961 was designed to test the ability of the reserves to assist the Air Force in recovery from nuclear attacks. ■

ARMY

DURING 1960, the Army made considerable gains in numbers of operational missiles and increased its active aircraft inventory by more than 300 planes.

At year-end, the Army was operating more than 5,500 aircraft of 15 different types. This was an increase from about 5,200 in 1959. The Army had 14 divisions, five regiments, 81 air defense battalions and an overall strength of about 875,000 troops.

In 1960 the Army started deployment of the Hawk, a highly mobile missile system capable of engaging high performance aircraft at medium and low altitudes. Hawk was being produced in Europe, as well as in the United States, under a NATO licensing agreement.

For high altitude aircraft, the Army had in service the improved Nike-Hercules, which was deployed around major U.S. cities and other strategic targets.

Army troops must also be protected from low level attacks by medium performance aircraft, large numbers of which were still in service during 1960 and promised to be for some time. This requirement called for a highly mobile short-range air defense weapon. To meet the need, a new surface-to-air shoulder-fired guided missile system called Redeye was developed and, at year-end, nearing production status.

NIKE-HERCULES air defense missile ready for action.

The Army was also expending its family of operational missiles having atomic delivery capabilities. The battlefield requirement for a heavy, free-flight rocket of adequate accuracy and quick reaction was being served by an improved version of the Honest John. The 85-mile range Corporal, deployed overseas for several years, was still in service, as was the 250-mile Redstone, which has been with the U.S. Seventh Army in NATO since 1958.

In early production status was Little John, designed for use by airborne units. Smaller and lighter than Honest John, it is ideally suited to the needs of fast-moving units.

The year also saw deployment of Lacrossė, a missile which provides pin-point accuracy for small yield delivery close in to friendly forces.

The Army embarked on a program of reducing the number of types of aircraft in its inventory and in this connection started or planned phase-out of such observation types as the L-19 fixed wing plane and the H-13 and H-23 helicopters. In the utility/tactical transport field, the Army announced plans to phase out the fixed-wing L-20 and the H-19, H-21 and H-34 helicopters.

First deliveries were taken of the new turbine-powered HU-1 Iroquois, which set a number of records during the year. In test status was the AO-1 Mohawk, the new medium observation aircraft. Equipped with light armor and self sealing fuel tanks, the Mohawk is intended to give the Army, for the first time, a limited penetration capability. Mohawk also carries a variety of sensory equipment, including cameras, infra-red and side-looking radar.

In the transport field, the Army had coming along a team composed of the AC-1 Caribou and the HC-1B Chinook medium helicopter.

Outlining the Army's plans for the future, as far as aircraft and helicopters are concerned, Lieutenant General John C. Oakes, Deputy Chief of Staff for Military Operations, said that the Army plans to have 8,000 new aircraft of seven different types by 1970. He indicated a requirement for approximately 3,500 observation helicopters, 2,500 utility/transport helicopters, and about 600 transports, equally divided between fixed-wing and helicopter craft, among the 8,000 units. He also listed a requirement for 250 planes of the Mohawk type by 1966, with the possibility of procurement of a more advanced type of surveillance plane by 1970.

Army aviation growth was indicated by the fact that one out of every 17 officers wore the aviator's badge and one out of every 70 enlisted men was an aviation specialist at the end of 1960. ■

NAVY

INTERNATIONAL TENSION involving repeated threats to world peace required augmentation of overseas forces and at various times kept all elements of the Fleet on the alert, sometimes at sea and sometimes on short notice for rapid deployment. Against this background, there was steady improvement in naval air weapons and their employment, a readjustment of programs and organization, and a general strengthening of the operating forces.

The greatest advance of 1960 was realized when the fleet ballistic missile *Polaris* went to sea aboard the first of the nuclear powered missile submarines and demonstrated its operational readiness in a series of successful firings under simulated combat conditions.

The successful operation of *Polaris* climaxed four years of intensive and exceptionally productive effort in an area where there was little experience upon which to base direction. During the year a series of firings from both ship and shore installations, some entirely successful, some only partially so, demonstrated satisfactory progress in the various elements of the total system that was verified when all were finally put together. Commissioning of a second missile submarine, the *Patrick Henry,* in April and of a third, the *Robert E. Lee,* in September, were other marks of progress in this vital area confirming the early prediction that the missile would be operational in 1960. Work on the missile itself also was advanced as tests of a longer range model began in November and as new contracts were left for the research and development of a 2500 mile range model.

In the anti-air missile category, continued availability of the operational *Terrier, Talos* and *Tartar* was assured by new contracts for additional production. *Sidewinder* and *Sparrow III* remained the basic weapons of interceptor aircraft; both were in production and higher performance types were under refinement. The close support missile *Bullpup,* also operationally deployed, was successfully fired for the first time from a helicopter, an HUS, in tests at Patuxent River during June. *Regulus I,* the old reliable among bombardment missiles, added to its score of firsts in March when it was fired from the USS *Halibut* off Oahu—the first missile firing from a nuclear powered submarine. Air firing tests of the *Corvus* air-to-air missile were made with an A3D early in the year, but its further development was suspended in July to permit emphasis on other weapons systems offering a broader scope of employment. Contracts were awarded extending the development program of the long range interceptor *Eagle,* and a contractor was selected to develop its companion launcher aircraft, the *Missileer.*

The addition of a missile facility at Eniwetok expanded the effectiveness of the Pacific Missile Range. Property on which the facility is located was formally transferred from the Atomic Energy Commission to the Department of Defense on July 1.

The Navy Space Surveillance System (SPASUR), which detected and identified an unknown satellite early in the year, was established as a facility on April 19, becoming the first operational space organization. It was assigned a mission of maintaining constant watch in the outer regions to provide immediate information on the existence, identity and orbit of all objects in space.

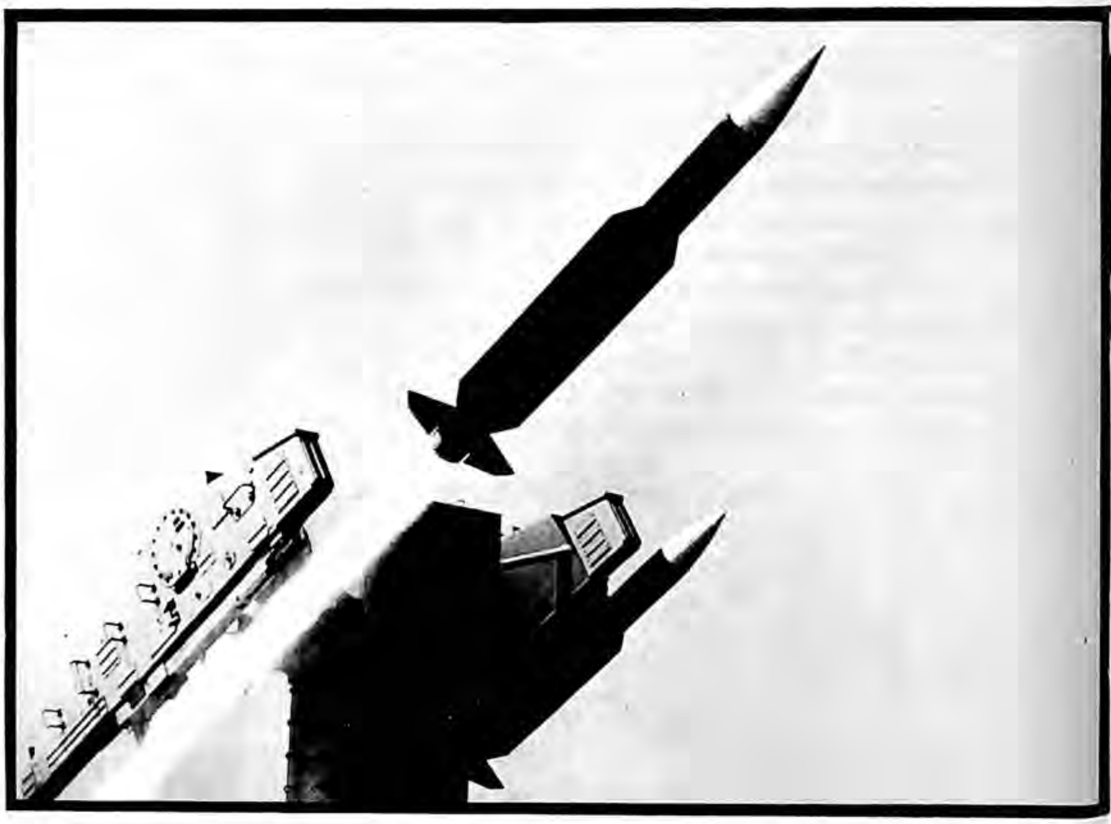
Navy responsibility for the navigational satellite was extended by the Secretary of Defense to include the overall administrative and technical areas. On 13 April, *Transit IB* was placed in orbit by an Air Force Thor-Able Star rocket launched from Cape Canaveral. Two months later, on 22 June, *Transit IIA* was also placed in orbit, carrying with it a second satellite designed to measure radiation, which separated from the parent body in outer space and entered into an orbit of its own. Initial use of data obtained from these space bodies provided more accurate fixes than had been possible by former means and did so under conditions not affected by darkness, cloud cover or weather.

The third training program for Project Mercury astronauts was completed at the human centrifuge facility of the Aviation Medical Acceleration Laboratory at Johnsville. This program provided the astronauts with acceleration experience for a normal *Redstone* suborbital manned space flight. In addition to the astronaut training, the Johnsville program provided training for the medical support personnel assigned to Project Mercury and assisted in preparing a mission exercise to be used during actual *Redstone* ballistic missions.

Project Mercury was given another Navy assist in August when a helicopter operating from the Pacific Missile Range ship *Haiti Victory* recovered an instrumented capsule discharged from *Discoverer* XIII on its 17th pass around the earth. The capsule was located about 330 miles northwest of Honolulu by Air Force planes which guided the ship to the spot. Recovery was made within three hours of the time the capsule hit the water, and was the first recovery of an object after it had been in orbit.

Carrier forces were strengthened with the commissioning of the USS *Coral Sea* in January after over two years in the yard for conversion. Her completion marked the end of a carrier modernization program for ships of World War II design that began with the *Oriskany* in 1947. The addition of this modernized attack carrier permitted another step in the orderly retirement of older ships in which the *Essex* was transferred from the attack carrier classification to that of support carrier which in turn permitted

NEW BOMB RACK adapter for Navy A4D increased bomb load six times.



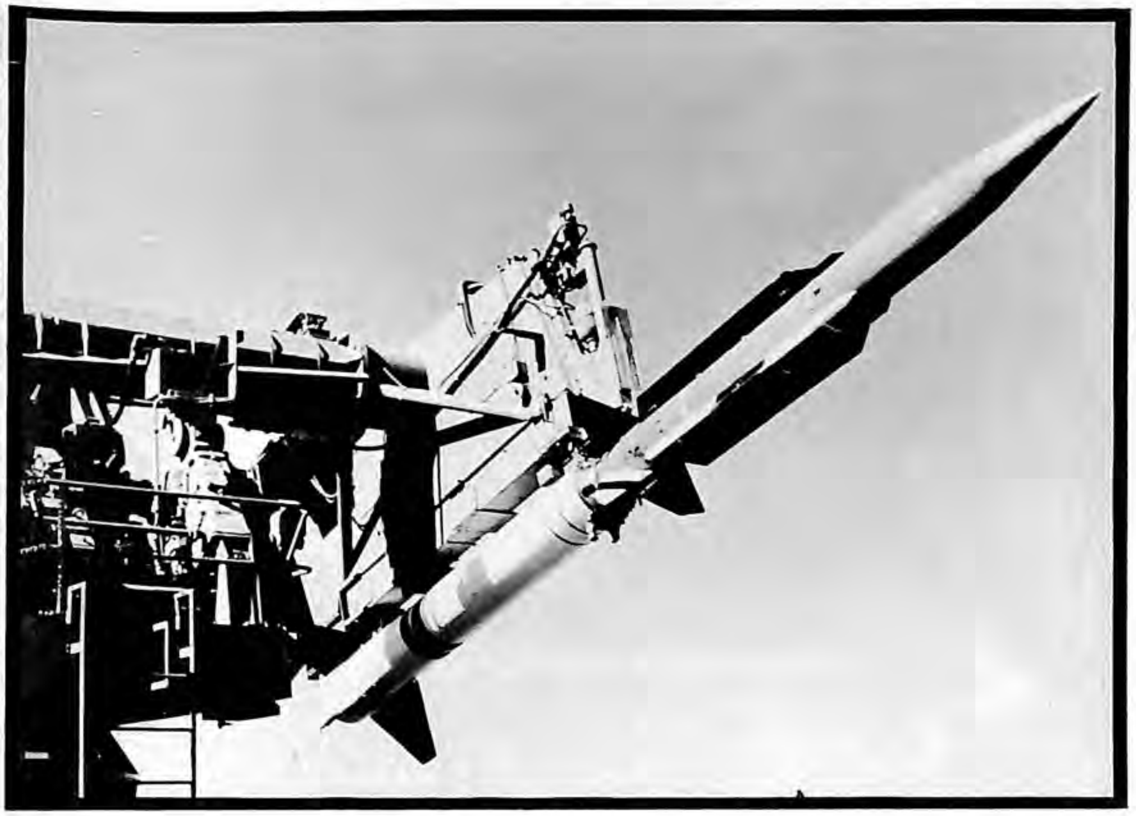
SURFACE-TO-AIR Tartar became operational in 1960.

the assignment of the less modern CVS *Tarawa* to the Reserve Fleet. The net result was to increase the operating capability of carrier forces without increasing the number of ships.

The promise of future strengthening was given as several new ships completed the first stages of construction. *Kitty Hawk* and *Constellation,* two carriers of the Forrestal Class, were launched. When operational next year, these ships will not only raise the overall level of carrier capability but will also provide additional *Terrier* missile capability in the fleet. Launching of the USS *Enterprise* in September marked good progress in the construction of the first nuclear powered carrier. A fourth ship, the *Iwo Jima,* also launched in September, will add the first specially constructed ship to the new line of LPH amphibious assault ships.

Two new aircraft joined the company of F8U *Crusaders,* F11F *Tigers,* A4D *Skyhawks* and A3D *Skywarriors* in the operating forces and others neared operational assignment. The WF-2 carrier early warning plane was delivered to a unit of the Atlantic Fleet in January. Production models of the F8U-2N *Crusader* took to the air in February and by mid-year were undergoing tests at Patuxent River preliminary to their assignment to fleet squadrons. The F4H-1 *Phantom* II, nearly ready for assignment, successfully passed its carrier trials in February and in September added to its previous world record laurels by surpassing existing world records for 100 and 500 kilometers with speeds in excess of 1350 and 1200 miles per hour respectively. Progress with the A2F *Intruder* was marked by its first flight in April at the Grumman plant. The GV-1 tanker and troop transport being procured for the Marines gave a simulated demonstration of its refueling capabilities on its first flight in January. The W2F *Hawkeye* made its first flight in October and ceremonies attending acceptance of the first aircraft in the same month underlined the significance of this new carrier early warning and interceptor control aircraft. This plane, which is powered by two T58A8 Allison turbo prop engines and carries a crew of five, has the equipment to detect and to evaluate the full nature of an air attack well in advance of the warning necessary to direct interception to destroy aircraft approaching naval task forces at high Mach number speeds.

Emphasis on the antisubmarine mission remained strong. The special task groups set up in both ocean fleets to develop specialized tactics and to promote the readiness of antisubmarine units generally, conducted both special and routine operations throughout the year. Antisubmarine Defense Force, Pacific was set up in March with headquarters in the Hawaiian area, bringing the ASW organization in that fleet parallel to that in the Atlantic. The plan to re-



ADVANCED TERRIER was scheduled for use on 27 ships.

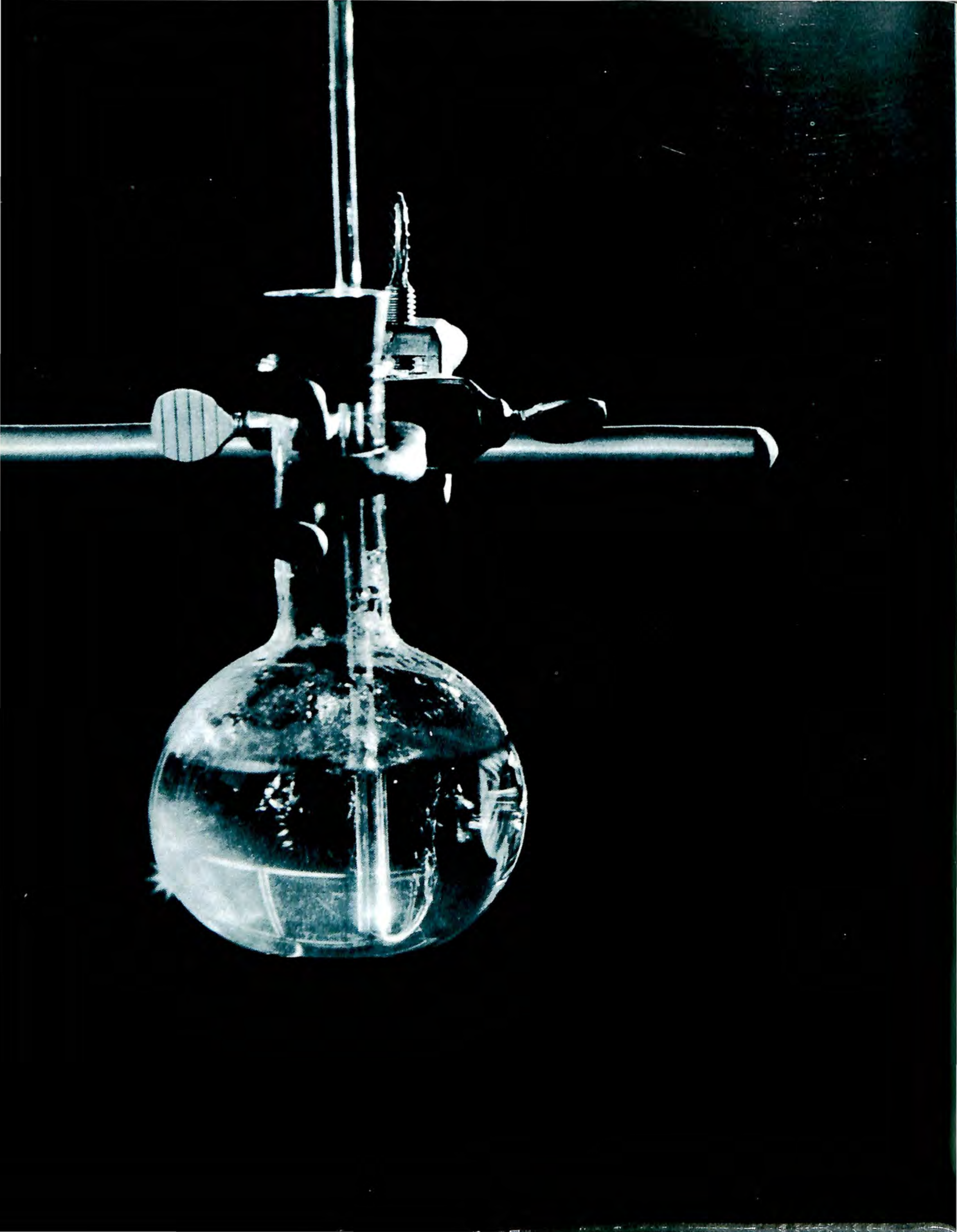
organize aviation forces assigned to this mission was initiated in April when Antisubmarine Carrier Groups (CVSG) began forming, each composed of two fixed wing and one helicopter squadrons. Special Replacement Groups and Replacement Patrol Squadrons were also set up to perform training and indoctrination functions. The change brought the organization of antisubmarine aviation into a command pattern similar to that of attack carrier aviation revised in the previous year.

Production of the HSS-2s and S2F-2 *Tracker,* used from antisubmarine carriers, was extended by new contracts. The long range P3V *Electra,* designed for antisubmarine operations from land bases, was also on order as was the new DSN-3 helicopter. An experimental DSN drone marked up a first in aviation in July by making the first controlled landing on a ship at sea, the USS *Mitscher.* Although manned by a safety pilot, the drone helicopter was flown by remote control from shore, directed to the ship and maneuvered into landing position, at which time the safety pilot took over to make the final let down.

Fleet forces conducted exercises as usual and again participated in special operations with the forces of NATO and SEATO nations. During one exercise involving a vertical envelopment landing on the southern coast of Taiwan, Marine aviation put on a convincing demonstration of its ability to go into action. Immediately upon landing they began construction of an airstrip where none had existed before and within 72 hours of the landing had it in full operation. The 3400-foot strip was surfaced with expeditionary field matting, equipped with MOREST arresting gear, a mirror landing system, TACAN navigation aids, a control tower, and a portable fuel tank farm. A4D aircraft operated from the strip with the aid of JATO units and F4Ds and F8Us used afterburners for take-off.

The USS *Valley Forge,* operating in the Caribbean with six destroyers, provided the platform for a scientific investigation of the upper atmosphere sponsored jointly by the National Science Foundation and the Naval Research Laboratory. Two giant balloons, of 10 million cubic foot capacity and carrying over a ton of payload, were released from the carrier to a height above 20 miles to collect and record cosmic rays data over an extended exposure period. Destroyers accompanying the expedition assisted in recovering the instruments after their descent.

As the year closed, preparations for the celebration of the 50th Anniversary of Naval Aviation were well underway. The celebration was to continue throughout 1961. ■



RESEARCH AND DEVELOPMENT

THE MILITARY SERVICES

Space vehicles and new automated weapons received the major emphasis in the year's military research and development effort and, in general, the year was a highly successful one, the major success being the first recovery of an object after space orbit.

THE AIR FORCE research and development program during 1960 showed great progress in the area of missiles and space achievements. Emphasis was placed on systems which had been initiated in prior years. Research and development activities covered a wide spectrum of interest ranging from basic research for new ideas in mathematics and science, to applied research in components and in testing the feasibility of new systems, and to the study of possible weapon systems which may become operational in the next decade and beyond.

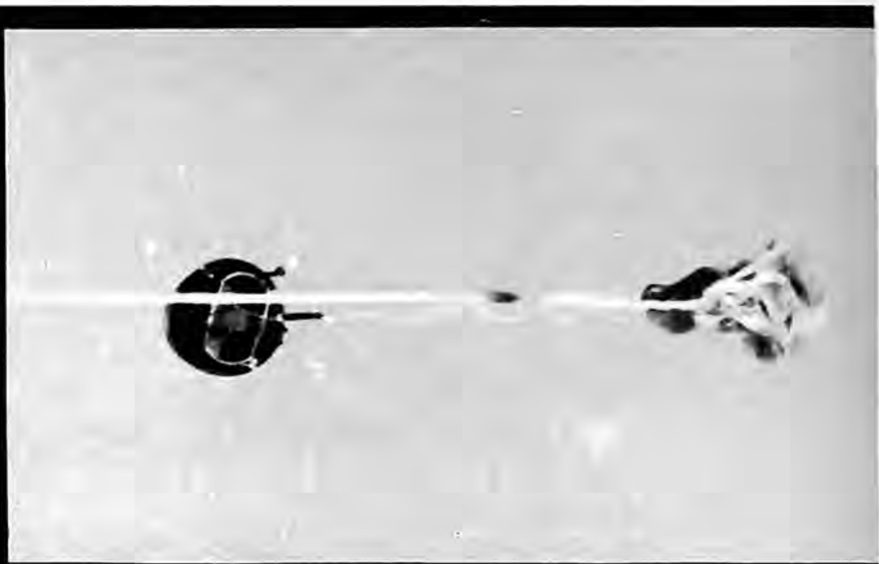
This year was marked by significant advances in weapon systems development. In the high priority ballistic missile systems the Air Research and Development Command launched a number of Atlas ICBM's and Titan ICBM's. These firings were conducted from Cape Canaveral and included testing of several advanced models of both ICBM's, the most notable Atlas achievement being a firing which covered some nine thousand miles.

The Titan ICBM had a very successful test program during the year. A major milestone was the separation and ignition of the second stage at 80,000 feet, this being a notable first in missile development. Titan had many successful firings over its full range of 5,000 miles and a Titan nose cone was recovered from the Atlantic "splash net," thus demonstrating the operational potential of this powerful weapon.

Development of a follow-on Titan called the Titan II was begun during 1960. Titan II will use storable liquids for instantaneous reaction, improved guidance, and simplicity in its support system.

Perhaps the most notable achievements were in the Minuteman program. Testing of the launch from the Silo was proven feasible after only eight firings out of a programmed eighteen. Also operation of trains which will ultimately carry the mobile Minuteman was begun. This test program was to explore the feasibility of random movement over the United States rail network and to test communications of this configuration. A most significant event was the announcement that the operational date for the Minuteman had been advanced 1 year—from 1963 to 1962. Contractors for all three stages were selected.

Several test programs which aim at giving more punch to Strategic Air Command, B-52 intercontinental bombers continued during this period. The Hound Dog had a very successful year of testing, including participation by Strategic Air Command. A SAC crew flying a B-52



THE ABOVE SEQUENCE of four photographs are the first still pictures released by the Air Force showing the successful air recovery of the capsule from Discoverer XIV. The historic air recovery was

carried a Hound Dog missile over the North Pole and back to the test range for launch at the end of a flight of some ten thousand miles. Development of the Quail, an air-launch decoy missile, continued.

The ARDC gave major emphasis to the development of the Sky Bolt, an air-launched ballistic missile, designed to have a range of over one thousand miles. This hypersonic missile was scheduled to become operational in 1964. The Royal Air Force joined in the development program with the objective of employing the Sky Bolt by its V-Bomber force.

In the field of manned bombers, the Convair B-58, the world's first supersonic bomber, became operational in SAC in 1960.

The Air Force continued to press for the development of the B-70, a Mach 3 intercontinental heavy bomber. Late in the year, an agreement in principle was reached to reorient the development to a YB-70 program with weapon system component developments added to the program. The importance of the B-70 to future supersonic jet transports was pointed out in testimony before a congressional committee.

For the tactical forces the Air Force continued development of the guided air missile called the Bull Pup. This missile will carry a nuclear warhead.

On the air defense side of research and development, testing of the advanced Bomarc B was continued in 1960. Bomarc passed several major milestones, including interception of supersonic missiles and destruction of a "specification size" bomber.

The defense against ballistic missiles passed a major milestone with completion of the first Ballistic Missile Early Warning System, BMEWS, site at Thule, Greenland. This site began operation in 1960. Construction of the second site at Clear, Alaska, was accelerated and the location of the third site in the United Kingdom was chosen.

Major emphasis was given to the research and development of command and control systems. These include electronic systems for collecting, transmitting and displaying data.

Investigation continued on nuclear propulsion systems for various types of weapon systems. For aircraft, development of reactors for both the direct air cycle and the indirect cycle reactors made definite progress. Significant advances were made also in the use of nuclear power for space systems under project SNAP and in the development of a nuclear powered ramjet under project Pluto.

Activities in support of space systems showed increased tempo during the year. These centered around Dyna-Soar, Midas, Samos, and Space Track. In addition in carrying out its responsibilities for the development, production, integration and launch of boosters for military satellite systems, the Air Force launched two of the Navy navigational satellites called Transit and the Army communication satellite called Courier. Transit I-B was placed into orbit in April and was hailed as a major advance in navigation for surface shipping. Courier I-B went into orbit in October and relayed a message from the President to the United Nations. For the NASA, the Air Force provided Atlas and Thor boosters for satellite

executed by an Air Force C-119 aircraft of the 6593rd Test Squadron at Hickam AFB, Hawaii.

launchings such as project Echo and space probes. The Air Force also continued support of project Mercury, the man-in-space program.

As part of the Discoverer program the Air Force launched 7 satellites, 4 of which went in to orbit.

Discoverer Table

Discoverer VII	7 November 1959
Discoverer XIII	10 August 1960
Discoverer XIV	18 August 1960
Discoverer XV	14 September 1960

A notable first in the Discoverer program was the recovery of a capsule from orbit on 11 August 1960. A week later the second successful recovery of a Discoverer capsule was accomplished by "air snatch" of the capsule by the crew of a C-119. Discoverer played a significant role in development of Midas and Samos satellite systems.

Two launchings of the Midas were conducted in 1960.

The first Samos was launched in October but failed to orbit.

The X-15 project which is essential to a manned space capability accomplished major achievements. Research flights up to the speed and altitude capability of the XLR-11 rocket power plant were completed. As of 21 October 1960 45 flights had occurred. During these research flights new speed and altitude records for manned aircraft were set. On 4 August 1960 the NASA pilot, Joe Walker, flew the X-15 to a maximum speed of Mach 3.31 (2196 mph). On 12 August 1960 Air Force pilot, Major Bob White, flew the X-15 to 136,500 altitude to set a new altitude record for manned aircraft. Flights have been made by pilots of the North American Aviation, USAF, NASA, and the U.S. Navy. First flight of the X-15 with the more powerful XLR-99 engine was made on November 16, 1960.

After a detailed technical investigation of the Dyna Soar project under what was called phase Alpha, Dyna Soar was given a full go ahead in the spring of 1960. The configuration and development program were approved and a first flight within three years was planned. The glider developed by Boeing will be launched by modified Titan booster developed by the Martin Company.

An important space project which passed a modified milestone was the Space Track. A new facility was dedicated at the Hanscom complex in Massachusetts.

The successful launch of the first Blue Scout, a research vehicle developed by Ballistic Missile Division was made during 1960. The Blue Scout is the Air Force version of the NASA Scout.

An important event in the world of science was the publication by the Air Force of a Lunar Atlas. This is the most comprehensive collection of photographs of the moon ever assembled. It is the first atlas of this nature published in this century. The project was directed by Geophysics Research Directorate of ARDC and the preparation of appropriate, accompanying maps was accomplished by Aeronautical Chart Information Center.

Announcement was made of several special studies which showed promise for the future. In the propulsion field a contract was let to test the feasibility of a segmented solid propellant rocket motor. To provide an active defense against the orbiting satellite, a study was begun of a satellite inspector and to defend against the ballistic missile a space based active defense system was studied.

In the area of management several important changes were made in Headquarters. A Directorate of Systems Development was organized. This office assumed responsibility for development of weapons and supporting systems, including ballistic missile and space systems. A complementary Directorate, Directorate of Research and Technology, was organized with the responsibility of management of the Air Force basic and applied research programs. This Directorate is responsible for the exploration of technology and the advancement of the state-of-the-art upon which to base future weapons systems.

The ARDC continued the reorganization begun in 1959.

The Aerospace Corporation was formed to assume the responsibilities and functions of the Space Technology Laboratory. Also increased emphasis was given to site activation and this responsibility was transferred from the ARDC to the Air Materiel Command.

The level of funding of Air Force research, development, test and evaluation program was approximately 2.9 billion dollars. Funding of basic research increased to 42 million and 243 million dollars were allocated to applied research. Between 4/5 and 3/4 of the total budget was allocated to systems development.

In the aircraft field, the Army concentrated its research and development effort on helicopters and light and medium planes, with the announced intention of reducing the 15 different types of aircraft in inventory during 1960 to only seven types.

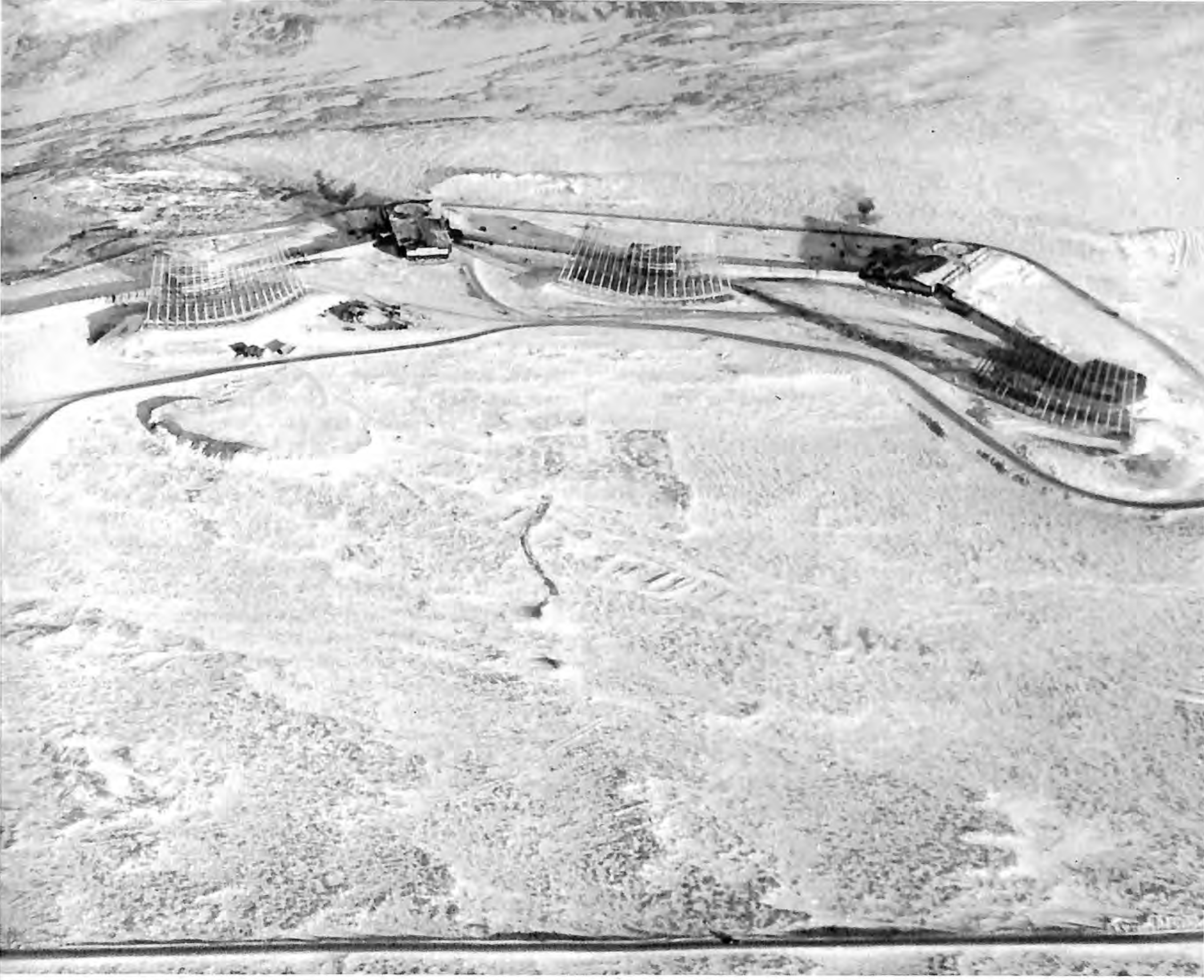
For the light observation requirement, the Army was emphasizing the turbine helicopter as a replacement for fixed wing and piston-powered helicopters in service during the year. The Army was seeking a relatively low cost turbine helicopter for this assignment, because of a high density requirement which envisioned a need of approximately 3,500 observation craft by 1970.

The turbine helicopter was also being developed for the utility/tactical transport requirement. It was expected to replace existing

helicopters and fixed wing craft in this category.

For its surveillance mission, the Army continued development of the Grumman AO-1 Mohawk, which reached flight test status. The twin-turbine Mohawk is equipped with cameras, infrared and side looking radar and has light armor and self-sealing fuel tanks for penetration missions. Unmanned drones were also being investigated as complementary machines for the surveillance requirement.

In the transport field, the Army continued development of its fixed-wing/helicopter team, including the STOL Caribou, which can lift three tons of supplies and equipment from an unimproved field less than 1,000 feet in length, and the HC-1B Chinook twin-turbine helicopter, designed to complement the Caribou in the mission spectrum.



PANORAMIC VIEW of the first Ballistic Missile Early Warning System (BMEWS) site, Thule, Greeland.

The Army continued extensive research in a number of new V/STOL areas toward future requirements. Of particular interest to the Army was the flying crane, a "short haul obstacle-crosser" which has application in a number of Army missions, and the GEM (Ground Effects Machine), which rides on a cushion of air rather than wheels or tracks. Flying crane progress had been held up pending development of a crane with sufficient capacity and low enough cost to allow procurement without cutting back other programs, but in 1960, the Army said, the crane was approaching a state of feasibility. The Army was vigorously exploring the GEM concept, but stated that it was still too early to predict what place the GEM would have in future requirements.

In its missile development program, the Army placed major emphasis on the Nike-Zeus, an anti-missile system designed to "kill" enemy ICBM and IRBM warheads. During the year, a number of test firings were made of Nike-Zeus, the third generation of the Nike family that started with the Ajax in 1955. Plans were being made for an intensified test program in 1961. The Army planned to put Nike-Zeus through a series of increasingly severe performance firings at White Sands Missile Range and at Point Mugu on the Pacific Missile Range. Later, the Nike-Zeus system was to be tested against Atlas ICBM's fired from the California coast. For this purpose, a Nike-Zeus complex was being installed on Kwajalein Island in the mid-Pacific.

Two more important missiles in advanced development during 1960 were the Sergeant and the Pershing. The Sergeant is a solid-fueled weapon of comparable range to the Corporal in Army service, but considerably more mobile. Pershing, also solid-fueled, was designed to replace the Redstone. Pershing offered the Army a relatively light weapon that can be quickly emplaced and fired and easily supported logistically, yet one which also has significantly greater range than Redstone.

Another development program of interest to the Army was Redeye, a highly mobile short-range air defense weapon, a man-portable system designed to destroy low flying jets or conventional aircraft. Redeye, about four feet long and only three inches in diameter, is a shoulder-fired missile weighing approximately 20 pounds. It is effective at altitudes and ranges commensurate with defense of field army positions and Marine Corps amphibious operations against bombing and strafing attacks. At year-end, Redeye was nearing production status.

A highlight of the Navy's missile development program was Polaris, the sub-launched fleet ballistic missile. The Polaris A-1, which has a range of 1,200 nautical miles (1,380 statute miles) completed its development flight test program during the year and became operational when it went to sea aboard the nuclear submarine USS *George Washington*. Over 50 test flights were made of the A-1 version over a 13 month period, including 12 launchings from submerged submarines and four other underwater launches.

With the A-1 Polaris in service, the Navy concentrated on development of the Polaris A-2. In October, the Navy awarded a $181,000,000 contract to Lockheed Missiles and Space Division for continuing development of the Polaris, bringing to $608,000,000 the total expended for research and development on this program.

First flight tests of the Polaris A-2 were made late in the year at Cape Canaveral. The A-2 version of the fleet ballistic missile was designed for a range of 1,500 nautical miles (1,725 statute miles). It has a longer first stage rocket and a lighter and more powerful second stage than the A-1. First successful launching of the A-2 in November climaxed a 10 year program to design a high performance, glass case, solid propellant rocket motor for the second stage. The new motor was designed and produced at Allegany Ballistics Laboratory, a Bureau of Naval Weapons facility operated by Hercules Powder Company. It was the first use of fiberglass reinforced plastics for rocket cases; previously all rocket chambers for military applications had been fabricated from steel or aluminum. Concurrently with the new structural material, a new type of solid propellant with a stronger specific impulse was used for the second stage of Polaris A-2.

A series of A-2 tests was planned for 1961, including firings from land launch pads, from the surface test ship USS *Observation Island* and from submerged submarines. Tests were to include general missile development, guidance systems, re-entry body development, arming and fuzing, as well as first and second stage motor performance and missile control action during powered flight.

As work progressed on the A-2 series, the Navy received authorization to proceed with development of Polaris A-3, a 2,500 nautical mile range (2,875 statute miles) version expected to be in operational service by 1965.

Another important Navy research and development program under way during 1960 was Eagle. In November, the Navy awarded a contract to Bendix System Division for $26,000,000 for continued development of the new missile. Eagle is a long range, air-to-air interceptor missile to be used against enemy aircraft or aerodynamic missiles. It is designed to attack targets at all operating altitudes under all tactical conditions and affords a considerably increased range over existing systems. The basic characteristic of the Eagle system is emphasis on high performance of the missile, while the launching aircraft is designed for top capability in endurance and firepower. Work was similarly under way on the launching plane, called Missileer and being developed by Douglas Aircraft Company.

In the aircraft field, a development program of major proportions reached culmination in 1960 with first deliveries of the McDonnell F4H Phantom II. During the year, extensive aircraft carrier suitability tests of the F4H were conducted and at year-end the plane was undergoing trials by the Navy's Board of Inspection and Survey at the Naval Air Test Center at Patuxent, Maryland.

The Navy also made first acceptance of the Grumman W2F-1 Hawkeye, a carrier-based early-warning and intercept control twin-engine aircraft. Hawkeye is designed to protect task forces from airborne attack by detecting and evaluating the full nature of the attack in advance of the minimum lead time necessary for interception and destruction of high performance attacking aircraft.

Incorporated in Hawkeye is an Airborne Tactical Data System (ATDS), consisting of auto-detection radar, airborne computers, a memory and high speed data link system. The system collects, stores, collates and relays information and gives Hawkeye automatic direct command and control of interception. The plane carries a crew of five and is powered by two Allison T56-A8 turboprop engines fitted into a high fixed wing.

In the space field, the Navy was the major participant in the launching of the Transit series of satellites, designed to provide a worldwide, all-weather navigational system in which signals from the satellites will be used by ships and planes to provide a highly accurate navigational fix.

Two such satellites were launched in 1960. Transit IB, boosted into orbit by a two-stage Thor-Able vehicle, was launched on April 13. Transit IIA, also boosted by the two-stage Thor-Able, was launched on June 22. Transit IIA was unique in that it actually consisted of two satellites launched simultaneously, the first multiple-payload firing. In addition to the Transit navigational satellite, the payload included a second sphere developed by the Naval Research Laboratory, designed to learn more about solar activity.

In a corollary research program, Navy scientists succeeded in virtually stopping the rotation of the Transit satellites after they were in orbit. The satellites were caused to spin upon launch for stability, but ultra-high stability radio transmission requirements for Transit made it necessary to reduce the spin rate for elimination of undersirable frequency noise.

Spin reduction was brought about primarily by the use of "de-spin rods." As the satellite spun in the Earth's magnetic field, the rods were magnetized first one way and then the other. Changing the direction of the magnetism caused internal friction on the rods. This required energy which had to come from the spin energy of the satellite. As more and more of the satellites' spin energy was removed, the rotation rate decreased.

Transit IB used both mechanical and magnetic devices to stop spin. Fourteen days after its launching (with an initial spin rate of 2.8 revolutions per second), the satellite's rotational speed was cut to less than one revolution in 250 seconds. On Transit IIA, only the magnetic rods were used, and 25 days after launch the rotation rate was less than one revolution in 1,000 seconds. ■

THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

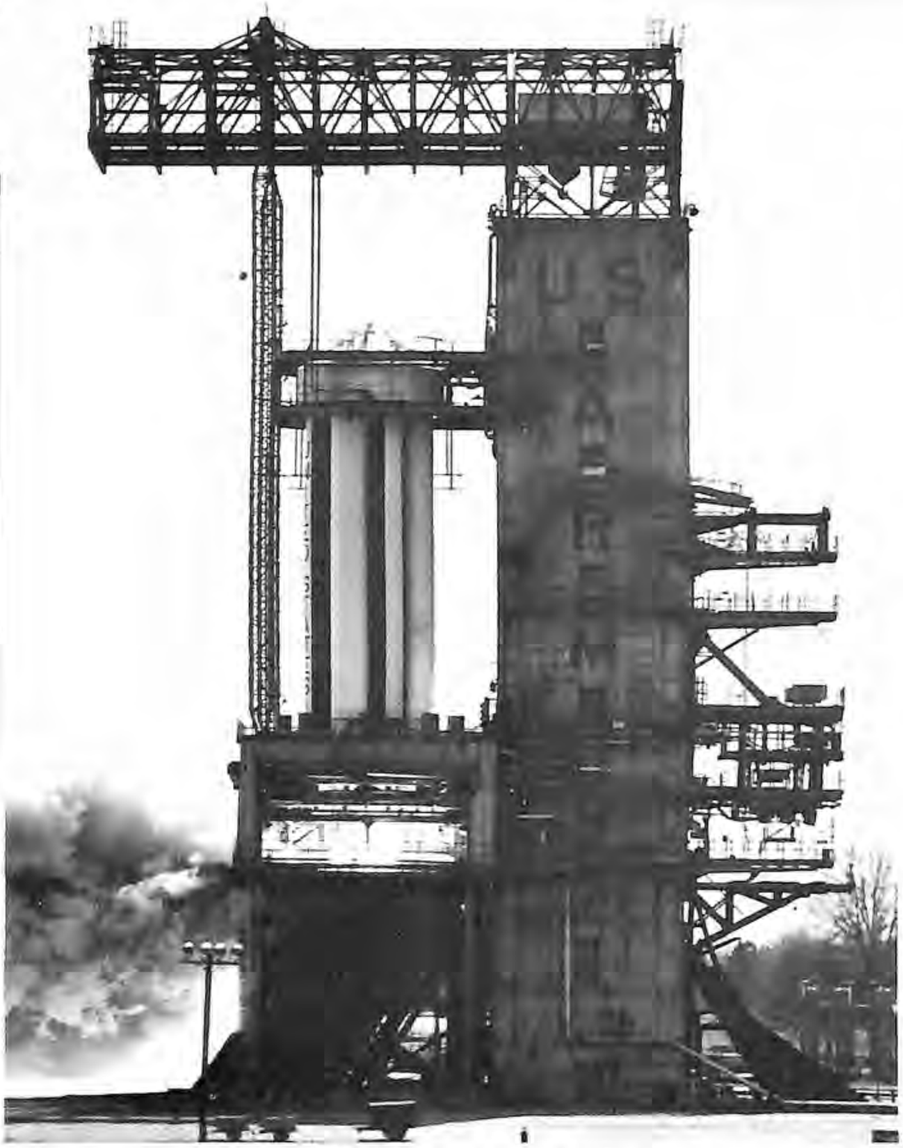
DURING THE YEAR NASA consolidated plans for a long range program of space exploration covering the period 1960-70 while making solid gains in both the aeronautical and astronautical fields of research. In the organization's research centers, work advanced on gas dynamics, combustion, higher impulse fuels and advanced materials and structures. NASA's 1960 effort delved into a wide variety of problem areas, ranging from the problems of aircraft hovering at zero miles per hour to investigation of re-entry problems of a space vehicle returning to the atmosphere at 25,000 miles per hour.

In 1960, the space flight program was highlighted by successes with Echo I, a passive communications satellite visible to the naked eye which had a strong international prestigial effect; Tiros I and II, experimental meteorological satellites; Pioneer V, a space probe which went into orbit around the sun; and Explorer VIII, an ionosphere probing earth satellite.

In aeronautics, notable successes were chalked up with the rocket-powered X-15 research vehicle. Using an interim XLR-11 engine, the X-15 set new unofficial records for speed (2,196 miles per hour) and altitude (136,500 feet). Later in the year, equipped with its new, much more powerful XLR-99 engine, the X-15 flew to 80,000 feet and 2,000 miles per hour with the engine throttled back.

During the year, the space agency made progress on its launch vehicle program, the key element of the 10-year space plan, as it started to replace older launch vehicles and began development of new, high-thrust vehicles. Vanguard and the Army-developed Jupiter C were dropped and plans were made to cancel the Juno II and the Thor-Able in 1961. Delta, an improved Thor-Able, was also scheduled for retirement after 1961. Their immediate replacements were to be the four-stage solid-fueled Scout, which can launch 150-pound earth satellites, and Thor-Agena B, with a 1,250 pound earth orbital capacity.

The first complete Scout vehicle was launched successfully during the year. With



SATURN space vehicle's super booster.

103,000 pounds thrust, Scout was designed for reliability, ease of handling and versatility.

Thor-Agena B is basically the same vehicle as that used in the Air Force Discoverer satellite program. Agena B is a 15,000-pound thrust liquid-fuel rocket stage; Thor has a thrust of 165,000 pounds.

In a more powerful class is Atlas-Agena B. With Atlas (360,000-pound thrust at lift-off, 80,000-pound thrust in its sustainer stage) the Agena B will be able to launch 750 pounds to the moon—including hard-landing payloads on its surface—and 5,000-pound earth satellites.

More powerful is Atlas-Centaur, the first U.S. launch vehicle to employ a high-energy upper stage, using liquid hydrogen-liquid oxygen (LOX) instead of hydrazine (kerosene) and LOX. The Centaur second stage consists of two rocket engines, each generating 15,000 pounds of thrust. The vehicle's capability: 8,-500-pound earth satellites, 1,450-pound lunar orbiters and 1,500-pound planetary probes and lunar orbiters.

The largest U.S. launch vehicle under construction at year-end was Saturn, whose first stage consists of eight clustered liquid-fuel engines totaling 1,500,000 pounds of thrust. Mounted on the cluster in the first or C-1 version will be two Centaur upper stages. The C-1's capacity: 19,000 pounds in earth orbit, 5,000 pounds on a lunar trajectory. Second-generation versions of Saturn were also under development.

Saturn, which shared top priority with Project Mercury, first phase of the manned space flight program, completed its first series of static tests satisfactorily with a 122-second firing of its prototype first stage during the summer.

Much study was devoted to defining the launch vehicle to follow Saturn. One of a number of possibilities is the Nova concept, which would employ the single-chamber, 1.5 million-pound thrust F-1 engine, now being developed. Under this approach, a number of F-1 engines would be used in the first stage and hydrogen-oxygen stages would be mounted thereon.

Work also progressed in the fields of electric and nuclear propulsion.

In Project Mercury, the production model flight capsule entered the shakedown stage. The one-ton, bell-shaped capsule passed a flight test of its rocket-equipped escape tower, the capsule-escape tower combination showing good aerodynamic stability. A high-atmosphere entry test of the capsule ended when its Atlas (MS-1) launch vehicle exploded after a 65-second flight.

In another test of the Mercury escape system, the capsule failed to separate from its Little Joe launch vehicle. The Little Joe, with capsule and escape tower still attached, fell into the Atlantic Ocean off NASA's Wallops Station, Va., launch site.

A later attempt to launch an unmanned Mercury capsule from the Atlantic Missile Range ended when a signal triggered by the Redstone rocket vehicle's ground connection shut down the MR-1A engine immediately after ignition.

The seven Mercury astronauts continued their training schedule, looking toward the first manned (Redstone) suborbital flight and the first manned (Atlas) orbital flight, both scheduled for 1961. At the same time, the world-wide Mercury Tracking and Ground Instrumentation Network moved toward completion in the first quarter of 1961, and formal agreements for all NASA tracking stations abroad had either been signed or were in final stages of negotiation in late 1960.

NASA's personnel increased from 9,755 to more than 15,600 during the year, reflecting for the most part, the transfer to the agency of the Development Operations Division of the Army Ballistic Missile Agency, Redstone Arsenal, Huntsville, Ala. On July 1, NASA officially took over the Division's personnel, facilities and 1,200 acres at the Arsenal. It was named the George C. Marshall Space Flight Center in honor of soldier-statesman General George Catlett Marshall.

To facilitate standardization of operations and facilities, the agency created the Launch Operations Directorate (LOD) within the Office of Launch Vehicle Programs. LOD will launch most NASA vehicles, support the launch operations of the remainder, and provide launch support for several Army missiles.

NASA also established the following Offices:

. . . the Office for the United Nations Conference, to direct U.S. participation in the First International Conference on the Peaceful Uses of Outer Space.

. . . the Office of Life Sciences, to operate a research program dealing with 1) survival and performance of man in space; 2) the effect of the space environment on biological organisms, systems and processes; and 3) the search for extra-terrestrial life forms.

. . . the Office of Reliability and Systems Analysis, to direct a program to evaluate and improve operational reliability of NASA launch vehicles and payloads.

. . . the joint Atomic Energy Commission-NASA Nuclear Propulsion Office to facilitate the joint effort in the development of nuclear rocketry.

On the operational side, one deep space probe and four earth satellites were successfully launched during the year. They were Pioneer V, Tiros I and II, and Explorer VIII. Here is a brief review of their accomplishments:

Pioneer V, a 94.8-pound probe designed to gather scientific data from deep space and to test communications over interplanetary distances, was launched from AMR on March 11 by a Thor-Able. The probe contained two radio transmitter-receivers, one of five watts, the other of 150 watts, as well as instrumentation to measure: 1) radiation streaming from the sun; 2) the spatial distribution of energetic particles and medium-energy electrons and protons; 3) the number and density of meteoric dust particles striking the probe; and 4) the strength of magnetic fields.

Four paddle-shaped, 14- by 18-inch vanes jut from the globe-shaped payload, each vane studded with 1,200 solar cells which provide power to recharge Pioneer V's nickel-cadmium batteries.

To achieve the desired orbit—perihelion approaching the sun and near the orbit of Venus —Pioneer V was launched in a direction opposite to that of the earth's revolution around the sun. With a speed less than the earth's—and hence with a reduced centrifugal force to offset the sun's gravitational pull—the probe would start falling inward toward the sun. (Previous probes had been launched so that their speed was added to that of the earth, and they thus moved outward, away from the sun.)

Pioneer V established the greatest range—22,462,740 miles from earth—over which man has tracked, received telemetry from, and maintained control over, an instrumented vehicle. The previous record was that set by Pioneer IV, which was tracked to 407,000 miles.

The probe's magnetometer confirmed the existence of an electrical "ring current" circling the earth at an altitude of 40,000 miles, a giant girdle of low-energy charged particles. The newly discovered current, the existence of which has been argued by geophysicists for more than 50 years, is not to be confused with the Great Radiation Region discovered by earlier U.S. satellites.

The probe also: 1) reported an intense zone of disturbed magnetic fields at distances of 40,000 to 60,000 miles; 2) revealed that the boundary of the earth's magnetic field is twice as far from earth as had been previously supposed; 3) made a detailed examination of the interplanetary magnetic field; and 4) reported the first direct observation of pure cosmic rays at altitudes completely free of the earth's atmosphere. The observation was made three million miles in space.

Tiros I (Television and Infra-Red Observation Satellite), a 270-pound, drum-shaped, experimental meteorological satellite, was launched from AMR on April 1 by a Thor-Able. The satellite went into a near-circular orbit with a perigee of 428.7 miles and an apogee of 465.9 miles.

Tiros I made meteorological history, giving scientists an unprecedented opportunity to study the earth's cloud patterns and relate them to the weather. Among the striking phenomena shown for the first time were large-scale cyclones, with spiral bands sometimes covering an area one thousand miles across.

Photographs transmitted by its two television cameras also indicated the presence of jet streams, regions of moist and dry air, thunderstorms, fronts, and other data. Experimental studies of Tiros data have already resulted in improved understanding and increased accuracy in weather forecasting, particularly over large ocean areas.

The satellite's cameras swept the earth's surface between 50 degrees north and south latitudes, a band extending roughly from Montreal, Canada, to Santa Cruz, Argentina, in the Western Hemisphere, and between Le Havre, France, to Southern Africa and from Northern Manchuria to New Zealand in the Eastern Hemisphere. One camera was capable of photographing hundreds of thousands of square miles in one picture, the area varying with the angle of the lens to the earth. The other instrument, a high-resolution camera, could photograph an area 80 miles on a side within the area covered by the first camera. The high-resolution camera, which provided 10 times the detail of the wide-angle camera, reproduced the structure and texture of clouds within the overall cloud mass.

About midnight on June 29, after Tiros I had completed 1,302 orbits around the world, attempts to interrogate the satellite ceased. Its effective lifetime, during which it transmitted 22,592 pictures, was at an end.

Echo I, the world's first successful passive communications or "radio mirror" satellite was launched on August 12 from AMR with the new Delta rocket vehicle (it was Delta's first successful launch). The 100-foot diameter, inflatable sphere of aluminized Mylar plastic, weighed 137.4 pounds and contained an additional 30 pounds of subliming chemicals to inflate it.

The sphere went into a nearly circular orbit which was confirmed when word of a sighting was received from a tracking station at Woomera, Australia. Echo's initial apogee was 1,049 miles, perigee 945 miles. During its first orbit, scientists transmitted President Eisenhower's tape-recorded voice from California to New Jersey, via the sphere. Numerous other communications experiments were conducted, transmissions including teletype signals, facsimile photographs, two-way telephone conversations using commercial equipment, transcontinental and trans-Atlantic signal relays, and experiments to learn more about the effects of the ionosphere upon radio signals.

Echo I's launching was part of NASA's program to investigate the feasibility of satellites for global communications, including worldwide telephone, radio, and television. Such satellites may eventually lead to worldwide "live" TV broadcasts.

Explorer VIII, a 90-pound satellite equipped to carry out the first intensive direct measurement study of the earth's ionosphere, was launched on November 3 from AMR by a Juno II. The spin-stabilized satellite, shaped like a toy top, went into an initial orbit with an apogee of 1,423 miles, a perigee of 258 miles.

The ionosphere consists of a series of regions of charged particles beginning about 50 miles above the earth's surface and extending for hundreds of miles into space. Here, ultra-violet radiation from the sun acts upon the atoms of the atmosphere, causing them to become ionized, that is, to lose their electrons. The result is a gaseous substance which scientists call plasma.

Because radio signals normally bounce back and forth between the earth and the ionosphere —like light relayed along a series of mirrors— international radio communications are made possible, despite the curvature of the earth. However, the composition of the ionosphere is constantly changing because of solar storms, auroral displays and other natural phenomena such as sunlight and shadow. These shifts sometimes disrupt communications, cause the radio signals to be absorbed in the ionosphere —or cause them to streak right through the ionosphere into space.

Data from Explorer VIII were still being analyzed at year-end, and it was too early to draw conclusions. But instrumentation of its eight experiments was functioning satisfactorily and scientists were hopeful that the data will prove very useful in the field of communications.

The satellite has two secondary objectives: 1) to measure the charge accumulation, that is, the static electricity, on the satellite's aluminum surfaces which can be related to the problem of electrical drag; and 2) to measure the number of micrometeorite impacts.

Tiros II, a 280-pound advanced version of Tiros I, was launched from AMR by a Delta on November 23, flying into an orbit with a 387-mile perigee, a 453-mile apogee. The satellite was equipped with a narrow-angle and a wide-angle television camera, each the size of a water glass, plus infrared sensors to measure solar and terrestrial radiation. The radiation experiment will assist research meteorologists in studying general circulation of the atmosphere and in determining many features of atmospheric composition and temperature.

At the end of 1960, data from Tiros II were still being analyzed. At that time, the narrow-angle camera and the infrared sensors were working well, but the wide-angle camera was not providing pictures of as high quality as those produced by Tiros I.

The U.S. Weather Bureau was working closely with NASA scientists on the Tiros II experiment as it did with Tiros I. Weather Bureau scientists were analyzing the pictures and transmitting them to the Bureau's National Meteorological Center near Washington, D.C. From the NMC, the pictures were relayed by facsimile and teletype circuits to military and civilian meteorological centers in different parts of the country. The Weather Bureau was also processing the radiation data.

During the year, NASA launched dozens of one- and two-stage sounding rockets—Aerobees, Nike-Cajuns and Nike-Asps—in its geophysical and astronomical programs. Many of the launchings were from Wallops Station, Va.

In aeronautics, NASA research ranged widely, from Vertical Take-Off and Landing (VTOL) and Short Take-Off and Landing (STOL) aircraft to Dyna-Soar, a joint project with the Department of Defense. Dyna-Soar is a manned maneuverable air-space vehicle which will explore hypersonic flight up to orbital speeds. Highlight of the aeronautics program was the progress with the X-15.

On August 4, at the Flight Research Center, Edwards AFB, Calif., X-15 No. 1 set a new world's speed record of 2,196 mph—more than three times the speed of sound (Mach 3.31). NASA test pilot Joseph A. Walker was at the controls.

The flight began at 8:58 a.m. PDT, after the airplane had been released from its mother ship at an altitude of 45,000 feet. Walker opened the two rocket engines to full thrust. In four minutes of powered flight before the fuel burned out at 66,000 feet, the X-15 attained the record speed, as Walker said, "for just the snap of a finger." The previous world record of 2,094 mph was set on September 27, 1956, by Air Force Captain Milburn G. Apt, who was killed when his X-2 aircraft went out of control and crashed.

On August 12, X-15 No. 1, piloted by Air Force Major Robert M. White, broke another four-year record by flying to an altitude of 136,500 feet, surpassing the previous world record of 126,200 feet achieved in 1956 by the late Air Force Captain Ivan C. Kincheloe in an X-2. White reported "a direct contrast in the sky, with a band of light below about 50,000 feet, and higher than that, a very deep blue. There was no restriction on visibility, however, just a much deeper blue sky."

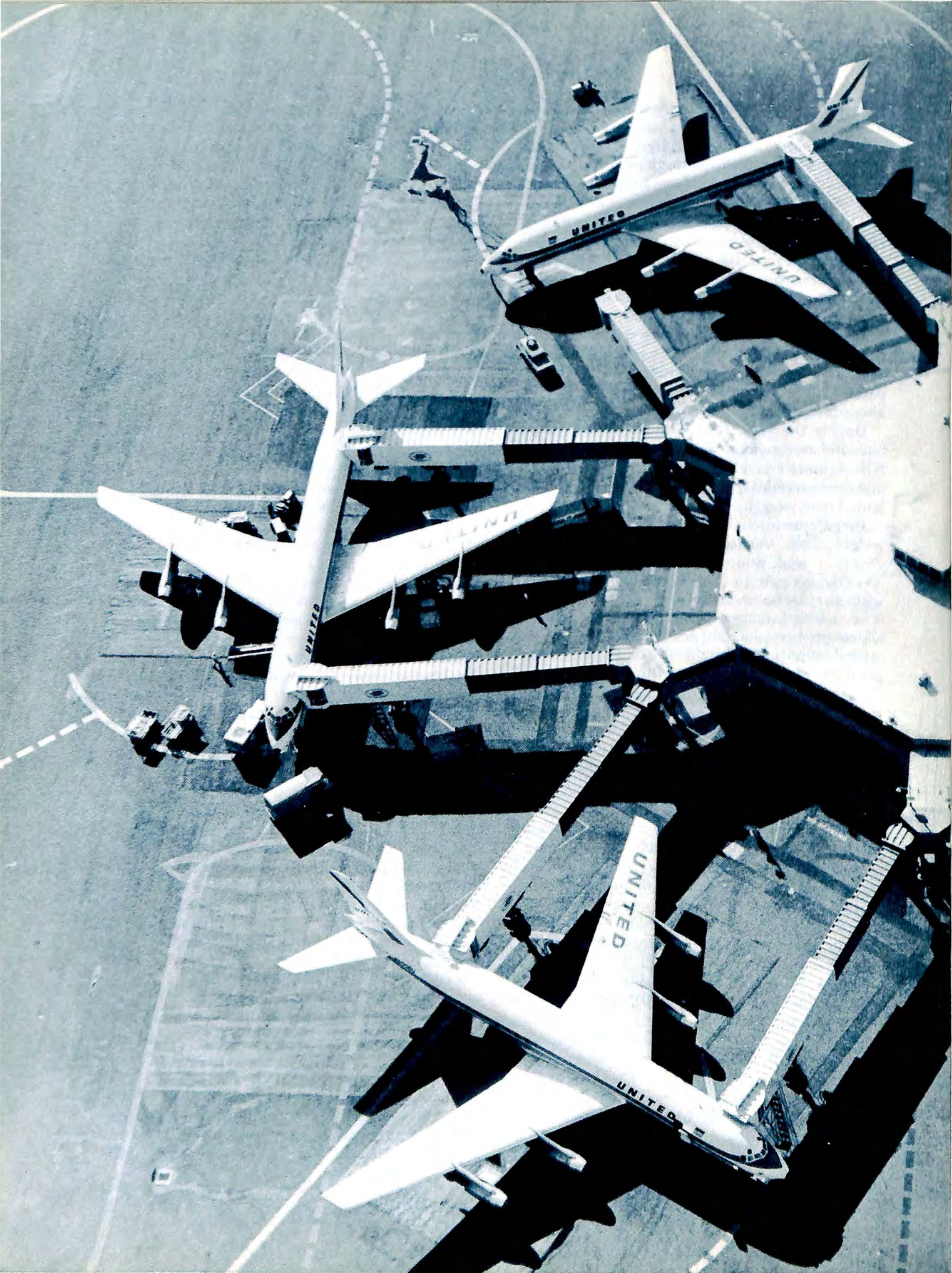
The X-15 climbed at Mach 1.9, at an angle of 50 degrees. Fuel in the two engines was exhausted at an altitude of about 120,000 feet but momentum carried the airplane to the record height of 136,500 feet. Then the X-15 nosed down and glided to 60,000 feet at about 1,000 feet per second, during which its stability was tested and found to be good. After a total flight time of 11 minutes, the aircraft glided to a landing on Rogers Dry Lake at Edwards.

As 1960 ended, NASA had accomplished several initial goals of its Long Range Plan, such as Echo I and Tiros I and II, and had revealed proposed advanced missions involving Ranger, Surveyor, Prospector, and Mariner spacecraft. Ranger will land the first survivable payloads on the moon; Surveyor and Prospector will make controlled landings on the moon; and Mariner will carry out deep penetrations of interplanetary space, including missions to Venus and Mars.

During the 1961-69 period, the U.S. planned to press forward with such lunar experiments. The most rewarding phase of lunar exploration will come when men reach the moon, probably after 1970. In a broad sense the main drive of the Plan consists of preparations for manned expeditions to the moon and nearby planets in the decades to follow. The U.S. is placing emphasis upon lunar experiments for several reasons:

First, in the words of a scientist in NASA's lunar program: "The moon may have the answers to some of the most important questions in science. How was the solar system created? How did it develop and change? Where did life come from? The particular importance of the moon is that it is the only accessible object that can give us these answers. The reason for this is that the moon has no wind and water to erode its surface, to wear away the record of history, to destroy the cosmic dust that has fallen there for billions of years."

Second, success in the lunar program will provide this country with the experience for attempting flights to the nearer planets. In short, NASA will be able to perfect its communications, guidance, and propulsion systems over the lunar distance—about a quarter of a million miles—and thus get "practice" for the longer voyages to Venus and Mars. ■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CIVIL AVIATION

THE AIRLINES

IN COMMERCIAL air transportation the year 1960 was one during which the doors opened wider on the jet age. It was a year the U.S. scheduled airlines, well into their $3 billion jet equipment program, were taking delivery on 155 pure jets and 39 turbo-prop planes, or at a rate of about one new jet-powered plane every 44 hours, thus adding an additional billion dollars worth of the finest, fastest and most thoroughly tested aircraft to their fleet. These were in addition to a jet fleet which at the end of 1959 included 85 pure jets and 313 prop-jets.

While statistics for the first six months of 1960 showed that the scheduled airlines were digesting their added capacity at what might be termed better than average, airline earnings were not as good as in 1959. For the most part, this may be attributed to a doleful first quarter in which numerous factors seemed to conspire with unusually severe weather to produce an over-all industry loss. Recovery started in April and the picture became brighter later in the year. Traffic-wise, 1960 was expected to be a record year for the airlines.

Coach service, which started in 1949, by 1959 on the domestic trunk lines had become more than 43 per cent of the revenue passenger miles and in June, 1960, for the first time passed first class traffic with 1.4 billion revenue passenger miles compared to 1.2 billion first class passenger miles.

In 1960 there were 55 airlines in the United States which had been certificated by the Government to render scheduled airline service, and their dollar turnover—that is, money taken in and paid out—was estimated at approximately five billion dollars, a reasonable estimate when one remembers it takes 100,000 different goods and services—from wingtip lights to teletype circuits to advertising—to keep the airlines flying.

REVENUE PASSENGERS FIRST EIGHT MONTHS

	First Eight Months 1960 (000)	*First Eight Months 1959 (000)*	*% Change*
Domestic Trunk Lines	30,493	29,316	4.0
Local Service Lines	3,679	3,395	8.4
Helicopter Carriers	333	226	47.3
Intra-Hawaiian Carriers	600	501	19.8
International & Overseas	3,556	3,204	11.0
Alaskan Carriers	252	249	1.2
Total	38,913	36,891	5.5

CONSOLIDATED AIRLINE TRAFFIC AND FINANCIAL DATA FIRST SIX MONTHS

	First Six Months 1960 (000)	*First Six Months 1959 (000)*	*% Change*
Revenue Passenger Miles	18,871,126	17,125,977	10.2
Revenue Ton Miles Traffic			
Passenger	1,813,376	1,643,331	10.3
U.S. Mail (Priority)	95,544	85,729	11.4
U.S. Mail (Non-priority)	9,696	8,618	12.5
Express	28,206	26,123	8.0
Freight	302,135	275,444	9.7
Charter Flights	159,204	150,648	5.7
Excess Baggage & Foreign Mail	26,297	25,732	2.2
Total Revenue Ton Miles	2,434,458	2,215,626	9.9
Summary of Profit or Loss			
Total Operating Revenue	$1,372,393	$1,234,981	11.1
Total Operating Expenses	1,369,584	1,178,428	16.2
Net Operating Income or Loss	2,809	56,553	(95.0)
Interest on Long Term Debt	30,849	21,002	46.9
Other Non-operating Income	18,997	27,547	(31.0)
Income Taxes	3,851	32,500	(88.2)
Net Profit or Loss	$ 12,894	$ 31,598	......

Commercial scheduled service was available to all U.S. cities over 100,000 population; to more than 75 per cent of those with over 10,000 population; and to 50 per cent of those communities with a population of over 1,000. These cities were receiving more than 20,000,000 ton miles of available airlift every day.

The airline industry in 1960 was becoming more and more a major factor in the country's economic picture. Hundreds of thousands of workers are employed by the airlines and the thousands of firms which supply the airlines or airline customers

In the case of the domestic trunk lines alone employees got $764 million or 42.5 per cent of all revenues in 1959.

Most of the fifty-five airlines operated conventional aircraft and serve passengers, shippers of freight and express, and the Post Office. Others were certificated for selected types of traffic or for the operation of specific types of aircraft, such as the helicopter airlines.

THE U.S. airlines became in 1960 the No. 1 form of intercity, common carrier travel in the United States, as measured by revenue passenger miles. Ranked well below railroads and bus lines in 1950, when they carried only 14 per cent of this traffic, at the rate of increase shown during the first six months of 1960, the airlines were expected to exceed the combined total of train and bus passenger miles between American cities.

In the international field, airlines replaced steamships as the No. 1 form of passenger travel. In 1950 the airlines carried less than half of the total passenger traffic between the U.S. and foreign countries. In 1960, more than 75 per cent of this traffic moved via air and the remainder by sea.

At the end of June, 1960, tourist service on the North Atlantic ended and the three class service which had been operated since 1958 became a two class service—first class and economy. This two class service also applied in other sections of the world. In addition, the international carriers added an experimental 17-day off-season excursion across the Atlantic between October 1 and March 31, with lower rates.

In the helicopter segment of the industry the gain in passengers during the first six months of 1960 was more than 65% with a total of 243,000 passengers.

In 1959, latest year for which complete figures are available and the first full year of the jet age, the U.S. airlines flew almost 56 million passengers. That was 6 million more passengers than were flown in the previous year and is the industry's greatest single-year increase.

The growth and impact of air transportation was outstripping the country's rate of growth in general. For example, while the gross national product increased about 68 per cent in the "Fifties," airline passenger traffic increased more than 300 per cent.

Despite this impact, commercial air transportation in 1960 is something of a statistical paradox. The certificated air carrier system accounted for but 2 per cent of the total civil aviation plane fleet and 16 per cent of the total hours in the air. Yet it transported nearly 60 million passengers and accounted for more than 90 per cent of the ton miles of traffic flown; and, in 1960, it was presently flying well over 60 per cent of the world air traffic outside the Iron Curtain.

The year 1960 saw the use of credit flying continuing to increase and it was estimated that approximately one out of four Americans are now saying "charge it." The defaults stemming from credit flying were relatively few in number. With some of the airlines, "on the cuff" travel was increasing at an even faster pace than passenger traffic itself. In 1959, the latest year for which full figures were available, net passenger billings for all forms of credit flying were nearly 21 per cent of their income from passengers and excess baggage. In the case of the trunk lines alone, the figures were more than 24 per cent.

IN the year 1960, the airlines continued to work on improving service in such matters as handling of reservations, baggage and connections. Through the Air Traffic Conference of the Air Transport Association they were having (1) a $73,000 study of interline procedures made by the Armour Research Foundation of the Illinois Institute of Technology; (2) a $10,000 study of interline baggage handling made by the Baggage Handling Subcommittee of the Ticketing and Baggage Committee of the Conference and; (3) an Interline Connections Committee giving continual attention to connecting times and schedules. In addition, the airlines are spending millions of dollars on the development of electronic reservations systems.

Aircraft noise is a problem that has concerned the airline industry for some years and the advent of the jet that makes a different sound from other large planes brought the problem more sharply into focus. Recognizing the national factors involved, the aviation industry was doing everything possible in the public interest, and despite the fact that the Federal Aviation Agency assumed responsibility in this field, the Aerospace Industries Association, the Air Line Pilots Association and the Air Transport Association formed a new organization, the National Aircraft Noise Abatement Council. The purpose of the Council was to make certain aviation was taking every possible step, nationally and locally, to abate noise.

Even before the first pure jet was flown, the manufacturers, it was estimated, spent $50 million on research development and testing noise suppressor devices. From the start the airlines equipped their four-engine pure jetliners with sound suppressors that use some 500 extra gallons of fuel, or 5 per cent of the 10,000 gallons a jetliner takes on for a coast-to-coast flight. It was estimated that the cost is about $1.7 million a month to operate the noise suppressors.

In 1960, the airline industry went on record that the United States should seriously consider starting the development of a supersonic transport capable of a cruising speed that would make possible the crossing of the country or the Atlantic in about two hours.

Stuart G. Tipton, president of the Air Transport Association, representing the scheduled airlines, testified before Congress at hearings on the feasibility of a supersonic transport, that the whole history of transportation indicated that such a plane will be built as the basic requirements of safety, comfort and cost are met. Reporting that the United Kingdom, Soviet Russia and the French in cooperation with West Germany were considering such a plane, he said: "The United States has traditionally maintained world leadership in aviation and there appears no sound reason why we should relinquish it." ■

ALLEGHENY AIRLINES

DURING 1960, Allegheny achieved several important corporate objectives and recorded new highs in all categories of service and traffic.

Chronologically, some of the high points of Allegheny's year, included:

* During February, the company completed an $11,725,000 financing program, and inked a contract with Napier Engines Inc. for the delivery of a fleet of jet-powered Convair 540s.
* Eleven Convair 340/440s were added to Allegheny's fleet during March.
* On April 12, the airline inaugurated the first phase of its new services into New England over routes awarded by the Civil Aeronautics Board at Boston, Providence, Bridgeport and New Haven.
* On May 20th, Allegheny proposed high-frequency, "no-frill" nonstop commuter serv-

ALLEGHENY introduced to passenger service the turboprop Convair 540

At an accelerating rate, Allegheny continued its "battle against red-tape" during 1960, eliminating wherever feasible time-consuming steps which have historically irritated airline passengers, particularly on short trips. Reconfirmation and check acceptance restrictions were removed; a plan by which two or more passengers traveling to the same Allegheny destination could be ticketed and processed as one was adopted.

ice between Washington and New York.

* June 1 brought the addition of New London/Groton to Allegheny's growing system and new north-south services at Trenton, N. J. and Wilmington, Del.
* On July 10th, with Civil Aeronautics Board approval, the airline extended its reduced-rate "commuter" fares to Boston-Philadelphia and Providence-Philadelphia flights.
* On September 1, the final phase of introductory service on Allegheny's New England routes got underway as service began at Hartford/Springfield and MacArthur Airport, serving the central-eastern Long Island Airport. Reading, Pa. became the 38th airport on the airline's 12 state system.
* The latest version of the jet-prop Convair 540 was introduced to travelers in several major eastern cities during October. Radar-guided and equipped with Lear's LIFE System, the 325 mile-per-hour, 52 seat turboprop is among the largest, and fastest aircraft in the nation's local service fleets.
* Late in 1960, Allegheny became the first local service carrier to offer its customers a "fly now-pay later" plan.

Throughout 1960, Allegheny continued to set new traffic records. With passengers exceeding 1959 by an average monthly rate of 25% and revenue passenger miles topping the previous year at a monthly rate of 43%, Allegheny expected to carry nearly 725,000 passengers during 1960.

The airline's services and airlift capacity grew at a comparable rate. During 1960, Allegheny added 15 aircraft to its fleet; the employee roster increased from 950 to 1,350.

At year-end, the airline was scheduling 95 flights daily, serving nearly 100 cities, including 9 of the nation's 14 largest centers.

In the area of route development, Allegheny actively sought extensions of its system to such cities as Toronto, Norfolk, Nashville and Louisville.

Allegheny introduced its "new look" during 1960, featuring a new Jet Age tail insignia and color scheme on all aircraft and incorporated in advertising and promotional literature. Allegheny's familiar green was replaced by red and varying shades of blue.

ALOHA AIRLINES

THE YEAR 1960 saw Aloha Airlines expand its fleet of turbine-powered aircraft from three to six Fairchild Jetprop F-27s. In addition, the airline was operating six DC-3 Vistaliner aircraft, featuring five-foot panoramic picture windows. In July the airline completed its fourteenth year of operations with a perfect record of safety. In August, Aloha carried 50,696 passengers for a new record of passengers carried in any one month. On Labor Day, September 5, the airline set a new one-day record when 3,235 passengers were carried.

Aloha completed and moved into its new administration building in September. The building, first structure to be completed in the new Honolulu International Airport complex, houses the airline's executive, accounting and reservations control personnel. The front portico of the soundproof air-conditioned building features a twenty-nine foot mosaic mural created especially for the airline in Cremona, Italy. The airline's new shops and hangar facilities will be completed early in 1961.

Aloha carried more passengers between the Hawaiian Islands in 1960 than in any year of its history and looks forward to a record-breaking 1961.

AMERICAN AIRLINES

AMERICAN AIRLINES, inaugurator of transcontinental jet service two years ago, concentrated in 1960 on stepping up service on numerous intermediate routes with its Boeing 707s.

The airline continued to break records for passenger miles and rolled up impressive gains in airfreight. As the year drew to a close, American was ready to pioneer a further giant stride into the jet age with the equipping of its entire jet fleet with powerful new turbofan engines. The fan-engined airplanes will be called "Astrojets" to distinguish them as possessing the "fan-type" powerplant.

The year saw such cities as Cleveland, St. Louis, Detroit, Toronto, Phoenix, Tucson and St. Louis served by American's jets for the first time. Expanded schedules were instituted between such previously jet-served routes as Boston-Chicago, Detroit-Los Angeles and New York-Chicago, where at year-end 17 out of 24 daily flights were by jet.

Also at year-end the airline unveiled its brand-new jet—the Convair 990—powered by General Electric turbofan engines.

Much of the new 1960 intermediate service was made possible through the introduction of the smaller, faster model 720 of American's big 707 Boeing jets. The 720, about eight feet shorter than the 707, normally accommodates 98 passengers, 20 fewer than the larger Boeing, and is designed to cruise at speeds near 615 miles per hour.

The year saw the passing from transcontinental service of the DC-7, the airliner with which American first pioneered non-stop coast-to-coast passenger service. American's DC-7s were switched to shorter routes where they upgraded service previously supplied by slower piston airplanes.

As American took the wraps off the Convair 990, which is expected to go into commercial service in the late summer of 1961, it was also testing aloft 707s and 720s equipped with the new Pratt & Whitney turbofans. These re-equipped airplanes were expected to appear in substantial numbers on American's routes in the early part of 1961. American expected to become the first airline to equip its entire fleet with the more powerful, more economical turbofans, considered the biggest development since the advent of the jets themselves. The turbofan "Astrojet" fleet, when complete, will consist of 25 of the 707s, 25 of the 720s and 25 of the 990s.

In October, American carried its 2,000,000th jet passenger, within a few days of carrying its 2,000,000th Electra passenger. Both the 707s and the turbine-powered Electras, of which American has 33, were jet-age companions introduced about the same time in 1959. Arrival of the additional 707s on intermediate routes permitted American to free Electras for stepped-up service on such short routes as New York-Boston, New York-Washington and Chicago-Detroit.

Cargo shippers took increasing advantage of the expanded jet schedules, including the service to new cities, to "ship when ready" and

AMERICAN expanded its airfreight fleet to 13 DC-7F's, broke all freight records gain full advantage of airfreight speed.

In October, American flew 11,201,000 ton miles of airfreight, setting for the second successive month a new record for domestic airfreight volume for any month and marking the first time any domestic scheduled airline exceeded 11,000,000 ton miles in a single month.

The company's DC-7F airfreight fleet reached a total of 13 by the end of 1960. The DC-7F, converted from the passenger-carrying DC-7 into an all-freight aircraft, cruises at 350 miles an hour and is capable of lifting 33,500 pounds of cargo non-stop from coast-to-coast.

On September 1, American launched the first DC-7F airfreighter service linking the United States and Mexico. The DC-7Fs fly from New York to Mexico City five days a week with stops at Detroit, Dallas and San Antonio.

In 1959, American became the nation's first airline to fly more than 100,000,000 ton miles of scheduled airfreight. The total in 1960 was 115,000,000 ton miles—some 12 percent over the 103,000,000 carried in 1959. Contributing to this 1960 record-smashing figure was increasingly heavy use by shippers of jetfreight. The airline also introduced "Truckair" in 1960, a nation-wide combination of truck and air service linking 575 communities with more than 60 cities on American's airfreight network.

In 1960 American carried 8,614,000 passengers a total of some 6,410,000,000 passenger miles.

American, along with other major carriers, received a much-needed boost in transcontinental jet coach fares in 1960. The boost restored these fares to about 75 per cent of first class fares. They had fallen to 60 to 65 per cent of first class and brought a drop in revenue as more passengers, impressed by the swiftness of jet travel, elected to ride in the slightly less luxurious coach sections.

Early in the year, American opened its new $14,000,000 passenger-tailored air terminal at New York International Airport. A combination of the aesthetic and the functional, the new terminal's exterior is highlighted by a 317-foot sweep of stained glass facade and distinguished by enclosed jetways that enable passengers to enplane and deplane without exposure to the elements.

The airline reported that "Aircheck," which it introduced in 1959, continued to exceed all expectations in 1960. "Aircheck" enables corporations literally to write their own tickets for air travel by their employees in their own offices on American and 32 other airlines, including helicopter lines. Businessmen use "Airchecks" at the rate of more than 7,000 a month.

Even American's Stewardess College at Fort Worth, Tex., got caught up in the record-breaking. Eight hundred girls were scheduled for enrollment in 16 classes during 1960, compared with 722 in 1959. More girls were needed because of American's expanding air fleet with its stepped-up requirements. Four girls serve on 707s, while many Electra runs require three stewardesses.

Charter mileage on American got a substantial boost from the Presidential campaign. American's DC-6s, Electras and 707s flew more than 150,000 campaign plane miles for all four major candidates, their parties and the accompanying press.

For the most part, President-elect John F. Kennedy flew in his own Convair, but the two specially-fitted American Airlines airplanes that accompanied the Convair carried the Kennedy staff, occasionally the candidate himself, and the press more than 75,000 airplane miles. Lyndon Johnson flew 34,000 miles in an American Electra and about the same mileage was logged with American by Richard M. Nixon. Henry Cabot Lodge flew almost 7,000 miles with American.

Most of the airplanes that were in regular use in the campaign had seats taken out to make way for desks, duplicating machines, beds and other special equipment. Use of the 707s and 720s made it possible for the candidates to make some spectacular "jet stop" tours, sometimes covering thousands of miles in a 24-hour period.

BONANZA AIR LINES

HIGHLIGHT OF Bonanza's 1960 year was retirement from scheduled service of its last DC-3, which made the airline the first in the U.S. to operate an all-turbine fleet. The event occurred in November, after which Bonanza served its schedules exclusively with the Fairchild F-27 Silver Dart.

During 1960, Bonanza was involved in two major route proceedings. In the Pacific Southwest Local Service Case, the airline sought to provide Silver Dart service on four new segments and to have operating restrictions removed on two other segments. The applications being pressed by Bonanza in this case were 1) Las Vegas-Fresno-Oakland/San Francisco (with non-stop authority); 2) Reno-Sacramento-Oakland/San Francisco; 3) Las Vegas-Palm Springs-San Diego (with non-stop authority); 4) Reno-Fresno-Bakersfield-Ontario-Palm Springs-San Diego (with two-stop authority). Bonanza was also seeking non-stop authority between Las Vegas and Los Angeles and non-stop turnaround authority between Los Angeles and San Diego.

In the Southern Rocky Mountain Area Local Service Case, Bonanza was pursuing applications for these routes: 1) Phoenix-El Paso, non-stop and via Tucson, Fort Huachuca and Bisbee/Douglas; 2) Phoenix-Los Angeles with one intermediate stop; 3) non-stops Tucson-San Diego, Tucson-Los Angeles, Tucson-El Paso; 4) Las Vegas-Albuquerque via Grand Canyon, 5) Tucson-Yuma; 6) Las Vegas-Denver, via Page and Grand Junction (with skip-stop authority); 7) Las Vegas-Salt Lake City, non-stop and with local service via St. George, Cedar City and Provo.

Bonanza completed its 14th year of operations in August, 1960. At year end, the airline was operating eight F-27's over 2,244 route miles. Bonanza had 500 employes and an annual payroll of about $3,300,000.

BRANIFF INTERNATIONAL AIRWAYS

HIGHLIGHT OF Braniff International Airways' activities during 1960 was the expansion of the airline's route to Mexico City. The new route was authorized under a bi-lateral air transport agreement between the governments of Mexico and the United States. Inaugurated November 9, the new route provided the first direct, one airline service from the north central section of the U.S. to Mexico.

Another important development during 1960 was the phase-in of the airline's entire initial order of pure jets and turboprop equipment as well as the complete retirement of DC-3 aircraft from its fleet. At year-end Braniff operated four Boeing 707-227 and eight Lockheed Electra airplanes in addition to its piston-engine equipment.

During the year, pure jet service was expanded to include such additional Braniff-served cities in the U.S. as San Antonio and Houston and to Panama, Lima, Peru; Buenos Aires, Argentina; Sao Paulo and Rio de Janeiro, Brazil, and Bogota, Columbia. The airline

BONANZA became an all-turbine airline, flying Fairchild F-27A Silver Darts

inaugurated its first pure jet service to Dallas, Chicago and New York in 1959.

Braniff also placed an order during 1960 for three Boeing 720-027 jet aircraft for delivery one each in February, April and September, 1961.

A prominent development in 1960 was the vast expansion of the coach service offered by Braniff. Available coach seat miles during the first nine months of 1960 increased 109.6 per cent over the same period in 1959, and revenue coach seat passenger miles advanced 92.6 per cent.

The year also was an important one in the field of Braniff's air freight activities. This was due to the additional lift capacity of the jets and turboprop aircraft as well as the purchase of a four-engine all-cargo plane which went into service between Dallas and New York in December.

CANADIAN PACIFIC AIRLINES

DURING A YEAR of expansion for Canadian Pacific Airlines in 1960, the company took a major step towards a globe-circling air service by establishing the first Canadian air link between Canada and Italy, ordered a fleet of Douglas DC-8 airliners, and achieved all-time record passenger and cargo increases.

CPA became the first Canadian carrier to provide direct service between Canada and Italy on March 4, when jet-prop Britannias began twice-weekly service from Toronto and

CANADIAN PACIFIC ordered four Douglas DC-8's, optioned for five more

Montreal to Rome, via Lisbon.

In commenting on the air agreement which gave CPA the right to operate to Rome, Canadian Transport Minister, Honorable George Hees, stated that the agreement with Italy "represents an excellent basis for ultimate expansion of service around the world."

If granted the necessary permission, CPA would operate a non-stop service between Rome and Bangkok as the final link in a round-the-world route. Rome is one of the greatest collection and distribution funnels for Europe, while Bangkok is an equally important traffic center for all Asia.

To meet "pure jet" competition on its international and domestic route pattern, CPA ordered a fleet of $6,000,000-dollar DC-8 jet airliners last October. These aircraft were to be delivered early in December this year.

The 159-passenger DC-8 will be equipped with Rolls-Royce Conway Mark 15 engines capable of developing 18,500 pounds of thrust.

As part of its jet program, CPA has joined 19 other major international air carriers to form a world-wide pool of jet equipment.

The company will act as "host" airline in Vancouver and two other bases on its route pattern, as yet undesignated, supplying engines, parts and ground support equipment to members of the world pool. As an operating member, the airline will participate in parts and equipment sharing at Rome, Toronto, Montreal, Tokyo, Amsterdam, and other overseas destinations served by the Company.

As a pool member, CPA will save 75 per cent of the cost of jet spare parts it would normally have to stock at Vancouver and other route points. For a capital outlay of approximately $250,000, the airline will be able to draw on $1,000,000 worth of spare parts.

CPA was building up a stock of over $160,000 worth of spare parts and equipment at its Vancouver maintenance headquarters as its contribution to the pool in that city.

Reflecting the popularity of the company's service both in Canada and overseas, passengers carried by CPA on its Canadian transcontinental and overseas routes increased by a record 55.7 per cent during the first six months of 1960, over the corresponding period last year. Air cargo uplifted on these routes increased by 35.2 per cent.

During the first half of 1960, the airline carried over 86,000 passengers, and 844,256 lbs. of cargo on these routes.

The company's transcontinental service was largely responsible for the great gains in passenger traffic. International traffic flying across Canada increased significantly because the transcontinental service links the airline's network of international services at Vancouver on the West Coast, and at Montreal, in eastern Canada.

In May, 1960, the company established an all jet-prop service linking both eastern and western Canada with Mexico, Peru, Chile and Argentina. CPA replaced its 300-mile-an-hour Super DC-6Bs with 400-mile-an-hour Britannia airliners on its Latin American network south of Mexico City.

At year-end, CPA employed approximately 2700 employees, including 210 pilots and 180 cabin attendants.

CAPITAL AIRLINES

ANNOUNCEMENT OF a plan to merge Capital into United Air Lines was the most significant development at Capital Airlines in 1960. The merger proposal, which was formally announced by both carriers in July, was under consideration by the Civil Aeronautics Board at year-end. Other major actions by Capital in 1960 were an increase in the company's air-coach operation and a plan to lease Boeing 720 pure jet airliners for jet service between Miami and the Great Lakes area in early 1961.

The course towards merger was taken by Capital after a first quarter period of severe operating conditions forced the company into a financial situation which was climaxed by the announcement that Vickers-Armstrongs Ltd., British manufacturers of the Viscount, had started proceedings leading to foreclosure of the chattel mortgage held on Capital's fleet. Efforts to develop a plan for refinancing of the Vickers debt and for acquisition of pure jet equipment proved unsuccessful, and Capital then turned to its only alternative—merger. Under the direction of the board chairman, Thomas D. Neelands, Jr., a prominent investment banker and merger expert, an agreement was reached with United which both carriers felt would best protect the interests of Capital employees and stockholders and the traveling public in general. Stockholders of both United and Capital approved the merger on October 14, and the Civil Aeronautics Board Examiner conducted hearings on October 19. The two airlines requested that the CAB expedite the proceedings so that the merger might become effective by February 1 of next year.

The program for expanded coach service was announced in March at Capital's yearly sales conference held in Williamsburg, Virginia. The plan called for leasing of additional DC-6B airliners from Pan American World Airways to be used on the Great Lakes to Florida run as well as Capital's major east-west routes. A total of eleven DC-6Bs were involved in the leasing agreement, representing a 35 per cent increase aircoach revenue seat mile capacity over Capital's 1959 figure. The DC-6Bs carried 88 passengers and featured comfortable, luxurious interiors accenting a new concept of de luxe aircoach service, called Cardinal Coach flights, which the company introduced in the spring of 1960.

Late October saw the announcement of Capital's plan to lease Boeing 720 jet airliners for service between Miami and the Great Lakes cities of Cleveland and Pittsburgh. Two daily round trips between Miami and each of the two northern centers were to begin in early January, 1961. The new Capital pure jet flights will feature four classes of service, one of which should appeal to everyone desiring a Florida vacation this winter. The Boeing 720s were to be leased from United Air Lines.

Other significant developments at Capital in 1960 were:

- Introduction of Festival Fares from 46 cities on Capital's system to New York City. The innovation in economy travel, calling for reductions of 25 per cent in first class fares and 18 per cent in coach fares, was tied-in with New York's famous Summer Festival event. A joint air fare and New York tour package promotion, the Capital Festival Fare plan resulted in the sale of 2,000 tour packages to Summer Festival visitors, an increase of 100 per cent over Capital's total New York package sales for the entire year of 1959. Capital estimated that its new program channeled about a quarter of a million dollars into New York's traditional soft summertime economy in the form of monies spent at hotels, restaurants, theaters and sightseeing establishments.
- Inauguration of Air Bus Service between Pittsburgh and Miami. Air Bus flights were started in October and were aimed at attracting travelers who normally use train, bus and private auto for their transportation on vacations to Florida. Main feature of the service is a $40 one way fare which compares favorably with all forms of surface travel. It is a "no frill" operation which offers fast, comfortable transportation without some of the extras for which other travelers pay more, such as en route meals.
- A new corporate identity and trademark for Capital designed to better reflect the company's goals and service standards. The new trademark is a "flowing oval" with the company name imprinted on a panel of Capital blue. The program called for the new trademark to appear on company aircraft, advertisements, letterheads and all other material visible to the public.

• Introduction of new service between West Palm Beach, Florida and the Great Lakes and between Youngstown, Ohio and Florida.
• Development of a new "write-it-yourself" ticket, called Air Travel Check, for use by Capital's commercial accounts.

CHICAGO HELICOPTER AIRWAYS

CHICAGO HELICOPTER AIRWAYS experienced considerable expansion during 1960, both in terms of passengers carried and frequency of flights.

Starting the year with 138 daily flights in the Chicago area and suburbs in Illinois and Indiana, CHA increased frequency to 206 flights by year-end. The airline was providing 2,292 seats on 191 daily flights on its service to Midway Airport, O'Hare Field and the Chicago Loop (Meigs Field). In addition, it was offering seven flights to Winnetka, Illinois, and eight to Gary, Indiana, daily except Saturdays and Sundays.

CHA carried more than 320,000 passengers in 1960, increasing the total since it started operations in 1956 to 675,000. The 1960 traffic figure represented a 50% gain over 1959. CHA hoped to carry its 1,000,000th passenger before its fifth birthday on November 12, 1961.

The City of Chicago started construction on a new terminal building at Meigs Field, where CHA expected to occupy new facilities on completion.

At year-end, CHA was operating a fleet of seven Sikorsky S-58 12-passenger helicopters for passenger service and four Bell 47G's for its suburban airmail service to 54 communities near Chicago. The company had on order six, twin-turbine, 25-passenger Sikorsky S-61's, which were to go into scheduled service after mid-1961.

CONTINENTAL AIRLINES

CONTINENTAL AIRLINES, a small regional airline just a few years earlier, made great strides as a trunk carrier in 1960.

During the year, the Denver-based company expanded its operations considerably. Vying with larger airlines in the highly-competitive Chicago-Kansas City-Denver-Los Angeles market, Continental captured a healthy share of the business with intensive participation of its Golden Jet Boeing 707s. Between Los Angeles and Chicago, for example, Continental offered 13 jet flights daily, more than any other airline.

DELTA was first to inaugurate

On September 25, Continental further expanded its pure jet operations by inaugurating Boeing 707 flights between Houston, El Paso and Los Angeles on interchange with American Airlines. In addition, Continental said it was ready to start immediate service on any new routes granted it by the Civil Aeronautics Board. The company had applications pending to extend its system between mainland points and Hawaii, and between Texas, Arizona, Nevada, and northern and southern California.

The year 1960 saw Continental gain its reputation as a highly efficient jet operator with a utilization program that ran like clockwork. CAL recorded an average daily utilization of 10 hours, 42 minutes per Boeing 707. Some of Continental's Golden Jets were flying two round trips between Los Angeles and Chicago in one 24-hour period.

Continental's rapid growth was strengthened considerably when the company obtained the first long-term financing in its 26-year history. New loans, totalling $42,000,000, enabled CAL to refinance its bank debt with an extended repayment schedule running to December 31, 1972, and to secure $8,000,000 in additional funds.

The refinancing permitted Continental to substantially reduce its current short-term debt due within one year, to purchase its fifth Golden Jet Boeing 707, and to materially improve the company's working capital position.

In addition to the five Boeings, Continental's fleet consisted of 13 jet-powered Viscount IIs,

service with the new Convair 880

five DC-7Bs, one DC-6B, and six (leased) DC-3s.

Continental continued to phase out its surplus piston-engine aircraft, aiming at full transition to the jet age. In 1960, the company's jet-powered planes accounted for more than 83 per cent of the company's total daily seat miles, the highest percentage in the industry.

Total number of employees over the company's eight-state, 42-city, 6,000-mile system grew to 2,800, compared to 2,400 in 1959.

The extent of Continental's growth was shown further in the fact that revenue passenger miles flown during the first three quarters of 1960 totalled 681,600,000, compared to 469,900,000 for the same period in 1959, an increase of 45 per cent.

DELTA AIR LINES

DELTA AIR LINES, in 1960, scored many "firsts" in the field of pure jet operations.

Already the first airline to inaugurate service with the 119-passenger Douglas DC-8 jet (on September 18, 1959, between New York and Atlanta), Delta in 1960 was first to introduce Convair 880 jet service, first with all-jet operations at Idlewild, first to own two fleets of pure jet aircraft, and first to operate all three of the American-built jets (with the Boeing 707 on the American-Delta-National interchange route).

During the first year of operation, Delta's $88,000,000 jet fleet flew over 6,200,000 miles in scheduled service—equal to 14 round trips to the moon—and carried over a half million passengers.

With six DC-8's in operation, Delta was offering DC-8 jet service between New York-Atlanta, Chicago-Miami, Miami-Atlanta, Atlanta-Chicago, Dallas-Atlanta, Miami-Detroit, and Chicago-Tampa-Miami. Tampa, the newest city in Delta's DC-8 service pattern, received its first jet service on May 15, 1960.

DC-8's were also in operation between Atlanta and Los Angeles via Dallas and Ft. Worth, on the Delta-American interchange route.

On May 15, 1960, Delta inaugurated Convair 880 jetliner service between New York-Atlanta, New York-Houston, and New York-New Orleans.

Delta, which had nine all-first-class Convair 880's in operation at year-end, with three more on order, added the 615-mile-per-hour "Aristocrat of the Jets" in round-trip service, as follows: July 1—New York-New Orleans-Houston; New York-Atlanta-Dallas; August 1—Chicago-Houston; Chicago-Memphis-New Orleans; Atlanta-Chicago; Oct. 30—Houston-New Orleans-Washington/Baltimore (via Friendship Airport)-Philadelphia; Houston-St. Louis-Chicago; Dec. 16—Cincinnati-Miami; and Chicago-Miami.

The introduction of Convair 880 service to Memphis and Cincinnati marked the first jet service for those cities.

The swept-wing Convair 880 is powered by four General Electric CJ-805 jet engines—an adaptation of GE's J79 engines, which supply the thrust for the 1,500 mile-an-hour B-58 "Hustler" bomber.

On a delivery flight on February 10, 1960, Delta's first Convair 880 set a new southern transcontinental speed record by flying the 2,359 miles from San Diego, Calif. to Miami, Fla. in 3 hours, 31 minutes, 54 seconds. The average speed was 665 miles an hour.

Another Convair 880 jet spanned the Southern Transcontinental route between San Diego and Atlanta on May 11 in 3 hours 24 minutes and 59 seconds. Carrying press, radio, and television newsmen from throughout the nation, the plane averaged 580 miles an hour.

A new experiment in airport facilities was the modernistic jet terminal building constructed in 1960 by Delta and United Air Lines at Idlewild Airport. Completely air-conditioned, the terminal has smartly decorated passenger areas, restaurants, coffee shops, and cocktail lounges, with ample parking facilities.

Electronic aids and efficient counter procedure cut down check-in time.

The terminal will utilize the Delta passenger jetway, in use at Atlanta and secheduled for early installation at Chicago and Miami. With a gross weight of 12,000 pounds and a height of 12 feet, the two-level Jetway can be extended to a maximum of 6 feet, moving from an attached position at the terminal side to an airliner door in just a few seconds. Passengers disembark from the plane into the terminal without ever setting foot on the ground.

Delta's DC-8's were operating an average of 7 hours 17 minutes a day, or 1130 hours a month; the Convair 880's had a daily utilization of 5 hours 12 minutes (935 hours a month). Average stage length of the medium-range Convair 880 was 844 miles.

Maintenance on Delta's jet fleet was performed at jet hangars in Dallas and Miami (completed in 1959) and at the airline's multi-million dollar jet overhaul center completed in 1960 at the Atlanta Airport, its home office. Approximately 1,700 persons were employed at the huge Atlanta facility, which has the largest doors (open area) of any such structure in the United States and possibly the world. More than 45 departments at the base were capable of overhauling every system and every component of the big jets—from airframe structure to the most intricate radar equipment.

Another jet addition to Delta's maintenance and flight training program facilities was the million dollar simulator, manufactured by Link Aviation, Inc., which realistically duplicates all flying conditions in the Convair 880 cockpit from take-off to touchdown, including instrument simulation cockpit motion, and sound simulation. First to install the Convair 880 simulator in service, Delta used it to train flight crews and also mechanics and inspectors who compose Convair 880 ground crews.

Yielding to the more modern means of transportation, Delta's DC-3 fleet was retired in 1960 after almost 20 years of dependable service. Commemorative covers, marking the End of an Era, were flown on the last DC-3 flight from Knoxville to Atlanta on October 29, 1950.

Public acceptance of jet travel was excellent, and Delta's jet fleets were producing in average load factor of approximately 65 per cent.

Marked gains were recorded in all categories of traffic for the first 10 months of 1960. The company's operating revenues totalled $108,-657,000, up 21 per cent over the first 10 months of 1959. Net earnings after taxes of $2,457,000 equaled $2.19 per share, compared with $2,-047,000 and $1.82 a share the previous year.

Estimating the final days of December, Delta will carry 3,390,000 passengers a total of 1,-870,000,000 miles. This represents a 10 percent increase in passengers and a 15 percent increase in passenger miles over 1959.

Four cash dividends of 30 cents a share each were paid on March 1, June 1, September 1, and December 1, marking the 12th consecutive year of such payments.

Delta, which pioneered the trans-southern route in 1929, had been seeking a direct route to the West Coast for over 10 years. The Civil Aeronautics Board's Bureau of Air Operations on December 15, 1959, recommended in the pending Southern Transcontinental Case that Delta be awarded an Atlanta-West Coast route, and CAB Examiner Edward T. Stodola, on June 20, 1960, also recommended the extension of Delta's trans-southern route west of Dallas and Fort Worth via Lubbock, Albuquerque, Tucson, Phoenix, and San Diego to Los Angeles/Long Beach, and via Las Vegas to San Francisco/Oakland. A decision was expected at the end of the year.

EASTERN AIR LINES

THE YEAR 1960 marked the full entry of Eastern Air Lines into the jet age, and a turning point in its approach to the problems of development of broader markets for air transportation.

Eastern started the year with an intensive training program on its new Douglas DC 8-B jets, equipped with the larger Pratt & Whitney J75 engines which do not require water injection. The first passenger-carrying schedules with these aircraft were flown between New York and Miami on January 24th, and by the year's end 11 of an initial order for 16 DC 8-B jets were in service over principal routes linking New York not only with Miami, but also with Mexico City, D.F.; San Juan, Puerto Rico; West Palm Beach and Tampa, Fla.; Atlanta, Ga.; New Orleans, La.; and Houston, Tex.; Chicago with Miami; Detroit with Miami; and Boston with Philadelphia and Miami.

During the latter part of the year Eastern placed additional orders for jets with the Boeing Airplane Company—15 of the type 720 medium to long-range jets for delivery in 1961 and 1962, and 40 of the type 727 short to

EASTERN Air Lines introduced jet service between New York and Miami on January 24. By year-end, the line was operating 11 of an initial order of 16 Douglas DC-8B's. Projecting further jet expansion, EAL ordered 15 Boeing 720's for 1961 delivery and 40 of the medium range Boeing 727's to be placed in service in 1963.

medium-range jets to be placed in service in 1963.

With these orders, plus the large fleet of prop-jets which were introduced in 1959, Eastern's investment in jet-powered equipment will rise to nearly one-half billion dollars, and Eastern will become one of the first of the world's air carriers to equip itself with jet aircraft for all trunkline services, both medium and long-range, to replace propeller-driven equipment now in operation.

Under the leadership of Captain Eddie Rickenbacker, Board Chairman, and Malcolm A. MacIntyre, Eastern continued to add to its route structure and to plan ahead for further expansion of its ground facilities.

New cities placed on Eastern's map in 1960 included Cincinnati, O., Milwaukee, Wisc., and Minneapolis/St. Paul, Minn. Authorization was granted by the CAB late in the year also to serve Sarasota/Bradenton, Fla.

Among the new passenger terminals into which Eastern moved during the year were notably those at Ottawa and Montreal in Canada; Corpus Christi, Tex.; Savannah, Albany and Macon, Ga.; Ashland/Huntington, Ky.; Melbourne, Fla.; and Winston-Salem, N.C. At New York's fabulous International Airport, Idlewild, the first anniversary of the opening of Eastern's own $21 million "unit" terminal was celebrated in October, with some 3½ million passengers and visitors having gone through it during the first 12 months of operation.

Innovations were many during the year on Eastern Air Lines, chief among them being the launching of the nation's first frill-free "Air-Bus" service, utilizing 95-seat Super-C Constellations, between Pittsburgh, Cleveland, St. Louis and Miami, at fares which were below the cost of either rail or highway transportation when the cost of meals is considered. "Flite-Cheks" were added as a feature for Eastern's air travel card holders to simplify and speed up the process of ticketing. A new Customer Services Department, headed up by a Vice President, was organized to handle every relationship between the airline and its customer from the moment he phones or calls in person for a reservation, through his boarding the plane, his meals and other requirements in flight, his deplaning, and the time he picks up his baggage on arrival.

Efforts were made, and with success, to improve the character of Eastern's service and its on-time performance throughout the system, and in tightening up its schedules to provide a quality rather than merely a quantity of service to all points.

In another side of air transportation, steps were taken during the year to capitalize on the growing volume of air freight, air express and air mail—as well as non-priority first-class mail—now moving by air. Five Super-C Constellations were converted into all-cargo "Flying Freighters" and placed on scheduled runs between the principal markets and manufacturing centers of the Northeast, South, Southwest and Caribbean. Sales and service staffs were expanded to seek new business for these and for Eastern's many dual-purpose passenger/cargo aircraft on all routes.

One of the major accomplishments of 1960 was the signing of a mutual assistance agreement between Eastern Air Lines and Aeronaves de Mexico, under which the two carriers plan to render technical aid to each other and to further encourage tourism across the border in both directions. By relinquishing its prior position on the DC 8-B jet assembly line, Eastern enabled Aeronaves to join the growing list of jet operators a year earlier than might otherwise have been possible, and in return was privileged to broaden the market for vacation travel to and from Mexico through addition of a tourist class to its previously limited first-class "Golden Falcon" service.

FLYING TIGERS prepared to introduce the swing tail CL-44 airfreighter in 1961

THE FLYING TIGER LINE

THE YEAR 1960 was a year of preparation for The Flying Tiger Line.

In May, 1959, the airline signed an order for the largest number of freight aircraft ever placed and the first for turbine-powered freight ships, a $55,000,000 fleet of ten Canadair CL-44D-4 turbo-prop jets.

With delivery scheduled for the spring of 1961, the airline turned full attention in 1960 to laying the groundwork for introduction in service of an airplane which it believed would make the long-heralded breakthrough in airfreight—the movement of freight by air at rates competitive with the truck and railroad.

Research into automated freight terminals, radically revised tariffs, new sales methods to discover new industry concepts of the distribution of products by air, special training of personnel for the new airplane and new route systems kept special staffs of experts busy in 1960.

Additionally, the carrier pressed its application for a new freight route across the Pacific from Los Angeles, San Francisco, Portland and Seattle to the Orient and won a favorable recommendation from a Civil Aeronautics Board examiner.

Still another phase of its activities centered on a re-assessment of government policies in respect to the allocation of military air passenger and cargo traffic to commercial air carriers.

A year of changing times, 1960 also saw the airline adopt a new insignia and letter format, designed to fit in with its new concept of airfreight for the "Decade of the Sixties."

With such major carriers as American and United converting surplus DC-7 equipment to freighters and TWA adding Super H Constellations to domestic freight schedules, the end of the year saw all major lines offering daily all-freight airlift capacity of more than 250 tons, of which the Tigers now supplied approximately one-third, or 84 tons.

As a result of this sharply increased competition over Tiger routes, which are paralleled by at least one and usually all three of the competitive passenger carriers on the main segments, Tigers' freight showed a decline in 1960 of about 10 per cent from the 1959 record. The mid-1960 setback in business also aggravated this traffic slump.

Another disturbing traffic loss also occurred in the military contract field, where Tiger business declined as much as 50 per cent. President Robert W. Prescott ascribed this loss to a "paralyzing rate situation" which was beginning to be corrected as the year drew to a close.

While operating its fleet of 14 Super H Constellations on domestic freight routes and overseas contract work across both the Atlantic and Pacific, the airline had both sales and operating personnel busy preparing for the advent of the CL-44, which was to replace the Constellation fleet in 1961.

A special research staff was completing a new tariff proposal for the Civil Aeronautics Board designed to bring about rate reductions of as much as 50 per cent in some commodity classifications. This staff also devoted extensive studies

FRONTIER adopted a new crescent arrow insignia

to the use that varying industries could make of airfreight at rates which would be attractive to new business as well as profitable for the carrier.

Studies completed during the year showed that the CL-44 could bring about a reduction of direct ton-mile operating costs of as much as 40 per cent. This, in turn, would permit low rates to attract into the air a portion of the huge volume of freight now moving transcontinentally by truck and rail.

At Chicago, on O'Hare Field, the airline broke ground for the nation's first automated freight terminal. The CL-44, which introduces a new efficiency in cargo handling because of a swing-tail permitting straight-in loading and unloading, was expected to reduce ground operating costs by as much as 35 per cent and cut ground time more than one-half.

The design of the O'Hare terminal will permit the unloading and loading of a CL-44, with its 65,000-pound payload, in a matter of minutes instead of hours and will substitute mechanical devices for hand labor.

In still another field, the company prepared to enter 1961 with renewed vigor. This pertained to the development of low-cost group tourist travel across both the Atlantic and Pacific.

The airline originally pioneered this type of traffic in 1950 and at one time had developed annual revenues of more than $4,000,000. However, increasing competition from passenger lines plus restrictions laid down by the Civil Aeronautics Board had shrunk the company's participation in this business. During 1960, company inquiries with travel groups indicated their desire for a specialized, experienced carrier in the field. As a result, the airline reopened offices in London, New York, Tokyo, Los Angeles, Chicago and Frankfurt, Germany and launched a sales program offering rates overseas as low as $230 round trip between New York and Europe on a pro-rated basis.

The airline planned to use both Super Constellation and CL-44 equipment in this business, with the CL-44 expected to fly as many as 165 people non-stop across the Atlantic.

FRONTIER AIRLINES

FRONTIER AIRLINES' 1960 was highlighted by two major events—public acceptance of the airline's Convair 340 operations over five of its route segments and the move of Frontier's administrative offices to a brand new building.

In September of 1960 Frontier moved the bulk of its administrative offices into a new two-story brick and tile building in Denver. This leased, million-dollar, air conditioned building eliminated the overcrowding which had previously existed. Occupying the new headquarters were the executive offices and the departments of traffic, sales, treasury, legal, public affairs, economic controls, personnel, purchasing and publicity. Other departments of Frontier Airlines which remained at Stapleton Airfield in Denver were operating from newly relocated and enlarged facilities. These included the offices for maintenance, engineering, flight operations, dispatch, reservations, communications and stores.

In 1960 Frontier Airlines completed its reorganization which affected all departments in the company. The airline's officers were Lewis B. Maytag, president and chairman of the board, G. Ray Woody, executive vice president, Ray P. Minniear, vice president of operations and J. Dan Brock, vice president of traffic and sales, plus Edward F. Dolansky, treasurer.

Frontier continued to operate 44-passenger Convair 340's over five of the company's heaviest passenger density routes between Denver, Colorado, and Tucson, Arizona; Denver and Riverton, Wyoming; Denver and Grand Junction, Colorado; Denver and Kansas City, Missouri; and Albuquerque, New Mexico, and Salt Lake City, Utah. The Convairs started scheduled operations on July 1, 1959.

LAKE CENTRAL AIRLINES

ROUTE DEVELOPMENT was the highlight of 1960 for Lake Central Airlines. During the year, the Civil Aeronautics Board issued final decisions in the three major route cases in which Lake Central was involved. These included the Cincinnati-Detroit Suspension Investigation, an expedited portion of the Piedmont Area Local Service Investigation, and the Great Lakes Local Service Investigation.

Decisions in the three route cases extended Lake Central service to 50 cities in the District of Columbia and the eight states of Indiana, Illinois, Ohio, Pennsylvania, New York, West Virginia, Michigan and Maryland.

In the Cincinnati-Detroit case, Lake Central was awarded authority to serve a north-south route between the two terminals and the intermediate cities of Columbus, Dayton, and Toledo, Ohio, with unrestricted non-stop privileges.

The CAB decision in the expedited portion of the Piedmont case added Evansville, Indiana to the route structure of the local service carrier. Lake Central will offer exclusive service on a non-stop route between Cincinnati and Evansville and provide Chicago-Evansville and Indianapolis-Evansville service, via Terre Haute, Indiana.

A total of 16 cities, served through 13 airports, were added to the Lake Central system in the Board's final decision in the Great Lakes Local Service case. These cities are Jackson, Michigan; Columbus, Indiana; Sandusky, Marietta, Findlay, Akron and Canton, Ohio; Parkersburg, Clarksburg, Fairmont, Charleston, Elkins, Wheeling and Morgantown, West Virginia; Baltimore, Md.; and Washington, D.C.

The CAB decisions also provided Lake Central with authority to serve many new routes between cities currently served by the airline. Among them were such routes as Erie-Pittsburgh; Detroit-Cleveland; Bloomington-Cincinnati, via Columbus, Indiana; and east-west service linking such industrial cities as Detroit-Cleveland-Youngstown and Pittsburgh.

Lake Central announced a tentative schedule to inaugurate service over its new routes, beginning January 1, 1961, when Evansville and six West Virginia cities were to receive first-time Lake Central service. Service to other cities and over other newly awarded routes is scheduled to begin each consecutive month through May of 1961.

During October, Lake Central accepted delivery of the first of five 44-passenger Convairs which were ordered during the first part of the year. The second Convair was delivered in November and a third in December. After undergoing modification to Lake Central specifications, the aircraft are to be put into operation during the early part of 1961. Lake Central also increased its fleet of DC-3s from 12 to 15 during the last quarter of 1960. Plans for 1961 include a greater increase in DC-3s and delivery of the remaining two Convairs.

With the increase in aircraft and route expansion, Lake Central has recorded a large personnel increase. By the end of the year, the number of pilots employed by the local carrier had increased from 76 to over 100. With the inauguration of service over the entire system, the number of pilots was to be increased to a total of 165. Including the pilots, total personnel increase during the year went from 448 to approximately 560.

On November 9, Lake Central filed a registration statement with the Securities and Exchange Commission for 130,000 shares of convertible preferred stock at a par value of $20. During the first week in November, Lake Central also completed arrangements for a $3,000,000 bank loan. Proceeds of the convertible preferred stock offering and the bank loan will be used to acquire aircraft and to meet other requirements of the company's expanded route system.

With the increase in aircraft and personnel, Lake Central doubled its hangar facilities in Indianapolis and announced plans for constructing a third floor on the existing office building at the Indianapolis headquarters.

In June of 1960, Lake Central received the

National Safety Council's Award of Honor for flying 75,000 aircraft hours without a major accident. Lake Central has received this award for eleven consecutive years, having received the award each year the airline has been in operation.

Lake Central, in cooperation with American Airlines, continued its "Main Street to the Jet Age" advertising program in ESQUIRE Magazine through April of 1960. During August, the local carrier adopted a new symbol of service which will appear in the future on all advertising and graphic products. The symbol includes a stylized airplane inside an ellipse and an outer circle with a straight vertical line, representing the shortest distance between two points, touching the left side of the circle. An asterisk, representing the sun, is also included in the design.

MOHAWK AIRLINES

MOHAWK AIRLINES continued its fast-paced expansion in 1960 by inaugurating many firsts: new routes, new service, new airplanes, new uniforms, new air-conditioning, new radar.

These were Mohawk's 1960 highlights:

New service to both Idlewild, New York and Bradley Field, Connecticut; added routes to Providence and Cleveland, and White Plains to Boston, Jamestown and Olean.

Purchase of two Convair 240's and an option on three more. The new airplanes were being used on Mohawk's recently instated schedule of three daily round-trip flights between Cleveland and central New York State, Massachusetts and Connecticut. The three airplanes on option were to be used to inaugurate service over anticipated route awards from the CAB which the company hoped to service in 1961.

Announced plans to retire its remaining seven DC-3's by the end of 1961. One airplane was sold to Trans-Sierra during 1960.

Introduced for sale and installation a new type of air conditioning and heating unit for Convair 240's and 340's which operates on the ground as well as during flight. These units were designed jointly by Carrier and Mohawk and were being used on all of Mohawk's 240's.

Became the first airline to use Collins Radio Company's new WP-103 Weather Radar Systems. This also marked the first time Collins leased its electronic or radio equipment to any airline.

Departed from the convention of having stewardesses dressed in military-type uniforms, and introduced a summer outfit consisting of a sheath and a short box jacket, which was well received by both the stewardesses and passengers.

Hosted the Tenth Interline Sales Conference at the Thousand Islands Club in upstate New York. More than ninety representatives of airlines all over the world attended.

This was the first full year of Mohawk's contract maintenance division which earned $135,000 from January through September. The division, which maintains and overhauls corporate aircraft, expected to earn $234,000 by the end of 1960.

Created a Convention and Tour Bureau within the company.

Installed new electronic phone systems in reservations in both Syracuse and Newark, speeding the reservation process considerably.

Perhaps the most unique of Mohawk's innovations during 1960 was the inauguration of its Gaslight Service. Two of the airline's remaining DC-3's were redecorated in the Victorian manner, complete with antimacassars, red velvet curtains with gold tassels, simulated brocade wall paper, Currier & Ives prints, and carriage lanterns. These flights are exclusively for men and the only woman on board is the stewardess who is all dressed up in a Gay Nineties costume. Free beer, cheese and pretzels are served, and good five-cent cigars are available.

During 1960 Mohawk applied for routes from Elmira to Washington, D.C., White Plains to Washington, and Ithaca, Utica to Washington. The airline was waiting for the final decision on its route extension to Pittsburgh which had received a favorable nod from both the Bureau Counsel and the Examiner in the case.

NATIONAL AIRLINES

IN 1960 National Airlines, first with jets in commercial service in the United States, became the first airline anywhere to fly both 707s and DC-8Bs. During the year, three DC-8Bs were put into service. In 1960, for the first time, National continued its pure jet service between Miami and New York during the summer vacation months. Tampa and New York, and Miami and Philadelphia were also jet-linked for the first time.

The Southern Transcontinental Route Case decision, of major importance to National, loomed at year-end. In July, 1960, CAB examiner Edward T. Stodola recommended that National be certified to fly the Miami-Houston-Los Angeles route, and the Miami-Houston-Dallas-San Francisco route. Final decision of the board was anticipated at the end of the year.

During the year National had several other applications pending before the CAB for route extensions and modifications. Route applications were pending from Miami to Mexico City via Tampa; New Orleans to Mexico City; Miami to Jamaica and Panama; Miami to Nassau; and Miami to Toronto, Canada, via Buffalo.

A DC-8 jet simulator owned jointly by National Airlines and Pan American Grace Airways, 50-50, was put into operation at National's Miami base in July, training crews in transition from prop-jets to pure jets. The Link-manufactured simulator, which cost approximately $1,000,000, cut the expense of training crews in DC-8s. It was available for leased time to airlines other than the two co-owners, and as the year ended was in use about 18 hours a day. An Electra prop-jet simulator owned entirely by National was also put into operation.

The fiscal year ending June 30, 1960, showed a net loss to National of $2,958,179. One steep drop in operating revenues resulted from the political situation in Cuba, which discouraged tourist traffic almost to the vanishing point. Revenue from the Cuban operation was reduced by nearly $2 million from the previous fiscal year. The company took delivery of more than $35 million in new flight and ground equipment during the year. This was accomplished with only $20 million in new borrowing, the balance being generated from internal sources. Increased operating expenses resulted in part as an incident to introduction of jet aircraft, and in part from an unusually heavy overhaul program for piston-engined craft, including major engine modifications.

Expanded during the year were National's charter and air freight services. In April 1960 the airline inaugurated Super H Constellation Star Air-freighter service between Miami, Orlando, Philadelphia and New York. These aircraft can carry 40,000 pounds per flight and handle any size shipment moving by commercial air freight. Further expansion of the freighter service was planned.

Charter flights also became an important source of revenue. Charter revenue for fiscal 1960 was $1,040,000, a 57 per cent increase over 1959. About 25 per cent of this revenue was derived from movements of military personnel, with the balance coming from civilian flights.

In March, 1960, National brought Florida's west coast its first pure jet service, with inauguration of daily non-stop Douglas DC-8B flights between Tampa and New York. Miami and Philadelphia were also linked by National with their first pure DC-8B jet service in the same month.

NEW YORK AIRWAYS

HIGHLIGHTS OF New York Airways' 1960 year were receipt of its first twin-turbine helicopter and opening of the new Wall Street heliport.

NYA became the first helicopter airline in the world to introduce twin-turbine equipment when it took delivery of a Boeing-Vertol 107 helicopter in December. The Boeing-Vertol, powered by two General Electric T58 turbine engines, accommodates 25 passengers. According to an announcement made in January, 1960, NYA was to purchase five of the 107's, the last to be delivered in the spring of 1961.

On December 7th, NYA and the Port of New York Authority officially dedicated the Wall Street heliport, New York City's second heliport in Manhattan. The following day, NYA started operations at the new site with 22 daily flights in and out of the heliport.

New York Airways, which flew its first passenger in July, 1953, flew the 500,000th revenue passenger in 1960.

NORTH CENTRAL AIRLINES

NORTH CENTRAL AIRLINES increased its certificated route mileage by nearly one-third during 1960, a year marked by outstanding growth.

During the year, North Central route extensions totaled 1,529 miles, and the Civil Aeronautics Board awarded the Minneapolis/St. Paul-based airline 17 new cities, increasing the system to 90 cities in 10 midwest states and the Canadian province of Ontario.

The company's largest route award of the year was announced by the Board August 29. This, the vast Great Lakes Area investigation, added 1,267 miles to the system of 5,366 route miles.

The order added Cleveland, Ohio, and 14 new Michigan cities to the North Central sys-

NEW YORK AIRWAYS took delivery of its first Vertol 107

tem. Included are Pellston/Cheboygan/Harbor Springs/Petoskey; Traverse City; Manistee/-Ludington; Cadillac/Reed City; Alpena; Saginaw/Bay City/Midland; Port Huron; Flint; Pontiac and Muskegon.

Service was inaugurated to all cities on the new segments with the exception of Cleveland and Manistee/Ludington, December 1.

On Sept. 7, President Eisenhower signed the Board's order extending North Central service to Port Arthur/Fort William, Ont. on two new routes: one from Duluth, Minn./Superior, Wis., and the other from Houghton/Hancock, Mich. The two segments—totaling 262 miles—give North Central its first international routes.

Another application to extend service to Regina, Sask., from Minot, N.D., was pending before the CAB which was studying subsidy requirements of the route.

Desiring to expand its system westward, the airline applied for authority to serve points in Wyoming and South Dakota on routes to Chicago. Included are the following routes:

—Between Sioux Falls, S.D., and Chicago nonstop;

—Between Sioux City, Iowa, and Chicago via Waterloo, Iowa;

—Between Huron, S.D., and Chicago via Brookings, S.D., Rochester, Minn., and Madison, Wis.;

—Between Sheridan, Wyo., and Rapid City, S.D., via Spearfish, S.D.;

—Between Casper, Wyo., and Chicago via Rapid City, Pierre, Huron and Sioux Falls, S.D., Worthington and Rochester, Minn., and Madison, Wis.

In another application, North Central asked for authority to extend its system to St. Louis on a route from Omaha including stops at Chillicothe and Moberly, Mo.

During 1960, North Central set a new record for the local airline industry when its passenger boardings for the year topped the one-million mark. In August, the company's 37 aircraft carried 101,705 revenue passengers.

North Central's first full year of Convair operations was highly successful. The speed and efficiency with which the twin-engine pressurized Convairs were integrated into the fleet was evidenced by the high performance factor attained: 99.82 per cent of the scheduled miles flown.

The company received several honors during the year, most notable being the National Safety Council's Award of Honor for an outstanding 1959 safety record. The citation went to 10 airlines which did not have a fatal accident during the year and which had a major accident record lower than the average for their group during the preceding three years. North Central has received the Council's award every year since it began scheduled operations in 1948.

In April, North Central was honored by the American Red Cross for maintaining 100 per cent first aid qualification in its stewardess corps for five years. Each stewardess is required to complete the Red Cross' standard first aid course, plus a six-hour refresher course each year. The company was the only scheduled airline to receive the award.

In line with its rapid expansion, the company retained an industrial design specialist to develop a corporate identity program covering all visual aspects of the airline. The exterior design features of the Convairs and DC-3's were gradually being streamlined. Ticket offices were being redecorated as well as counter areas at the stations throughout the ten-state system.

In November three Convair 340's were added to North Central's fleet, bringing the total to eight Convairs and 32 DC-3s.

NORTHEAST AIRLINES

DURING 1960 Northeast Airlines completed its first full year of Boeing 707 "Intercontinental" jet operations, and entered its 28th year of scheduled airline service. Northeast's huge jet reequipment program provided for the introduction by year's end of the Convair 880's—world's fastest jetliners. These pure jets were introduced into service between major East Coast cities and Florida by the start of the winter vacation season on December 15th. Total value of the six-plane fleet is more than $30 million.

The 880's were chosen by Northeast after several years of careful investigation. Powered by four General Electric CJ 805-3 jet engines, they have the performance characteristics and operating flexibility that are ideally suited for the airline's route structure.

The introduction of the 880's on Northeast's major routes also paved the way for the rerouting of more of its DC-6B equipment to key New England points. In September, for the first time, modern pressurized service with four-engine equipment was operated from Portland and Bangor, Maine, directly to New York and Washington. New Bedford and Worcester, Mass., both received their first full pattern of DC-6B service to New York on a year-round basis with increased service inaugurated from Manchester, New Hampshire to New York. Northeast also opened a new era at New Hampshire's Lebanon Regional Airport by inaugurating the first four-engine service ever operated there on a regularly scheduled basis.

The airline's "commuter service" operations—primarily flown with four-engine jet-prop Viscount equipment—continued to capture ever-increasing portions of the "businessmen's" markets between Montreal, Boston, New York, Philadelphia, and Washington, D.C.

For example, prior to its inauguration of a high frequency schedule, the largest share Northeast ever enjoyed of any of these competitive markets was ten per cent or less.

However, results in 1960 indicated that Northeast captured between 30 and 60 per cent of these markets, depending upon the segments involved.

Frequency was the keynote of this high-density operation, and during the fall, service between Washington and New York jumped 90 per cent. Non-stop service from Boston to Washington went to six flights daily.

For the increased convenience of the many business and professional people using the carrier's service on a daily basis, Northeast placed its commuter flights on an easy-to-remember "every hour" schedule. Service between these major cities left every hour on the hour (or at other uniform intervals) from early morning until late evening.

NORTHEAST acquired four of its planned

In other large metropolitan markets, a full pattern of four-engine service linked Boston, Philadelphia, Montreal, and Washington. Even more service was planned, as Northeast announced its interest in acquiring a number of additional jet-prop Viscounts.

As part of the master plan to bring uniformity and increased convenience to its many ticketing locations, in 1960 Northeast opened new offices in downtown Manhattan, Boston, and Washington. During the two years of the program, the airline opened 18 new offices throughout its system—which extends from Montreal to Miami.

Along with its "new look" in remodeled and new ticketing locations, the line completed its changeover into new, more stylish uniforms for stewardesses, pilots, and other aircrew members.

During the year Northeast moved into its new $2.5 million combination General Office and Maintenance building at Boston's Logan International Airport. The new facility was the newest structure in the airport's multimillion dollars redevelopment program.

six Convair 880's during the year

In its New York-Miami "vacation" market, Northeast's success with the 707 "Intercontinetal" pure jet prompted it to operate two additional 707 round-trip flights to Florida on weekends, thereby tripling its New York-Miami jet service on Saturdays. The operation of these flights—coupled with the combination first-class and coach services already available on its daily 707 services enabled Northeast to keep abreast of the steadily increasing demand for both types of jet seats in the Florida market.

A highlight of the year's 707 operation was the establishment of new unofficial speed records on the East Coast run between New York and Miami. Northeast held both northbound (1 hr. 45 minutes) and southbound (1 hour 56 minutes) records for several months.

Traffic-wise, new records were set when Northeast estimated its year-end results would show some 1,412,000 passengers carried during the year, with approximately 1,086,192,000 seat miles and 557,460,000 revenue passenger miles flown during the 12 months ended December 31. Revenue passengers carried were up some 14 percent over the previous year. Similar gains in freight, mail and express were reported. As of November, 2654 personnel were employed, 345 on the pilot list, and 201 as stewardesses.

During the year the company announced consideration of the feasibility of an ultimate merger of Northeast and Trans World Airlines. The proposed merger was still subject to final approval of the stockholders of both companies, the TWA board of directors, the Civil Aeronautics Board, the Securities and Exchange Commission, and the senior creditors.

NORTHWEST ORIENT AIRLINES

NORTHWEST ORIENT Airlines during 1960 noted two important milestones.

*Jet service was inaugurated by the airline with its new Douglas DC-8C jets, across the Pacific and in transcontinental service between Seattle-Tacoma and New York.

*Northwest moved its overhaul facilities into a new, $17.5 million Main Base at Minneapolis-St. Paul International Airort.

Service with DC-8C's across the Pacific was begun by Northwest in July, with flights both from Seattle-Tacoma, via Anchorage, Alaska, to Tokyo, and nonstop from New York to Anchorage and on to Tokyo. Later in the year, nonstop DC-8C jet service was started from Seattle-Tacoma to New York.

With delivery of Northwest's fifth and final DC-8C of the airline's original order scheduled around the end of the year, jet services were to be expanded.

When Northwest's new General Office building, now being completed in the same building complex as the Main Base facility, is finished in 1961, the airline will have the most completely integrated airline installation—all under one roof—in the world. Its floor area of 1,114,307 square feet will be the largest facility ever constructed in the Upper Middlewest in terms of total floor area.

During 1960, Northwest added two new cities—Fort Lauderdale, Fla., and Baltimore—to its route system and resumed service to Newark, N.J.

OZARK AIR LINES

OZARK AIR LINES started the year 1960 with the introduction of jet-prop service to 14 midwest cities. The three 40-passenger Fairchild F-27 radar equipped planes were operated on the airline's more heavily traveled routes and, during the year, accounted for approximately 20% of the airline's traffic.

Three new cities were added to the Ozark system during the year: Austin-Albert Lea, Minnesota; Galesburg, Illinois and Kirksville, Missouri. Service was suspended at St. Joseph, Missouri and Pittsburg, Kansas.

The most beneficial route development of the year was the temporary suspension authorization by the Civil Aeronautics Board of American Airlines at Springfield and Peoria, Illinois and Trans World Airlines at Peoria. In 1959, Peoria generated 98,214 passengers with Ozark handling 83% of the traffic. At Springfield, 73,866 passengers used the air service with 77% being handled by Ozark. In the same authorization Ozark was granted a one-stop authority between St. Louis and Chicago.

Departmental reorganization of the airline along functional lines was made during the year. Nine departments were established, each headed by a vice president under the immediate supervision of Joseph H. FitzGerald, president. The vice presidents and their departments are: Edward J. Crane, comptroller; Rex E. Creighton, purchasing and properties; Francis M. Higgins, information; Sidney F. McCullough, advertising and sales; Charles C. Mounts, customer services; R. Grant Rees, operations and maintenance; Paul J. Rodgers, public and interline relations; Henry L. Sweezy, administrative and economic controls and Clarence L. Tabor, assistant to the president.

Other organization changes during the year included the establishment of an auxiliary crew base in Chicago and expansion of the Rockford maintenance base. Approximately 7000 square feet of additional office space was acquired also during the year for an expansion of the general offices of the airline at Lambert St. Louis Municipal Airport.

During the year, facilities for Ozark were being developed at O'Hare International Airport, Chicago, including space in a new terminal building and a $750,000 hangar. Ozark planned to move part of its operations from Midway to O'Hare early in 1961.

On September 26, 1960, Ozark marked its tenth anniversary of scheduled operations. During the ten years, the airline expanded from a four plane operation with 40 people serving six cities, to an operation serving 54 cities on 5,273 miles of routes in 10 states. A fleet of 24 DC-3's and 3 F-27 jet-prop airplanes was being used in the operation. During the decade the airline operated nearly 50,000,000 miles and flew nearly 3,000,000 passengers with a perfect safety record.

PACIFIC AIR LINES

THE YEAR 1960 was an expanding one for Pacific Air Lines.

First came the introduction of eight Martin 404's into Pacific's fleet as the airline launched a program of providing its passengers with additional pressurized and air conditioned aircraft over its routes in California, Oregon and Nevada.

Next was the opening of two new city sales and service offices, one in downtown Eureka, California, to make greater facilities available for Pacific's patrons in the Humboldt County area, and the other in the heart of downtown Sacramento, capital of California.

Following this was the extension of F-27 Jethawk service to Medford, Oregon, and to Crescent City and Santa Rosa, California, coupled with excursion fares on a five-day roundtrip basis between Crescent City, Eureka-Arcata, and Portland, Oregon. Earlier, Pacific Air Lines had instituted an excursion fare on a three-day roundtrip basis between Burbank, California, and Las Vegas, Nevada.

The year also saw Pacific Air Lines inaugurate intensive training programs to provide initial and recurring training for employees in all job classifications. Pacific also undertook the expansion of its engineering and maintenance operations at San Francisco International Airport during the year by establishing separate engineering, maintenance and production control departments.

The year 1960 also saw Pacific Air Lines make one of the broadest moves since it started airline operations in 1947, when it filed applications with the Civil Aeronautics Board to extend its routes into six additional western states—Idaho, Utah, Colorado, Arizona, New Mexico and Washington.

During the first eight months of 1960, Pacific Air Lines flew over 4 million miles, carrying well over 300,000 passengers. For the 12-month period ending August, 1960, Pacific flew more than 5½ million miles to carry nearly a half-million passengers.

Pacific also hosted the July quarterly conference of the Association of Local Transport Airlines when the presidents of 15 local air carriers from throughout the United States, Alaska and Hawaii gathered at the Beverly-Wilshire Hotel in Beverly Hills.

The introduction of the 404 Martinliners into Pacific's fleet enabled the airline to dispose of some of its Martin 202's. By adding the 404's to the six F-27A's, which it placed in service in 1959, Pacific was able to extend its program of providing service with pressurized, air conditioned aircraft.

To keep pace with the ever-changing needs of airline operations, Pacific in 1960 completed the installation of the newest up-to-the-minute equipment on its communications network linking all the cities it serves in the three-state area.

Basic equipment of the new communications network was a new teletypewriter operating on a private line circuit that can transmit 100 words a minute. Pacific's stations in all three states are connected with the relay center at San Francisco International Airport, also the control station on the system. Each individual station has its own call directing code and through this code a message is automatically directed to the proper station. Only the station to which the call is directed is able to receive the message.

Initial presentations on Pacific's applications to extend its routes throughout the additional western states were prepared with hearings expected to get under way late in the year.

The year also saw Pacific Air Lines expand its travel program with more than two-score tours and package deals from the cities it serves in the three-state area. The tours range from sea level to ski level, from Alaska to Disneyland and from glamorous Hollywood to the fabulous strip at Las Vegas. One of the Pacific tours includes famous Timberlake Lodge on Oregon's beautiful Mt. Hood, the only American resort offering year-round skiing.

PAN AMERICAN WORLD AIRWAYS

PAN AMERICAN World Airways passenger traffic continued to soar during 1960 as the popularity of jet travel kept pace with the increasing number of Jet Clippers entering service.

Of its 53 jets received or on order, Pan American had 45 in operation by the end of the year. The jet fleet consisted of 23 Boeing Intercontinentals, six 707's and 16 Douglas DC-8C's. The remaining eight jets were scheduled to be in service by early 1961.

The demand for space on jet aircraft, which resulted in record loads during the summer rush to Europe, continued heavy during the fall months. Stimulating the fall traffic increase was the new 17-day European excursion fare which went into effect on October 1.

To accommodate the traffic anticipated on the basis of advance bookings, Pan American scheduled the largest transatlantic capacity ever provided for the fall-winter period. During October, Pan American offered 25,000 seats on European jets alone and scheduled 43 Jet Clipper flights a week. In addition there were piston-engine flights.

During 1960 Pan American opened transatlantic jet service from Detroit, Washington/Baltimore, Chicago, and Philadelphia. Jet service already had been provided from New York and Boston and West Coast cities to Europe.

Jet Clipper service was instituted to Lisbon, Barcelona, Nice and on to Rome. Jets make the New York-Lisbon portion of the trip in six hours and 15 minutes compared to the piston engined aircraft time of 10 hours and 50 minutes.

Pan American also put into effect its first daily nonstop jet service between New York and Frankfurt and the first Jet Clipper schedule to Shannon from Boston and New York. The Frankfurt flight is made in seven hours and 20 minutes.

In March Pan American increased jet schedules from the West Coast to Hawaii, to Australia, and to Europe.

The increase in Honolulu service from Seattle/Portland was from three roundtrips a week to four; from Los Angeles, from eight a week to 11, and from San Francisco, from eight a week to 10.

Jet Clipper service from the West Coast to Sydney, Australia, was expanded from one to two flights weekly and the polar jet service from West Coast cities to London was increased from two to three weekly.

Intercontinental Jet Clippers were added to the Manila route, flying via Honolulu and Guam. Flights, out of Los Angeles, reduced the elapsed time to Manila nearly by almost half to 19 hours and 30 minutes, compared to piston-engine time of 34 hours and 55 minutes. A second weekly roundtrip was to be added to

the schedules by the end of the year.

Singapore, Saigon, and Jakarta were linked to the United States by Jet Clippers, with overnight flights from Los Angeles. Once-a-week service to those cities resulted from an extension of Manila flights.

Jet Clipper service to Alaska was inaugurated from Seattle with four nonstop flights weekly to Fairbanks. The 3 hours and 20 minutes northbound jet flight, cut approximately 2½ hours off piston-engine flight times.

Pan American jet service from the West Coast over the northern Great Circle route to Tokyo was resumed on July 1 after a temporary cessation. The great circle jet flights, operating out of both San Francisco and Los Angeles, shorter by 1,000 miles compared to the Central Pacific routing, reduced flight time from San Francisco to 13 hours, about six hours less than the Central Pacific routing.

Jet Clipper flights to Latin America, inaugurated in 1959, fanned out from the United States to 10 different lands in the Caribbean and South America by the end of 1960.

Service was opened between New York and Brasilia, the new capital of Brazil, with Intercontinental Jet Clippers making the 4,300-mile flight nonstop in 8 hours and 30 minutes. Jets were also put on the runs to Rio de Janeiro and Sao Paulo.

Additional islands of the Caribbean also received Jet Clipper service. Along with increased schedules from New York, jet flights to Puerto Rico went into effect from Baltimore/Washington, Philadelphia, and Boston. Service also was opened to Jamaica, direct from Miami and from New York via Ciudad Trujillo; to Panama, from Miami; and to Trinidad, from New York.

Pan American increased its cargo-carrying capacity in 1960 with the introduction of the first scheduled all-cargo air freight service direct from the midwest to Europe, and a new cargo service to the Orient. The airline also completed arrangements with two trucking firms for a combined truck-air service to expedite cargo deliveries throughout the world.

Pan American put into service 10 high-speed, all-cargo DC-7F's converted from DC-7C passenger aircraft. A large cargo capacity also was provided in the passenger jets.

The new Midwest-Europe air service provided 32 tons of cargo capacity each week in

THE PAN AM Building in New York, to become the airline's home office in 1963.

DC-7F's, the most modern air freighters in service. Flights were out of Chicago and Detroit twice weekly. European cities served include London, Amsterdam, Frankfurt, Stuttgart, Munich, and Vienna.

The new Pacific cargo service links the United States and the Far East with three all-cargo flights a week. Flights leave San Franciso for Tokyo via Honolulu. One of the return flights stops at Los Angeles.

Of the two truck-air cargo systems established, one was with Consolidated Freightways, the country's largest motor freight carrier. The system links Consolidated's 145 terminals in the United States and Canada and its services in Europe and Asia with Pan American's Clipper Cargo flights throughout the world. The arrangement makes possible direct shipments with single documentation procedure to and from interior cities as well as gateway points on all six continents.

A similar arrangement was set up with Ryder Truck Lines, one of the nation's 10 top trucking firms, to expedite freight service between the U.S. and Latin America.

Keeping pace with the Jet Age revolution aloft, Pan American's new terminal at New York International Airport was opened in the spring of 1960. The four-acre circular terminal brings the plane to the passenger, with an overhanging roof which enables passengers to board undercover, eliminating long walks and exposure to the elements. The terminal incorporates advanced designs in baggage handling and check-in procedures and is capable of handling eight fully loaded 120-passenger Jet Clippers every hour. A unique feature of the Pan Am terminal is the world's largest air curtain which forms the entrance, eliminating conventional doors.

In the fall of 1960 Pan American and Grand Central Building, Inc. announced a long-term lease by the airline of 613,000 square feet of space in what will be the world's largest office building over Grand Central Terminal in New York. Named the Pan Am Building, the 59-story structure will become the company's home office in 1963.

PANAGRA (PAN AMERICAN-GRACE AIRWAYS)

BY FAR the most significant highlight of Panagra's operations during 1960 was the introduction of jet service in May to cut travel time between the United States and key cities in South America almost in half.

In a year which saw Panagra revenue passenger miles and cargo ton miles climb to a new record high, the pioneer U.S. flag airline stepped up its services with the addition of three Douglas DC-8 intercontinental jetliners to its El Inter Americano luxury passenger service.

By October, Panagra had increased its jet frequencies from New York to Lima by way of Miami and Panama to a daily service, and was providing immediate DC-7 schedules for Santiago, Chile six times a week, to La Paz three times a week and to Antofagasta twice a week.

These 110-passenger jets cut as much as nine hours from previous DC-7 schedules to link New York and Miami with Panama City, Lima and Buenos Aires in eleven hours and forty minutes flying time. Regarded as the newest and most advanced commercial airplanes operating in South America, the Panagra DC-8 jets have accommodations for 40 first class and 70 tourist class passengers, a luxurious Fiesta Lounge and stand-up snack bar, soda dispensers, bed-sized berths, and a wide selection of the finest international foods and beverages from the airline's Gourmet Galley. They are powered by four Pratt & Whitney JT4A-9 (J75) engines with 16,800 pounds thrust each and their latest design incorporates the most modern improvements in jet transports.

To stimulate more travel to South America from key cities in the United States, aid travel agents in devising lower priced package tours to South America's west coast and place the principal attractions on the southern continent within the reach of the two week vacationist, Panagra introduced new excursion fares which cut the price of a trip around South America by as much as 35 per cent.

This brought the price of a round trip tourist excursion fare from New York to Buenos Aires to $600, from New York to Santiago to $539.30 and from New York to Lima to $401.50.

The year also saw an increase in group travel to South America with special tours for medical, fraternal, business, farmer, and other groups being offered by travel agents.

To keep pace with the demand for shipping heavy industrial machinery, oil drilling equipment, air van packaged household goods, and compact cars, Panagra in July introduced the first DC-7F all cargo service between the United States and South America. A Douglas DC-7F airfreighter with a capacity of 29,000 pounds replaced the DC-6A put in service earlier in the year, on a once-a-week schedule from the Miami gateway to Panama, Guayaquil, Lima, La Paz, and Cochabamba.

In the way of passenger service innovations Panagra's Gourmet Galley introduced a unique airborne food service to provide international menus ranging from Hungarian Paprika Chirke to Irish Stew on a 24-hour advance notice.

Continuing its intense promotion of travel to South America, the airline with the co-operation of Pan American Airways produced a new 16 mm sound and color motion picture titled "Continent of the Sun." The film was being circulated to groups, clubs, and interested organizations throughout the world and it was being shown on television in the United States.

Special booklets were also published by the airline to better inform travelers on customs and immigration procedures as well as local customs, services, and facilities in South American cities on the airline's route. Titled "Take My Tips on Arriving," the booklets covered Lima, Santiago, and Buenos Aires and were distributed to passengers prior to landing in each city.

In 1960, Panagra awarded seventeen travel fellowships to South American students to study in U.S. colleges and universities thus helping to foster closer relations and create better understanding between the Americas. These brought to 343 the number of travel fellowships awarded by the airline since the program was launched 23 years ago with the co-operation of the State Department and the Institute of International Education.

For its perfect safety record over the past 16-years during which time Panagra has flown a total of 2,188,771,000 passenger miles without a single accident or fatality in passenger service over its routes in Panama, Colombia, Ecuador, Peru, Bolivia, Chile, and Argentina, the airline received special aviation awards from the National Safety Council and the Inter American Safety Council.

In May, when a disastrous earthquake and tidal wave destroyed a section of Chile's coastal cities, Panagra went to the assistance of the stricken nation. An aircraft and crew was placed at the disposal of the Chilean government to fly in medical supplies and clothing and evacuate the wounded. The airline also joined the airlift carrying tons of serums, drugs and other relief items free of charge on its regular flights and provided the U.S. Air Force with its navigational and communication facilities for its "Operation Samaritan."

SOUTHERN AIRWAYS

SOUTHERN AIRWAYS year was marked by expansion of its Tennessee routes. On August 20, the airline started service between Nashville and Memphis via Jackson and on November 1 service was inaugurated on another segment between Memphis and Tri-Cities via Jackson, Nashville and Knoxville. On November 15, Southern started service between Tri-Cities, Tennessee, and Huntsville, Alabama, via Knoxville, Chattanooga and Shelbyville, Tullahoma, Tennessee.

The company was planning additional new service late in the year, with, for the first time, direct air service between Memphis and Meridian, Mississippi.

In October, Southern carried 27,279 passengers for the third best month in its operating history. This was also an increase of 14% over the same month in 1959.

During the year, Southern topped the 300,000,000 passenger mile mark since its start of service in 1949. It flew 1,755,000 passengers with a perfect safety record in eleven and one half years of operation. At year end, the airline employed 950 and was flying over 26,000 route miles daily.

TRANS-CANADA AIR LINES

TRANS-CANADA Air Lines introduced jet travel to Canadians on April 1, 1960, with the inauguration of Douglas DC-8 jet service between Montreal, Toronto and Vancouver on a daily round-trip basis.

And on June 1, 1960, the Canadian flag carrier began daily return jet flights across the North Atlantic between Montreal and London, Eng.

On Oct. 1, Winnipeg was added to TCA's jet routes, giving that city jet service to both eastern and western Canada for the first time.

At year-end, with seven of 10 ordered DC-8's delivered and an additional three expected, the airline was operating two daily trans-continental jet flights between Vancouver, Toronto, and Montreal, with one making an en route stop at Winnipeg, plus a daily round-trip flight between Canada and the United Kingdom.

In its first six months of jet operation, TCA carried more than 75,000 passengers, logging some 3,500 revenue hours and travelling 1,750,000 miles, a distance equal to 70 trips around the world at the equator. In addition, the DC-8's put in more than 400 hours on training and familiarization flights.

The airline established two official trans-Atlantic speed records between Montreal and Ottawa and London, Eng., May 28 on a pre-inaugural jet crossing. The two records—five hours, 55 minutes from Ottawa to London, and five hours, 44 minutes between Montreal and London—were confirmed by the Federation Aeronautic International, official custodian of all air speed records.

On January 2, 1961, TCA expected to begin operating only jets across the North Atlantic to London, Prestwick, Shannon, Paris, Brussels, Zurich, Vienna and Dusseldorf. At the same time, Halifax was to be added to the domestic and overseas jet routes.

On Oct. 29, TCA retired all of its sturdy North Star aircraft from routes in Western Canada, and the remainder were to be withdrawn from service when the airline takes delivery of the first of 23 ordered Vickers Vanguards late in 1960 and begins to place them in scheduled service early in 1961.

The turbo-prop Vanguards will be used on TCA's medium range domestic and trans-border routes and on services to the Caribbean.

By the summer of 1961, TCA expected to be operating an all-turbine fleet, using the Vickers Viscounts, with which it introduced turbine travel to North America in 1955, Vanguards and DC-8's.

Its fleet of 13 Super Constellations, 21 North Stars and nine DC-3's were to be retired from service by this time.

To overhaul and maintain this new turbine fleet, TCA built at Montreal the world's first overhaul and maintenance base designed exclusively for turbine aircraft.

This $20,000,000 facility, which went into operation when the first DC-8 was delivered in February of 1960, will accommodate both DC-8's and Vanguards, while the Viscounts will continue to be overhauled at Winnipeg.

A new line maintenance base, costing more than $5,000,000 was under construction at Vancouver, while a $1,500,000 facility was being erected in Halifax to accommodate the turbine-powered aircraft.

In 1960, the Rolls-Royce Dart engines of TCA's Viscount fleet achieved an unprecedented 3,100-hour life between overhauls, proof of the ability and efficiency of its maintenance staffs and methods.

The airline's new $3,500,000 automatic reservations system was nearing completion and installation of field equipment was expected to have started by the year's end. This new system, which will completely revolutionize reservations procedures, giving passengers almost instantaneous answers to reservations requests, was expected to be in operation by the end of 1961.

TRANS-CANADA planned for introduction of the turboprop Vickers Vanguard in 1961

TRANS WORLD AIRLINES

DURING 1960 Trans World Airlines increased its prestige as a leading world air carrier, adding to its reputation in all areas of performance.

Having inaugurated trans-Atlantic service with its SuperJet flights to London, Frankfurt, Paris and Rome late in 1959, TWA steadily expanded its SuperJet pattern on world routes throughout the past year. These advances in jet services resulted in greatly increased international traffic and revenues over the previous year and a longer peak season for trans-Atlantic traffic.

During the four-month period of June, July, August and September of 1960, 79 percent of TWA's trans-Atlantic frequency was in SuperJet operations. During peak trans-Atlantic week from June 26 to July 2, TWA's trans-Atlantic passenger traffic in both directions was 91 percent above the volume for the comparable week in 1959.

During the year TWA expanded its international SuperJet services with increased schedules to London and Paris, non-stop SuperJet schedules to Rome and to Frankfurt, and

TWA's NEW LOOK, created by industrial designer Raymond Loewy

the inauguration of SuperJet schedules to Lisbon and Madrid, and to Athens, last spring. In the fall SuperJet flights to Milan, to Dhahran, Saudi Arabia, and to Bombay, India, were inaugurated. The latter schedules provided the first direct jet service between the United States and the oil capital of Dhahran, and the fastest travel time between the United States and India. Today TWA's SuperJet international pattern provides jet service to ten major overseas cities.

On the domestic front in 1960, TWA set for itself new goals in advancing its reputation for reliability, and by September was leading the industry in on-time performance. In July, for example, TWA led its Big Four competitors in both jet on-time performance and in on-time performance for all equipment, with an 80.6 percent monthly average.

Early in the year TWA added to its jet services on United States routes by putting the SuperJet into transcontinental service between New York and Los Angeles and New York and San Francisco, thus providing the traveling public with the fastest and most luxurious transcontinental service. TWA is the only carrier offering SuperJet service on United States routes.

Also during the year TWA increased all its domestic jet services, increasing daily frequencies and adding more cities to its jet network, and by year's end was serving 13 U.S. cities with daily jet flights.

In 1960 TWA put fresh emphasis on the development of cargo sales and traffic. The system cargo sales staff was expanded, the position of a vice president for Cargo Sales and Market Development was created and filled, and a new cargo service division within the Transportation Division was established. In mid-summer TWA began a program of conversion of six Jetstreams from its piston-powered fleet to all-cargo transports, and will convert six more in early 1961.

As a result of these first conversions in November TWA announced a major expansion of its "Super Sky Merchant" air freight service, domestic and international, providing, with the all-cargo version of the Jetstream, the fastest and only true over-the-weather non-stop all-cargo transcontinental flights. The total all-cargo program provides three transcontinental all-cargo frequencies a day, plus a New York-Chicago daily round trip, and five trans-Atlantic all-cargo flights a week.

A major program developed during 1960 was the creation and projection of a "new look" throughout the TWA system. With Raymond Loewy Associates, industrial designers, and under the direction of Rex Werner, TWA's Design Director, a coordinated program is in progress to restyle all facilities and equipment, from ticket offices to ramp equipment. Highlights of this program are a new corporate insignia and a completely new uniform style for TWA's corps of 1,400 hostesses. The new corporate insignia retains the traditional red block TWA letters, but surrounded by a gold out-line of inter-locking hemispheres symbolizing TWA's world-wide services.

In line with its "new look," the airline has developed a "Travel in High Style" program to introduce new luxuries and conveniences in its first-class passenger service. One phase of this program includes periodic refresher training courses for cabin attendants.

To keep pace with its expanding jet services and growing volume of passengers, TWA was also building new or enlarging existing passenger service facilities at major cities. At New York International Airport exterior work on the new $15,000,000 terminal, designed by Eero Saarinen, was completed and interior work begun. Occupancy was expected late in 1961. In the meantime, TWA enlarged and improved its interim terminal facilities at this airport, at a cost of $300,000.

Building of a new food unit was begun at Kansas City. At Los Angeles TWA was completing its own passenger loading facility which will provide a covered concourse and ten gate positions.

At Chicago's O'Hare airport the TWA ticket counter was being enlarged and two new gates and other facilities added. At San Francisco TWA contracted for its own jet piers at the International terminal there. Expansion of TWA passenger service facilities was also underway at London, Paris and Madrid.

UNITED AIR LINES

THE MOST SIGNIFICANT events in the 1960 progress of United Air Lines were (1) the proposal to merge Capital Airlines into United; (2) recovery of the company's competitive position in the industry; (3) extension of DC-8 jet service and introduction of the Boeing 720 jet; (4) activation of the third stage in United's jet equipment purchase program.

United's jet equipment program entered its third stage in February when a $65 million order for 20 twin-engine jet Caravelles was placed with Sud Aviation. This marked the first move by any U.S. airline to provide for jet service in the short haul travel market. Delivery of Caravelles was to begin in the spring of 1961 and the aircraft were to enter service in summer.

United also ordered 40 Boeing 727s in December at a cost of approximately $175 million. These short-to-medium range jetliners will be powered by three Pratt & Whitney JT8D turbofan engines mounted at the rear of the fuselage. Cruising speed will be 550-600 mph and the aircraft will be able to operate from 5,000 foot runways, carrying full payload. Passenger capacity, depending on cabin configuration, will be 70 to 114.

Delivery of the 727s will begin late in 1963. The contract is firm for the first 20 aircraft and it automatically becomes firm for the second 20 either when the proposed merger of Capital Airlines into United is consummated, or upon the achievement of certain projected financial ratios.

Boeing 720s were introduced in July, filling United's requirement for a mid-range jetliner. Eleven more Boeing 720s were ordered in the fall, increasing the company's total commitment for this type of aircraft to 29. Thirteen of the planes were delivered in 1960 and United inaugurated 720 service at 17 cities.

Delivery of DC-8's, which United had introduced for long haul service in September, 1959, continued on schedule. Thirty-two were received by the end of 1960, with the remaining eight to be delivered in 1961. Twenty-two of the company's total fleet of 40 DC-8s were to be powered by advanced J-57 engines, 15 by J-75s and three by turbofans.

Jet competition in the period before United inaugurated jet service had resulted in some inroads on traffic but the company fully regained its competitive position in the summer of 1960. June traffic, for example, was 6 percent above 1959 and August revenue passenger miles represented a 17 percent increase over the same month in the previous year.

At summer peak United operated 341 flights daily, flying 364,386 scheduled miles every 24 hours. Traffic records were set in each of the summer months. In September an all-time single day company record was established—22,827,000 revenue passenger miles.

Meanwhile, on July 28, W. A. Patterson, president of United, and T. D. Neelands, Jr., chairman of Capital Airlines, jointly announced that an agreement had been reached to merge Capital into United. Directors of both companies approved the agreement on August 11, followed by the approval of United and Capital stockholders on October 14. Hearings before the Civil Aeronautics Board began October 19.

Training of jet crews at United's flight training center in Denver was enhanced by adding a Boeing 720 electronic flight simulator, the first acquired by an airline. This increased United's "fleet" of jet and piston engine flight simulators to eight—the largest concentration of

UAL's JETARAMA exhibit continued to draw large crowds in 1960

such equipment in airline use.

A Caravelle simulator also was ordered, along with two jet procedure trainers and a visual flight simulator attachment. The last, designed to duplicate low ceiling and restricted visibility landing conditions, was installed on a DC-6B simulator.

A jet engine overhaul shop was opened at United's maintenance base, which adjoins the San Francisco International Airport. Designed for assembly line operations, the new facility has an extensive conveyor system for small parts and an overhead monorail to carry jet engines from various work stations. The shop is equipped to overhaul five engines per 16-hour day when peak capacity is reached in 1963.

Throughout 1960 United was responsible for notable improvements in ground handling of baggage and passenger traffic. Express check-in counters, for example, were introduced at the company's new passenger terminal at New York International Airport. The counters, patterned after the type used in super markets, appreciably speed the flow of check-in traffic. Baggage is weighed automatically and passengers who already have purchased tickets can make out their own baggage tags.

"High Speed Ticketing" was introduced by United in April for Air Travel Plan customers. This innovation permits ATP travelers to enplane without buying a ticket in advance; they merely sign a simplified ticket at the check-in counter. Another feature of this service allows ATP and Cash Block Ticketing customers to write their own simplified tickets.

United also introduced Jetways at the New York, Seattle/Tacoma and San Francisco International Airports. Jetways, developed by the company, are self-powered telescopic corridors which extend between the second floor of terminal buildings and the doors of aircraft. The mobile corridors eliminate stair climbing, provide shelter in inclement weather, and remove passenger traffic from the ramp. United had 23 Jetways in use in 1960 and additional units will be provided where feasible.

Baggage handling at United's passenger terminal in San Francisco was greatly improved by installing more than a half mile of high-speed conveyor belts. In addition to carrying baggage to and from the ramp at a fast rate, the outbound conveyor belt has an automatic sorter which aligns baggage in terms of destination and specific flights.

Conveyors also were installed in United's new freight terminal at San Francisco, resulting in a 40 percent reduction in the time required to process shipments. A similar system had been placed in operation at the company's Chicago freight terminal at Midway Airport in 1958 as the first of its type in the air transport industry.

Six DC-7A Cargoliners which had been converted from passenger planes were placed in service, supplementing the company's all-cargo fleet of seven DC-6As.

The company's cargo lift in all types of aircraft increased 130 percent over 1959 capacity.

United began its second year of jet operations on September 18, with a record of having flown 1,440,000 passengers on jetliners in 12 months. In that period the jets had flown more than two billion revenue passenger miles.

At year's end, United's DC-8 Jet Mainliners and Boeing 720s were serving 19 cities and accounting for more than 60 per cent of the company's average available seat miles.

WESTERN AIR LINES

WESTERN AIR LINES highlighted its 34th year of operations with full-scale entry into the Jet Age via a fleet of Boeing 707 turbojets.

The airline leased its 707's from Boeing Airplane Company and inaugurated jet service linking major Pacific Coast cities on June 1, 1960. Western also purchased four lighter, swifter Boeing 720B turbofan jets, for 1961 delivery.

Hoping for favorable decisions in two major route cases pending before the Civil Aeronautics Board, the trans-Pacific Route Case and the Southern Transcontinental Service Case, WAL took options on five additional 720B's for early 1962 delivery.

In February 1960, Western reported its 1959 earnings and revenues set new records. Earnings totaled $5,016,656, or $4.82 a share, on operating revenues of $63,253,971.

Reflecting the higher cost of airline operations in the Jet Age, and the Electra problem, WAL did not fare as well in 1960. Earnings for the 10 months ended Oct. 31, 1960 totaled $2,-278,000, or $1.59 a share, on operating revenues of $58,276,000.

Western's board of directors declared four regular quarterly dividends of $0.25 each during 1960, plus a five per cent stock dividend. Payment of the cash dividends marked the tenth successive year that WAL has paid cash dividends to its shareholders.

During 1960, Western was cited by the American Institute of Management as one of the best-managed companies in the U.S. and by the United Shareholders of America for "meritorious achievement in the field of management-shareholder relationship."

In a survey of airline employee productivity, based on third quarter 1959 operations, the March 1960 issue of *Airlift Magazine* reported Western ranked first among the 12 domestic trunklines in transportation revenue dollars generated per employee, revenue passenger miles flown per employee, revenue passengers boarded per employee and revenue ton miles flown per employee.

Western closed the year awaiting CAB decisions in the Trans-Pacific case, in which the airline sought authority to link major Western cities with Hilo and Honolulu, and the Southern Transcontinental case, in which WAL asked to extend its service to Dallas, Houston and Ft. Worth. ■

WESTERN found high passenger acceptance of its Boeing 707 Champagne Jet Flights

HELICOPTERS

PRESIDENT EISENHOWER was cited by the American Helicopter Society in recognition of his use of helicopters. Left to right: the President, Ralph P. Alex, AHS board chairman, and Charles H. Kaman, AHS Awards Chairman.

IN MY CASE, it was not what I did for helicopters, it's what helicopters did for me," commented President Eisenhower in accepting a citation at the Honors Night Dinner of The American Helicopter Society in recognition of his use of helicopters throughout the world.

As the first president in history to regularly and extensively use single-engine rotary-wing aircraft, Mr. Eisenhower focused world attention upon the ease and reliability with which helicopters can reduce to minutes trips that by surface travel might be measured in hours.

During the 1960 campaign the helistop replaced the whistle stop in many areas. Candidates of both political parties found helicopters made it possible to keep on schedule and meet the voters in the off-railway and off-airport towns.

In addition to serving as political transports, the majority of commercial applications of the helicopter were routine business operations—air taxi, power-line patrol, geological survey, construction work, forest fire patrol and agricultural crop dusting and spraying.

In the 1960 Helicopter Council survey, there were 193 operators in the United States and Canada using 705 rotorcraft. Of this number 50 operated helicopter flight schools.

The first Directory of Heliports/Helistops in the United States and Canada was compiled by the Council during the year. This Directory revealed that thirty-three States, including the District of Columbia, and Canada had 327 established heliports/helistops and 27 proposed facilities. Of the established heliports, 283 were ground level and 44 elevated. In addition, there were approximately 100 oil rigs in the Gulf of Mexico equipped with helistops. Of the proposed facilities, four major municipal heliports were completed during the year—Patterson, New Jersey; Fort Worth, Texas; Philadelphia, Pennsylvania and New York City's second heliport on Pier No. 6 in the East River.

The new District of Columbia Stadium scheduled to be opened in September, 1961 will provide the most modern facilities for its customers. Spectators will be able to arrive by bus, car, boat, train or helicopter. Helicopter facilities will be provided in the stadium area.

The Council continued its campaign for the establishment of city-center heliports throughout the country. To assist in this project, one thousand copies of the Council's Legal Advisor's report, "Legal Aspects of Planning for Urban Heliports" were distributed to city planners and state and local governments.

The cooperation of national groups of major structure was developed by the Council, as evidenced by The American Legion's adoption of the following Resolution to "Encourage Utilization of Helicopters":—

WHEREAS, The helicopter has proved itself a useful and versatile vehicle for both military and peaceful uses; and

WHEREAS, There is need for increased emphasis on the many services the helicopter offers to enhance our way of life;

NOW, THEREFORE, BE IT RESOLVED, By The American Legion in National Convention assembled in Miami Beach, Florida, October 17-20, 1960, does reaffirm the principles and objectives of Resolution No. 639 adopted by the 40th National Convention to the end that we promote and encourage the development and use of helicopters and the passage of necessary ordinances and regulations as will permit their efficient operation.

The scheduled 1961 opening of Dulles International Airport at Chantilly, Virginia (30 miles from Washington, D.C.) pointed the need for a municipal heliport in the Nation's Capital. The Council was seeking congressional action authorizing the District of Columbia Commissioners to conduct a survey for a recommendation of suitable heliport sites throughout the area. The Metropolitan Washington Board of Trade adopted a resolution supporting this proposal.

At year's end, the Civil Aeronautics Board announced an investigation of the eight pending applications for helicopter service in the Washington, D.C. area. The hearings, to be held early in 1961, should further illustrate the lack and need for adequate downtown helicopter facilities to permit practical city-center to airport transportation.

One of the surveys conducted by the Council during the year was concentrated in the field of executive and corporate use of helicopters. It was learned that helicopters were taking over the crucial job of moving executives, key personnel and industrial equipment to the right spot in the minimum amount of time, becoming airborne "executive suites." Industries operating their own rotorcraft (or leasing from a commercial operator) included mining, textiles, electrical, radio, gas, oil, construction, food, banking, broadcasting and lumber—as well as the aerospace industry.

Another survey initiated by the Council was the first list of Foreign, Military, Government and Commercial Helicopter Operators. Based on the information received, there were 262 operators in 63 foreign countries operating 1,662 helicopters. In addition, 184 helicopters were on order.

Of these 1,662 helicopters in use, 1,370 were American built. Of the 184 helicopters on order, 103 will be USA exports.

Government agencies in the United States and Canada continued to use the helicopter for traffic surveys, tracking criminals, searching for lost children, rescues and as stand-bys in the event of local disasters. Thirty-three of these agencies are operating helicopters.

The Council's over-all educational efforts were given a major assist when the Federal Aviation Agency developed and carried out a program described by that organization as "Project Hummingbird." A detailed briefing of this campaign was given the Council prior to its introduction to public groups. During the year a graphic presentation showing the need for long-range planning for the provision of facilities for helicopters and possibly other steep-gradient aircraft was given by FAA personnel before thousands of industry members, civil leaders and public officials in all areas of the country.

The first report issued under FAA's "Project Hummingbird" presented the economic future of the helicopter. The report covered the potential uses of the helicopter and other V/STOL aircraft in short-haul commercial air transportation during the next ten years. In addition to providing overall traffic forecasts for New York, Chicago, and Los Angeles, the three metropolitan areas which had scheduled helicopter service, the report evaluated the requirements for helicopter service in other metropolitan areas and the outlook for intercity and commuter service in the 1960-1970 period.

Objectionable aircraft noise, which, with the rapid expansion of jet usage, has become an international problem, was brought effectively to the attention of helicopter manufacturers at a Council meeting featuring the presentation of a special paper on the subject. The head of the National Aircraft Noise Abatement Council emphasized the point that removal of jet airports to sites far from the cities they serve brings the helicopter to the forefront as the most effective transportation to reduce to a minimum the time spent in travel from airport to city. By the same token, however, the landing of the helicopter at urban heliports brings its own operating sounds right into the midst of business or residential areas. It was recommended that use of roof-tops, waterfronts and industrial areas would do much to keep the noise nuisance factor to a minimum. The Council was working closely with NANAC in achievement of its objectives.

Military uses of the helicopter are almost endless in variety, including rescue. Helicopters serve as troop transports, as fire-fighters in crash rescue and perform yeoman service in anti-submarine warfare. Rotorcraft are in use in every branch of the armed forces. They can swiftly deliver ammunition to forward areas, or equipped with armament they can serve as a striking combat force. They can tow mired trucks, tanks, downed aircraft—even beached naval vessels.

During the year, the Army announced the proposed light observation aircraft replacement would be a turbine powered helicopter. Army specifications for this aircraft were submitted to the industry. After extensive tests and evaluation, one design will be selected for production.

The three scheduled helicopter airlines—Los Angeles Airways, Inc.—Chicago Helicopter Airways, Inc.—New York Airways, Inc.—continued to set new records in the number of passengers carried and miles flown during the year. In 1959, the three carriers flew 366,000 passengers. It is estimated 504,000 passengers will have flown in 1960—an increase of 38%.

With the advent of larger equipment, with resulting lower operating costs and higher load factors, it was predicted these three airlines will number their passengers in the millions.

Noteworthy "Firsts" during the year:

May—A rescue helicopter landed and took-off from 18,000 feet on Mt. McKinley, the highest landing and take-off ever made by an aircraft of any type.

June—First FAA certification of a helicopter for instrument flight.

July—Seven new international helicopter records in categories of speed, climb, and distance over a closed course were made. Three of these records were formerly held by the U.S.S.R.

September—The world's first turbine-powered helicopter was delivered to a scheduled airline.

October—First flight of first twin-turbine transport helicopter. ■

GENERAL AVIATION

AS IT HAD for every year in the past decade, general aviation continued to grow during 1960. General aviation, by definition, includes all civil flying except that of the airlines.

During 1960, unit sales of general type aircraft numbered about 7,800 with a retail value of more than $200,000,000. Hours flown numbered an estimated 12,800,000, an increase of 400,000 hours over 1959. At year-end, the active general aviation fleet numbered more than 70,000 units and flew almost two billion miles.

The general aviation fleet at the end of 1960 was 35 times larger than the airline fleet and several times larger than the military fleet. Hours flown by general aircraft more than trebled those flown by the airlines.

The Utility Airplane Council of Aerospace Industries Association estimated that general aviation's contribution to the national economy, counting sales of new aircraft, fuel, oil, parts, supplies and service, had reached an annual

volume of $2 billion by the end of 1960.

The largest single segment of general aviation continued to be business flying.

During 1960, business flying experienced another year of solid growth. Production of new business and utility aircraft approached 8,000 units having a retail dollar volume of over $200,000,000. The 1959 total was 7,689 aircraft costing $129,000,000. In addition, 65 turbo-prop executive transports were delivered to corporate users during the year. At year-end, the business fleet had 100 turbo-prop aircraft in operation, including Allison-Powered Convairs, Fairchild F-27s, Grumman Gulfstreams, and Vickers-Armstrongs Viscounts. The first delivery of a turbo-jet business transport, the Lockheed JetStar, was scheduled for early 1961.

Of the 70,000 active civil aircraft registered with the Federal Aviation Agency, more than 30,000 were being used primarily for business purposes. Of these, 7,000 were multi-engine. In 1960, the business aircraft fleet flew 6,300,000 of the 12,800,000 estimated hours flown for all of general aviation. The annual hours of use of the business aircraft fleet has doubled in the past ten years and is forecast to double again within the next ten.

Business flying continued to enjoy an excellent safety record. The National Business Aircraft Association, at its 13th Annual Meeting and Forum in Los Angeles, presented NBAA safety awards to 58 leading business and industrial companies whose aircraft had completed one million miles or more of business flying operations without accident or injury. In addition, 96 business pilots were honored for having flown one million miles or more without accident or injury and 121 business pilots for having flown 500,000 miles in safety.

The topics discussed during theNBAA Annual Meeting were: Federal Aviation Agency proposed Maintenance/Overhaul Standards for Business Aircraft; Flight Characteristics of Present and Future Business Aircraft; Aeromedical Aspects of Aviation Safety; Helicopters for Business; and Small Turbine Engines for the Business Fleet. A static and in-flight display of the latest business aircraft was held at the Lockheed Air Terminal, Burbank, California.

The Utility Airplane Council predicted that sales volume will double by 1965 and redouble by 1970, with related increases in the size of the general fleet and hourly usage. Translated into 1970 figures, this would mean that dollar value of new aircraft sales would reach almost one billion dollars, fleet size would increase to 120,000 planes, and general aviation would fly about 25,000,000 hours annually. ■

GOVERNMENT AND AVIATION

THE SECOND SESSION of the 86th Congress, convening during a presidential election year, took up a host of aviation/missile and transport subjects, talked and debated, but adjourned with a somewhat less than spectacular record of achievement.

Defense and space policies were debated throughout the year but the net result was a minor increase in military appropriations and no change in laws affecting space, patent or contract developments.

Legislation to restrict the defense-industry employment of retired officers, to limit negotiated procurement and incentive contracting, and to liberalize NASA's patent policies moved through the House but died in the Senate.

After strenuous argument, Congress approved a $39,996,608,000 fiscal 1961 defense bill, an increase of $661 million over the President's request. One of the big gains for industry was establishment of an "airlift modernization" account with $310,788,000 for development, procurement and modification of a readily available long-range turboprop or turbofan aircraft to back up SAC and the Strategic Army Corps.

Early in the year funds for the North American B-70 supersonic bomber for Fiscal 1961 were drastically cut back by the Administration to $75 million. This was later reprogrammed to $110 million. An almost unanimous Congress protested and added $190 million (for a total available of $300 million) with another $100 million annuity if progress warrants. By year-end, the Administration had parcelled out $265 million, apparently planning to point the program toward the status of a full supersonic bomber system.

NASA got exactly what it asked for in 1961 appropriations—$915 million. A $23 million supplemental, mostly for Project Mercury, was approved early in the year.

Approved for military construction was a $1,185,320,000 bill carrying extra authority for one additional Minuteman squadron site and two Titan squadron sites.

Approved also was a bill to extend the "anti-kickback" law to cover all negotiated contracts. Previously, the law was limited to cost-plus-fixed-fee and reimbursable contracts. Violators convicted of offering gratuities with the idea of influencing contract awards could be fined $10,000 or imprisoned up to two years.

Routinely extended until June 30, 1962, was the Defense Production Act, which continued the President's power to establish priorities for defense contracts; authority to make loans and purchases to build up the country's defense capacity and to assure adequate supplies of defense materials. Included were provisions for establishment of a reserve of trained executives for emergency mobilization of government offices and anti-trust exemptions for business men who voluntarily cooperate in defense efforts.

The Aircraft Nuclear Program was awarded the full Atomic Energy Commission request of $73 million for reactor development, with the promise that the program will undergo close examination next year by the House Appropriations Committee. Department of Defense was granted $75 million for its part of development.

Also passed was a one-year extension of the 52% corporation tax.

Air transport legislation also suffered from an over-talkative but relatively inactive session, although several investigations moved toward what could prove to be major actions in 1961.

The House Commerce Committee promised a comprehensive review of jet transition data, maintenance and scheduling problems, and other matters, early in the session but produced little. The investigation may resume in 1961. A House Space Committee urged a national program for the development of a supersonic transport, and the Senate Space Committee recommended that the B-70 be re-established as a full weapon system, concluding that this would also provide a prototype for a future supersonic transport. A special House Airlift Subcommittee got behind a movement to develop economical cargo planes, re-equip MATS and provide adequate troop-carrying airlift. Aircraft noise and aviation insurance practices were problems that also received congressional attention.

As far as actual air transport legislation passed, the record was disappointing. Supplemental airline certificates, voided by an Appeals Court decision in the Spring, were extended 20 months. The passenger tax continued at a ten percent rate. CAB was granted authority to approve free or reduced rate transportation for nearly anyone who had ever had a connection with an airline. Also CAB was granted the power to dispense with hearings on certain minor matters. Military procurement of airfreight for shipping household goods was limited by bill to cases where cheaper, surface transportation was not available.

In the matter of appropriations, CAB and FAA both made substantial gains over the previous year. Totals were: CAB—$7.4 million for salaries and expenses; $65 million for subsidy payments; FAA—a total of $690,494,000. Congress also appropriated about $7 million for research and development on a combined aviation weather service by the Weather Bureau, FAA and the Air Force. In addition, funds were provided to add weather staffers at jet terminals, and an extra $1.7 million was voted for aviation forecasting equipment.

Some of the transport matters taken up during the session, but killed, were: a plan for guaranteed loans for cargo planes; a ban against drinking aboard domestic airline flights; non-priority mail' legislation requiring airmail stamps on all letters flown; several measures establishing rules governing off-the-cuff exchanges between members of regulatory agencies and individuals with cases pending before these bodies; bill to increase tax on aviation fuels to 4½ cents per gallon and establish new 4½ cents per gallon tax on jet fuels; anti-subsidy bills; bill requiring the installation of voice recorders aboard airlines to aid accident investigators; legislation to permit private planes transit back and forth across U.S. borders without having to reimburse custom inspectors for weekend and holiday pay; a Senate-passed bill establishing a U.S. Travel Office in the Commerce Department and a $5 million travel promotion fund to go along with it; and proposals to give CAB a veto over certain FAA rulemaking and enforcement actions.

A summary of aerospace activities at the varieur agencies follows. ■

FEDERAL AVIATION AGENCY

AT THE CLOSE of its second year, the Federal Aviation Agency reported notable advances in air traffic management, aids to navigation, aviation medicine, research and development, and the highly complex area of air safety.

During 1960, the critical airspace problem was partially solved. Some 9,560 sq. mi. of formerly restricted airspace was made available for civilian use, making a total of 18,000 sq. mi. returned to public domain since the FAA began operating. The airway structure was reorganized; the world's first computer network for the control of air traffic went into operation; major navigational facilities were installed and commissioned at the rate of more than one a day; 4,000 qualified physicians were designated as FAA Medical Examiners; encouraging progress was made toward a semi-automatic system of air traffic control; the first jet-powered helicopter was certificated, and some changes made in the Civil Air Regulations in the interest of greater safety.

THE ORGANIZATION

The Administrator of the Federal Aviation Agency and the Deputy Administrator are appointed by the President and confirmed by the Senate.

Assistant Administrators are in charge of the Office of Management Services, Office of Personnel and Training, and Office of Plans.

Agency operations are conducted by six major Bureaus whose functions are reflected in their designations—Bureau of Research and Development; Bureau of Flight Standards; Bureau of Facilities and Materiel; Bureau of Air Traffic Management; Bureau of Aviation Medicine, and Bureau of National Capital Airports. Each is headed by a Director.

Completing headquarters structure are the Office of Management Services, Office of Personnel and Training, Office of Plans, Office of the General Counsel, Office of International Coordination, Office of Congressional Liaison and Office of Public Affairs.

There are also six Regional Offices, each headed by a Regional Manager, which provide the support necessary for operations in the field. These are located in New York, N.Y. (International Airport); Fort Worth, Texas; Kansas City, Missouri; Los Angeles, California; Anchorage, Alaska; and Honolulu, Hawaii.

Immediately below the Regional level are 27 field Areas with Area Supervisors for Air Traffic Management, Facilities and Materiel, (facility maintenance and materiel) and Flight Standards (facility flight check and procedures). They are responsible for these field activities within the boundaries of Air Route Traffic Control Center areas and are physically located near the Centers.

The Federal Aviation Agency employs approximately 40,000 persons, less than one-tenth in the Washington area. The others are assigned to the Regions and the overseas activities.

A special feature of FAA's organization is the civil-military character of its staffing. Among the total employees there are 126 officers of the Army, Navy, Air Force, Marine Corps and Coast Guard—not in liaison positions—but assigned to serve the FAA under the direction of the Administrator.

BUREAU OF RESEARCH & DEVELOPMENT

Work continued on the development of equipment for an experimental system of semi-automatic air traffic control for military and civilian aviation. A long step in this direction was achieved early in the year when the first all-transistorized computer, the Data Processing Central, was delivered to the National Aviation Facilities Experimental Center for testing. The Data Processing Central, which eventually will be installed in each air route traffic control center, is the heart of the automatic control system.

The Data Processing Central will accept and "remember" hundreds of flight plans and massive amounts of related information. It will calculate an aircraft's time of arrival at checkpoints, print this data on a strip of paper and present it to the controller in the proper sector. In contrast to operating computers, which require the manual transfer of flight progress strips from sector to sector, and updating of strips by hand, the DPC will continue to update the original strip as the course is flown. This is accomplished when the controller, after receiving changes in flight plans by radio from pilots aloft, feeds it into the computer on tape.

The Data Processing Central will *do* more.

It will calculate the estimated times of arrival at destination airports and help establish the most favorable landing sequence for each runway. Further, it will probe for, detect, and predict conflicts, warn about unsafe situations, and automatically suggest corrective action.

Plans called for installation of the first production model at the Boston Center in July, 1962, well in advance of the original target date.

Among other research projects under way in 1960 were five separate projects aimed at finding ways to prevent midair collisions; the FAA's own All Weather Landing System, a composite of the best parts of several existing systems used in conjunction with new and unique methods developed by the Bureau of Research and Development; automatic air-ground communications, and an automatic transmission of aircraft altitude via radar beacon which will further reduce pilot-to-controller voice communications.

BUREAU OF FLIGHT STANDARDS

The year 1960 proved an active one for the certification of new types of aircraft. A total of 36 were issued, including 12 new transport planes, five helicopters, 18 personal aircraft and one glider. Among the new transports were new models of the DC-8, Boeing 707 and a French jet, the Sud Aviation Caravelle.

Of great significance was the certification of the first turbine-powered, single engine helicopter, the Sikorsky S-62. This aircraft, the first transport category certificated in the United States, was scheduled to enter regular air carrier service in 1961.

Another helicopter milestone was established when a four-phase Cessna was certificated to operate under instrument flight rules in weather minimums equivalent to single-engine, fixed-wing aircraft.

SAFETY

In the interest of greater safety the Civil Air Regulations were changed in 1960 to provide for: annual proficiency checks for air carrier copilots; installation of airborne weather radar on transports; installation of approved flight recorders on turbine powered aircraft above 12,500 pounds, and FAA approval of air carrier training programs for crew members and dispatchers.

A new amendment required applicants for private and commercial certificates to demonstrate some knowledge and skill in the use of instruments before receiving these certificates. In the same area, procedures were being developed to help inexperienced pilots inadvertently caught on top of an overcast or in other areas of greatly reduced visibility. These are "talk-down hands off" letdown procedures which, when transmitted by Flight Service Station and control tower personnel, will provide the inexperienced pilot with a means of safe descent in an emergency situation.

To better cope with accidents, near-accidents, and violations of Civil Air Regulations, a Safety Evaluation Division was established within the Bureau of Flight Standards. The purpose of this new Division is to provide a more effective centralized control and analysis of accident, incident and violation investigations. Emphasis was placed on improved instructions, better reporting procedures and the accumulation of accident data for study.

BUREAU OF FACILITIES AND MATERIEL

The most extensive network of navigational aids and air-ground facilities in the world exists within the borders of the United States, maintained by the Bureau of Facilities and Materiel for the use of airline, military, and general aviation aircraft. At the end of 1960, these aids totalled approximately 9,500, and consisted of 60 types ranging from small location markers to large complex radar systems linked by radio to air traffic control centers hundreds of miles away. All operate 24 hours a day, a large portion of them unattended.

During 1960, 445 major facilities were commissioned. Increases in 1960 over 1959 are shown in the following table:

	December 30, 1959	December 31, 1960
Approach Light System (ALS)	102	140
Sequence Flasher Lights (SFL)	41	110
Airport Surveillance Radar (ASR)	48	55
Instrument Landing System (ILS)	174	192
Precision Approach Radar (PAR)	11	23
VOR (including TVOR)	661	706
TACAN	76	264
Flight Service Stations (FSS)	333	339
International Flight Service Stations (IFSS)	11	11
Flight Advisory Service (Class I) (FAS)	16	29
Peripheral Communications (RCAG)	255	279
Air Route Traffic Control Center (ARTCC)	35	35
Airport Traffic Control Tower (ATCT)	137	152
Combined Station Tower (CS/T)	84	75
Long Range Radar (LRR)	33	47
Radar Approach Control (RAPCON)*	28	28
Radar Air Traffic Control Center (RATCC)*	4	6
Airport Surface Detection Equipment (ASDE)	0	3
TOTAL	2049	2494

*Military

AIRPORTS

During 1960, 375 airport aid projects were approved involving Grant Agreements totalling $81,400,000 in Federal funds. A new policy, effective July 1, 1961, provides that airport owners pay for relocating FAA air navigation facilities occasioned by airport improvement or changes. Airport owners have long paid similar charges for commercial utilities.

The FAA also continued its advisory assistance program to help local airport owners and operators develop, protect, maintain and operate their airports. Such assistance consisted of issuing guides and rendering advice on airport zoning, publishing engineering criteria and standards, promoting airport ground safety and land use, and developing planning guides and techniques.

In the international field, technical coordination was rendered 17 foreign countries in airport development projects; U.S. National Standards were completed for marking hazards on airports; DME (distance measuring equipment) was loaned to Spain, Turkey and Switzerland; excess electronic equipment to Nepal, Iran and Belgium; and a C-185 Beechcraft to Chile. Also an Instrument Landing System (ILS) was loaned to Peru to serve U.S. and international carriers during an airport relocation project.

AIRMARKING

The Bureau's air marking program resulted in construction of over 2,170 signs showing the town name and the distance and direction to the nearest airport. This was accomplished at no cost to the Government for labor or materials.

BUREAU OF AIR TRAFFIC MANAGEMENT

When commercial aviation entered the age of jet flight many problems were created for the air traffic control system which the increased use of radar and automatic computers have helped solve. At the end of 1960 the picture was much brighter than it had been one year earlier and FAA's goal of a modern system of air traffic control designed to accommodate all users, civil and military, was in sight.

Within the continental United States the Federal Aviation Agency maintains approximately 130,000 miles of high frequency and 47,000 miles of low frequency airways connecting 600 communities in an air traffic network. The airways, each 10 miles wide, and divided into thousand foot levels, from 700 up to 24,000 feet, are key elements of the air traffic control system. Above 24,000 feet the airspace is known as the Continental Control area where flight under FAA control is optional in clear weather but compulsory during restricted visibility. Strategically located along these airways are thousands of aids to aerial navigation, among them 261 airport control towers, (including combined FSS/Towers, and military), 35 air route traffic control centers and 340 flight service stations, manned by technically skilled air traffic control specialists.

The increase in the number of civil jet aircraft (240 turbojets; 352 turboprops at year's end) and conventional aircraft as well, increased the need for new and special air traffic control techniques. During 1960, in order to handle such traffic more efficiently, the basic airway route structure was reorganized into a "three-layer" system of low, intermediate, and high altitude airways. The area between 14,500 and 24,000 mean sea level will be reserved for medium and long range flights (DC-7 and turboprop types), with the "short hops" operating at the lower levels (general aviation aircraft and DC-3 and 4 types) and jet aircraft (DC-8s, 707s, 880s, etc., and military) above 24,000 feet.

Flight advisory service, initiated on the jet routes in 1959, was expanded by 86 percent in 1960 as the total mileage covered increased from 25,455 to 47,597. Surveillance for these operations was provided by long range radar from both FAA and Air Defense Command facilities.

POSITIVE CONTROL EXTENDED

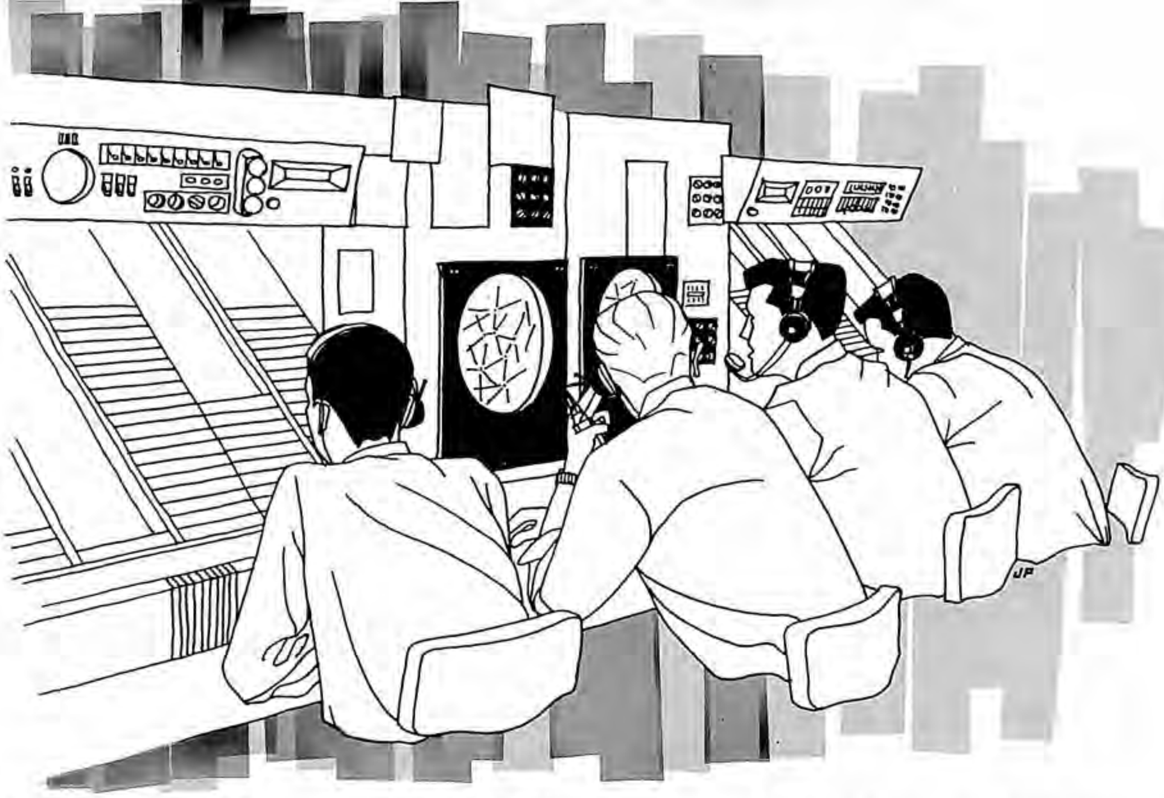
On October 15, 1960, positive control and separation of all aircraft flying between 24,000 and 35,000 feet was put into effect in the Chicago-Indianapolis area. As in the positive control transcontinental airways established between 17,000-22,000 feet in 1958, all traffic in the designated areas must be conducted with an ATC clearance and under positive control of a ground station, regardless of weather conditions. Further expansion of area positive control, both vertically and laterally, will be based on the experience gained in this initial program.

Also, on October 15, flight following service for general aviation aircraft was initiated from Flight Service Stations, giving pilots flying under Visual Flight Rules in aircraft equipped with two-way radio service comparable to that furnished the air carriers. When a VFR flight plan is filed at any Flight Service Station, the pilot is given a thorough weather briefing and a succession of Stations on his route, each within one hour's flying time of the other, are alerted to his presence in the air. In turn, the pilot must report to these stations not later than 15 minutes past certain designated arrival times. If he does not, the station will call him and if necessary a prompt searching operation will begin.

OCEANIC CONTROL

The consistent growth of international operations resulted in a revision of the Atlantic routes and reporting points in order to smooth the flow of traffic in the oceanic control centers in the New York, San Juan and Miami areas. Similar improvements for the Gulf routes operating to and from New Orleans, and the Pacific routes operating in and out of the centers at Oakland, Seattle, Anchorage, Honolulu, Wake and Guam were planned for 1961.

These oceanic centers provide around-the-clock air traffic service to hundreds of aircraft



every day. They provide separation by ATC clearances, up-to-date weather and position information, and search and rescue service if needed.

A year-long survey aimed at better use of the airspace across the North Atlantic was announced by the FAA in October, with Canada, Ireland and the United Kingdom participating with the United States. At present, aircraft must be kept 30 minutes apart longitudinally, 120 miles apart laterally, 1,000 feet apart in altitude up to 29,000 feet, and 2,000 feet apart above that altitude.

AUTOMATION

The world's first computer-to-computer network for the control of air traffic went into operation during the year when Univacs were commissioned at the Air Route Traffic Control centers in Washington, D.C., and Boston, Mass., and connected by landline circuits to computers in Centers at New York, Cleveland, Pittsburgh and Indianapolis. These were "off-the-shelf" commerical computers adapted to traffic control.

WEATHER

International weather reporting circuits from New York and Washington were extended to San Francisco via Detroit, Chicago, and Kansas City, closing one of the major gaps in the worldwide weather distribution system, and permitting rapid interchange of weather data between Europe and the Pacific area.

TRAINING

On-the-job training was continued at all air traffic management facilities. Approximately 1,000 new employees and 12,000 other employees of various experience levels received this training during the year. A program requiring extensive cross training of FAA and military personnel at FAA-operated military radar facilities was implemented (44 percent of the Agency's 39,000 employees were engaged in some form of air traffic control).

BUREAU OF AVIATION MEDICINE

Technical advances in the design, construction, and performance of modern aircraft presented the FAA with many problems touching on the health of flight crews, passengers, and certain Agency employees. Little had been done in this field since the first regulations were written in 1926, and knowledge relating to the effect of civil flying on the human body was almost non-existent.

Early in the year the physical and mental qualifications of airmen and others whose well-being affects the safety of flight were reviewed and brought into line with the times. A rule was passed requiring electrocardiographs every 6 months from airline pilots, and another requiring applicants for student and private pilot certificates to take their physicals from FAA designated Medical Examiners. Important in this latter connection was a revised application form providing for the medical histories of such applicants, information which had not previously been required, and which in light of the constantly increasing numbers of aircraft in the skies, has become vitally necessary.

In order to obtain the highest degree of performance on the part of Medical Examiners in conducting these examinations, a course in civil aviation medicine was developed. It was to be given at selected medical schools throughout the country beginning in 1961. To maintain their appointments examiners will be required to attend one such session every three years.

Other developments during 1960 included the participation of FAA's medical staff in aircraft accident investigations and the designation of 24 leading forensic pathologists (doctors who specialize in analyzing death from violence) as consultants in accident investigations.

Of utmost significance to the future of civil aviation was the establishment by the FAA of the world's first Civil Aeromedical Research Institute at Oklahoma City. Until completion of construction the work of the Institute will be carried on in rented buildings at Norman, Oklahoma, and at the Medical School, Georgetown University, Washington, D.C.

Under way were studies into the aging processes in humans; into the problems of fatigue and tensions as they affect air traffic controllers, and into the effects of high-speed, high-altitude flying on crews and passengers, as well as such diverse subjects as the center of gravity of infants and the tolerance of the body to vertical impact.

A training course was planned for designated Medical Examiners in the investigation of light aircraft accidents, to determine how frequently medical conditions are either the cause or a contributing factor. Specific data on the type of injuries suffered in light aircraft would be an invaluable aid to the FAA in its overall campaign of safety. It would also help manufacturers to incorporate design changes, if necessary, to assure the occupants greater protection in the event of a crash.

BUREAU OF NATIONAL CAPITAL AIRPORTS

The Federal Aviation Agency operated the Washington National Airport—at year-end the only Federally-owned metropolitan civil airport. The FAA was also constructing Dulles International Airport, (the world's first civil airport designed especially for jet aircraft) on a tract of almost 10,000 acres, near the crossroads of Chantilly, Virginia, 27 miles west of the White House.

Washington National Airport completed another financially successful year of operations during fiscal year 1960. The airport showed revenue of $4,270,049 while continuing a substantial improvement program and maintaining an excellent safety record.

The airport ranked second in the nation in total air carrier operations, being exceeded only by Chicago's Midway Airport. In order to keep pace with this activity, extensive improvements were undertaken during the year. Among these were additional aircraft parking ramps, air conditioning for the North Terminal and increased electrical capacity for hangar facilities.

This modernization program, underway to meet the needs of the air travelers, will encompass further major steps such as enclosure of all passenger concourses to protect travellers from inclement weather, or hazards of aircraft blast and vehicular movements in the adjoining apron area. Other major safety improvements in the landing area include extension of the existing aprons and provision for additional taxiways to alleviate hazards and delays in aircraft movements between aprons and runways.

When this modernization program is completed, Washington National will have the capacity to handle 6 million passengers a year. The Washington, D.C., traffic volume in excess of Washington National's maximum capacity and major jet airliner operations will be handled by the new Dulles International Airport.

Dulles International continued to progress rapidly during 1960 with all of the major items required for initial operation under contract.

Site preparation was completed and three runways and parallel taxiways paved. Construction of the terminal building, aircraft parking apron, fueling system and the access highway were well underway at the end of the year. Progress was made on the development of the prototype mobile lounge, a dramatic new concept for moving passengers from terminal building to waiting planes.

OFFICE OF INTERNATIONAL COORDINATION

The FAA extended and consolidated its world-wide influence in international aviation affairs in 1960. The American short-distance air navigation system, the VOR/DME—(very high frequency omni-directional radio range, plus distance measuring equipment) was adopted by the International Civil Aviation Organization (ICAO) as the world standard, after two years of effort by the FAA which took the lead in developing, defending, and validating the system's technical superiority.

Another example was the expanded world coverage of assistance provided by FAA/ICA Civil Aviation Assistance Groups, at year-end totaled 32 as against 28 in 1959.

The CAAGs, as the Groups are known, are made up of specialists in aeronautical fields. They supervise airport construction, installation of air traffic control facilities, communications equipment, and other navigational aids, as well as advise the various governments of safety, legislative, and other aeronautical matters.

In addition to their other duties, the CAAGs trained more than 1,200 foreign nationals to operate and maintain the aeronautical facilities within their own countries during the year.

Under the same joint FAA/ICA program, aviation training was given in the United States to 394 students from 45 different countries at the FAA Aeronautical Center in Oklahoma City. This was followed, in the majority of cases, by on-the-job training at FAA facilities, airline offices, manufacturing plants, engineering firms, and factory service schools.

THE AERONAUTICAL CENTER

The Aeronautical Center in Oklahoma is known as "The University of Civil Aviation," because it is the central point for indoctrination and advanced training of the FAA's own technical, flight and management personnel, and because so many foreign nationals come here to study.

Beyond its educational programs the Aeronautical Center plays a key role in the Federal Aviation Agency's other activities. It is the location of one of the largest warehouses in the world, and hub of a supply line that is global in extent. The Center also serves as a modern base for the overhaul and maintenance of Agency aircraft and the repair and fabrication of air traffic control equipment.

Ground was to be broken early in 1961 for the new Civil Aero-Medical Research Institute.

CIVIL-MILITARY COOPERATION

Considerable progress was made on "Project Friendship" under which the military functions pertaining to air navigation and air traffic control will be transferred to the Federal Aviation Agency.

A plan for the assimilation by the FAA of all flight-following, advisory, and communications functions and responsibilities of the Military Flight Service was developed in coordination with the Department of Defense.

Under the air traffic controller training program a pilot group of military trainees was to be enrolled at the air traffic control school at the Aeronautical Center early in 1961. Upon completion of this training final details will be developed for full FAA operation of both civil and military air traffic controller training.

In other areas, the FAA worked closely with the military agencies to assure maximum joint use of existing and planned facilities, and to insure that military operations are integrated into the overall air traffic management system with safety and efficiency.

The FAA participated with the Department of Defense in the conduct of 13 large scale military exercises. One of the largest, Operation Sky Shield, required the grounding of all other aircraft throughout the North American continent for a six hour period in the month of September.

GENERAL AVIATION

One of the main concerns of the Federal Aviation Agency, in its two years of existence, has been the safety of that varied group of flying activities covered by the broad term "general aviation."

Although the air carriers hold an important position as a transport medium, they rank below general aviation in hours and miles flown and number of aircraft utilized. Air carriers operated just over 2,000 aircraft in 1960. General aviation totaled some 70,000 at year's end, logging more than three times the flying hours of the domestic scheduled airlines.

General aviation includes flying instructors and student pilots, corporate and business pilots, cropdusters, weekend fliers, charter and taxi operators and helicopter pilots who operate in a range completely different from any other. The groups have little in common except joint-use of the airspace. It was for the safety of these pilots that the flight following service and the VFR flight plan was instituted.

The FAA has constantly stressed the importance of the VFR flight plan to general aviation pilots, including those who have minimum radio equipment, or none at all. A flight plan in such instances guarantees that the destination station will be on watch for the aircraft's arrival and will start a searching operation within an hour of its being overdue.

Much of FAA's Research and Development work will further general aviation safety. The visual glide slope is one example; improvement of radio voice intelligibility is another; runway lights, runway and taxiway marking, lightweight and low cost distance measuring equipment, and a low-cost all channel VHF airborne transceivers are all undertaken to benefit general aviation.

At the end of 1960, the Bureau of Research and Development was working on a small, light weight comparatively inexpensive radar beacon transponder for business and private aircraft.

NOISE

Noise reduction is second only to safety in FAA's lexicon. Recognizing its seriousness a Noise Abatement Branch was established within the Office of Plans to coordinate the over-all noise abatement program.

While the problem was accentuated in 1960 as the number of jets increased, not only on the airlines but in the business and executive fleets as well, partial solutions were found. Through the use of preferential runways, special arrival and departure routes, minimum altitudes and revision of air traffic rules afforded relief at major terminals. Improvement was noted in the high density areas of Washington, Los Angeles, and New York after special airport traffic rules were put into effect. An aggressive campaign to reduce aircraft noise to a minimum consistent with safety and the requirements of air commerce continues on all fronts, including development of a basic regulation governing flight activities near controlled airports to cope with the problem on a national basis.

A planning guide entitled "Noise Abatement Procedures" was made available to airport authorities, zoning commissions and other community organizations, advising against any type of new construction which would aggravate the noise problem at locations which have, or expect to have, turbojet service.

CIVIL AERONAUTICS BOARD

THE CIVIL Aeronautics Board, in a 1960 decision of major significance to the air transport industry, issued its opinion in the General Passenger Fare Investigation. In April the Board announced its tentative vote in the case, indicating that the fair overall rate of return for the domestic trunkline industry was determined to be approximately 10.5 percent, based on a somewhat lower return of 10.25 for the four largest airlines (American, Eastern, TWA, United) and 11.125 for the other trunks. Subsequent to the announcement by the Board, the trunk airlines filed tariff proposals for higher air fares in varying amounts. In June, the Board announced that it would permit the domestic trunklines to raise their passenger fares by 2½ percent plus $1.00 per one-way ticket, effective July 1, 1960. This increase amounted to about five per cent overall, and was estimated by the Board to increase the trunklines' revenues by approximately $84 million annually. It was further provided that present jet surcharges and the $1.00 increase expire June 30, 1961, while the 2½ percent increase will be permitted on an indefinite basis. Appropriate tariffs were filed by the airlines involved, and the fare increases became effective July 1, as scheduled. After July 1, airlines operating domestic jet coach flights increased fares to the extent necessary to bring jet coach fares to approximately 75 per cent of the regular first class fares.

The Board's general nation-wide review of local airline services progressed through the year with a total of seven cases on which decisions were issued. Five cases remained to be decided and at year-end were in various procedural stages. The local carriers continued to acquire larger and improved aircraft, including the F-27 turboprop, the turbine powered Convair 540, the Martin 202 and 404, Convair 240 and 440 aircraft. Only three local service airlines were operating with only DC-3 aircraft.

Authorizations in the local service cases were

THE CIVIL Aeronautics Board, as constituted at the end of 1960: l. to r., Maj. Gen. John S. Bragdon (Ret.); Vice chairman Chan Gurney; Chairman Whitney Gillilland; G. Joseph Minetti; Alan S. Boyd.

granted by the CAB on a "use-it-or-lose-it" basis, giving smaller communities an opportunity to develop their use of air service, but requiring the production of a minimum amount of traffic in order to retain the service authorized. At the end of the first 18 months of service, if such traffic standards have not been met, the Board will, except for unusual circumstances, initiate proceedings to terminate airline service at below-standards points.

The CAB stated its belief that every effort should be made to maintain economic operations of the local service routes, so the subsidy burden will not increase.

To that end, the Board, late in the year, instituted a proceeding directed to the establishment of a uniform class subsidy mail rate for local service carriers, effective January 1, 1961. The Board and its staff were studying the question of replacing the system of determining local service subsidy on an individual carrier-by-carrier basis, with a uniform rate formula. Such a class rate would have many advantages over the present system. It would enable the Board to simplify procedures, to the advantage of the airlines and the Board. Moreover, by requiring each carrier to operate under a rate determined on the basis of the results of all members of the class, stronger incentives would be created for greater operating efficiency, cost controls, optimum fare levels and economic scheduling. The proposed rate formula now under study by the Board, prepared by the staff after consultations with the airlines involved, would determine subsidy on the basis of the density of operations of the airlines, according to a uniform sliding scale rate that would decrease as the volume of service increases. This proceeding was expected to be completed early in 1961.

In mid-1960 the Board effected major changes in its policies regarding the authorization of civil air carriers to perform airlift services involving both passengers and cargo to and from overseas and foreign points for the Department of Defense. These policy changes culminated studies conducted during an extended period. The Board for a number of years had authorized by regulation and by order broad segments of the civil air carrier industry to participate in such charter services for the military. Such authorization enabled most U.S. air carriers to offer bids with respect to the various transportation requirements of the military establishment.

On the basis of its studies, the Board concluded that the circumstances which had previously warranted the "blanket" authorization of groups of air carriers to perform these services no longer obtained. The Board announced therefore its intention to discontinue after September 30, 1960, issuance of orders which would afford the "blanket" authorization and instituted a proceeding looking toward the rescission of an outstanding regulation which had essentially the same effect. Simultaneously the Board announced that it would entertain applications for the necessary authority to perform these airlift services on a carrier-by-carrier basis. The Board further noted three criteria to which it would give great weight in passing upon individual carrier's applications for such authority. These criteria are:

(a) The rates are deemed by the Board to be fair and reasonable.

(b) The carrier has executed a CRAF Standby Contract.

(c) The Secretary of the Air Force or his designee has determined that the contract is in the interest of national defense.

With respect to the rates of compensation for these airlift services, the Board set forth rates per passenger-mile as the minimum it would view as fair and reasonable absent a showing to the contrary in individual situations. Subsequently the Board announced a minimum rate for cargo transportation services.

The CAB instituted an investigation late in 1960 looking to the possibility of certification of one or more airlines to perform transatlantic charter service. Further, in a proposed revision of the present transatlantic charter regulation, the Board contemplated liberalizing the regulation to the extent that prior approval of charter trips would not be required in the future. The Board said that the standards for charter eligibility were sufficiently precise and understandable as to preclude inadvertent violations on any wholesale scale, and for this reason it believed that retention of the prior approval on individual charter flights was unnecessary. The Board said that since 1957 charter traffic has been growing at a rate believed to approach 50 percent each year. In 1957 it was estimated that charter flights accounted for about 6½ percent of the total transatlantic market in the April-September period; in 1960 the figure exceeded 11 percent. No final action had been taken at the end of the year.

In initiating an investigation, initial steps were taken by the Board to determine whether air freight minimum rates should be modified or revoked, to remove any possible obstacle to the accelerated growth of air freight. The CAB noted that the airline industry was planning the introduction of new turbine-powered aircraft which will add to the efficiency of air cargo operations. Together with the changed competitive situation in the air freight industry, the fact that the original minimum rates were determined more than 12 years ago, the new types of aircraft to be utilized, and the restricted development of the air freight industry, the Board's belief that suitable cargo aircraft and the movement of traffic may be interdependent, entered into the Board's decision to initiate this far-reaching investigation. At the end of the year airlines had filed comments, as requested, to the Board's order, setting out their views as to whether the investigation go forward now, or be deferred for actual experience with the turbine-powered aircraft to be used.

Decision was reached in the Pan American-National Agreement investigation, involving a short term equipment lease agreement between the two airlines of jet aircraft during certain seasons of the year, and a long term lease agreement which also encompassed exchange of stock of the two companies. In its final decision the Board found that the short and long term equipment leases were beneficial to the airlines and the public, and should be approved. However, the Board said that the option and stock agreement was not in the public interest because it had enabled Pan American to acquire control of National, and was contrary to the intent of the antitrust laws. The Board further found that the option and stock agreement would have unfavorable effects on the competitive situation in the areas involved. The Board ordered that Pan American and National, within 60 days from the date of the Board's order, return the stock acquired from each and cancel the stock option, or, in the alternative, file an appropriate divestiture plan or plans for Board approval.

AGRICULTURAL RESEARCH SERVICE

Department of Agriculture

INSECT INFESTATIONS, particularly of grasshoppers, were considerably less extensive in 1960 than in 1959, and consequently there was less use of aircraft by the Department of Agriculture for insect control and eradication. Between January and late summer of 1960, pilots of USDA's Agricultural Research Service flew 112,000 miles assisting in the supervision of control and eradication groups, conducting

"SMOKEJUMPERS" of the U.S. Forest Service leap into action over Okanagan National Forest.

experimental applications of insecticides, and performing insect and nematode damage detection surveys. During the comparable 1959 period, a total of 220,000 miles were flown.

About 522,000 acres were treated by aircraft in the campaign to eradicate the imported fire ant from nine southeastern states. Treatments in Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, South Carolina and Texas raised the total of treated acres to more than 1,800,000 since the Federal-State program started in 1957. Experimental use of helicopters in three Georgia counties showed that these aircraft can be used to inspect large areas for the ants in a few hours flying time.

In addition to control measures, insecticide tests with aircraft were conducted in Louisiana and Mississippi to develop improved fire-ant eradication methods.

Contract aircraft equipped to apply granulated insecticide treated 26,800 acres of Illinois farmland infested with Japanese beetles as part of the Federal-State effort to eradicate occasional infestations of this pest in the North Central States.

Special control steps were taken at many northeastern airports to prevent Japanese beetles from boarding jet planes and other aircraft headed for areas in the U.S. not already infested by the pests. Boarding passengers and the interiors of the planes were carefully examined for beetles, and airport grounds were sprayed to rid them of unwanted insect "hitchhikers." Increased precautions were adopted after large numbers of the beetles were found on jet aircraft arriving in western cities. Why the beetles seem to prefer jets was not determined.

Aircraft were used to apply liquid insecticides on gypsy moth infestations covering 31,341 acres of woodland in Michigan, New York, and New Jersey. Sprays of both DDT and Sevin were applied to control this serious pest of shade and forest trees.

ARS also conducted field tests with several insecticides and insect pathogens on woods infested with the gypsy moth in Vermont and Maine. Approximately 2,000 acres were treated by aircraft with single and double applications of experimental materials during different stages of insect development. The tests were aimed at finding a poison suitable for use in areas where applications of DDT would be hazardous.

An aerial survey of gypsy moth defoliation was conducted on New England forests to determine where future treatments will be required.

Because of effective Federal-State-rancher control programs during 1959, and weather conditions unfavorable to development of large grasshopper populations, no extensive program was conducted against hoppers during 1960. However, 85 large-scale aerial field tests of several new insecticides, in both dust and liquid forms, were carried out on about 12,000 acres of rangeland in California. The tests measured the effect of the new chemicals at different rates of application.

Because of success in 1959, the effort to eradicate the pink bollworm in Arizona was eased somewhat in 1960. Nine insecticide applications of liquid spray and dust formulations were applied by 36 aircraft at six-day intervals on 300,000 acres of cotton, compared with the use of 70 aircraft on 600,000 acres of cotton in 1959.

Aircraft distributed granulated insecticides on large populations of white fringed beetles threatening important crops in Alabama, Arkansas, and Georgia. Part of the 43,000 acres treated was also infested with the fire ant.

Successful aerial surveys to detect new soybean cyst nematode infestations at the edge of established infestations and to determine the boundaries of known infested areas were conducted in Arkansas, North Carolina, South Carolina, and Tennessee.

Success in the campaign against the screwworm, a costly cattle pest in the southeastern U.S., was marked by the closing of facilities at Sebring, Florida, for production of male flies made sterile by exposure to radioactive cobalt-60 and used in eradication. The flies were dispersed by aircraft throughout the infested area, where they mated with native females to produce infertile eggs, thus eventually destroying the native population.

This same technique for control of the oriental fruit fly was under test late in 1960. About 3,000,000 sterile male flies were produced and broadcast by airplane each week over Rota, a small, isolated Pacific island which is naturally infested with this costly agricultural pest.

Hoja blanca, a serious rice disease new to the U.S., can be controlled by aerial applications of a water mixture of malathion and DDT, the Department scientists reported. The poisons do not act on the disease itself, but kill the vector (carrier), a leaf hopper.

In experiments preliminary to manned space flights, no genetic damage to insects was observed from cosmic radiation that penetrated Navy balloon gondolas carrying insects nearly 15 miles above the earth. Fruit flies, house flies, and fleas carried by the balloons remained at altitudes of 78,000 to 82,000 feet for 16 hours and were under cosmic ray attack 60 times more intense than at sea level. Power of the rays, which caused no detectable damage to the insects genetically, was equivalent to a dose of 10,000 roentgens for less than a millionth of a second. Results of these experiments do not prove, however, that cosmic rays at such altitudes are harmless to all life.

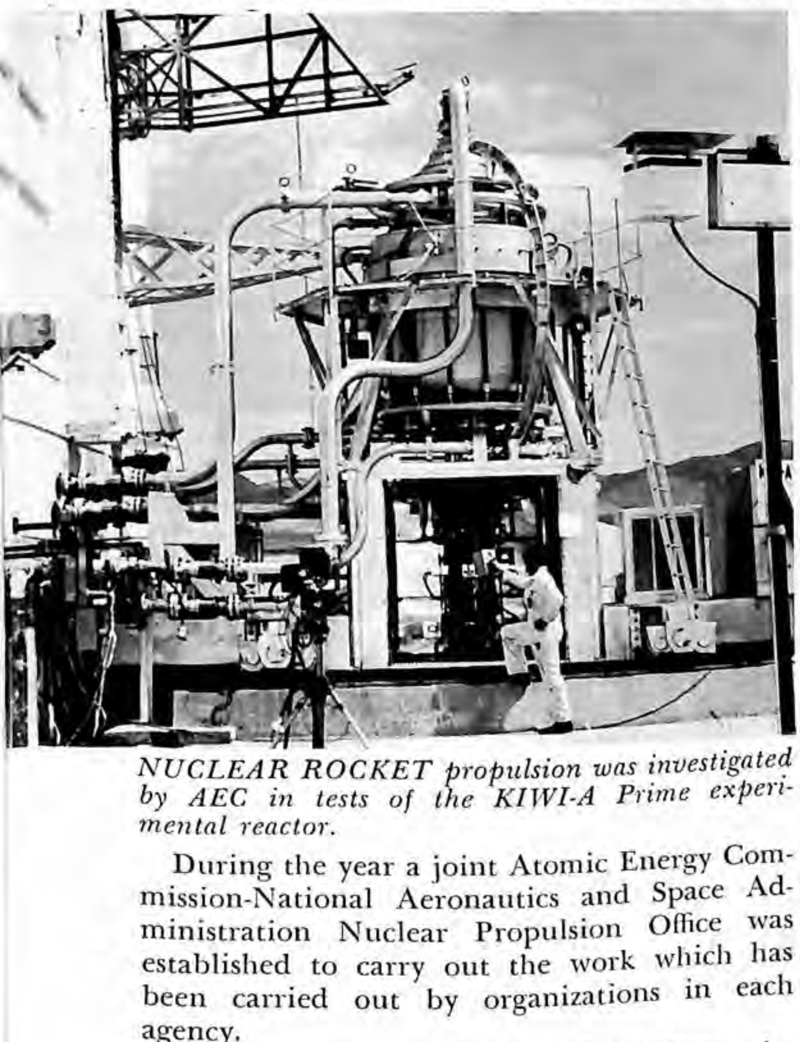
Of the more than 139,415 airplanes inspected under USDA quarantine regulations on arrival in the U.S., about one out of every three was found to harbor agricultural insect pests and diseases. In cooperation with the U.S. Customs, more than 10,776,000 pieces of baggage were inspected, uncovering 94,000 prohibited lots of plant material. Animal quarantine inspectors found and destroyed 32,861 packages (120,410 pounds) of prohibited and restricted airborne foreign meats and meat products which might have carried insects and diseases into this country.

ATOMIC ENERGY COMMISSION

DURING 1960, the Atomic Energy Commission continued research and development on the use of nuclear energy for rocket and ramjet propulsion, for manned aircraft, and for auxiliary power for space missiles systems.

Project Rover is the study of nuclear rocket propulsion which was being conducted by the Los Alamos Scientific Laboratory, operated for the Commission by the University of California.

The second and third experimental reactors in the KIWI-A series, named KIWI-A Prime and KIWI-A3 after the flightless New Zealand bird, were given power tests in July and October at the Jackass Flat area of the Nevada Test Site. KIWI-A, the initial reactor in the series, and KIWI-A Prime and KIWI-A3, were heat-exchanger devices operating on an open cycle, in which the propellant, heated in the reactor core, is expended to the atmosphere through a nozzle. Following the tests the experimental reactors were disassembled and the components were being studied by LASL scientists. The studies were expected to help develop more advanced reactors which ultimately may propel a rocket.



NUCLEAR ROCKET propulsion was investigated by AEC in tests of the KIWI-A Prime experimental reactor.

During the year a joint Atomic Energy Commission-National Aeronautics and Space Administration Nuclear Propulsion Office was established to carry out the work which has been carried out by organizations in each agency.

Project Pluto is a study to demonstrate the feasibility of using a nuclear reactor as the heat source in a ramjet engine of a strategic missile. Under this program, the Commission's Lawrence Radiation Laboratory, operated by the University of California, was building the Tory-IIA reactor, a non-flyable experimental reactor, in the Jackass Flat area of the Nevada Test Site.

Work continued on a number of projects in the Commission's program for the development of systems for nuclear auxiliary power—SNAP. The aim of the SNAP program was to develop small, lightweight nuclear-powered electric generators for satellites, space vehicles and special applications. Two approaches to provide nuclear heat were under development; one uses the heat from the radioactive decay of a radioisotope to generate electricity in thermocouples (as in SNAP-1A and SNAP-3), with the Martin Co. as the principal contractor. The other uses heat from very compact reactors to drive turbines (as in SNAP-2 and other even-numbered SNAP projects), with Atomics International as the principal contractor.

Hardware development was being completed for SNAP-1A by building three prototype units. SNAP-3, 3.5-watt polonium-fueled thermoelectric generator used as a proof-of-principle device, has satisfactorily completed shock, vibration and acceleration tests. This program was to be completed by June, 1961. The United States Coast Guard requested the Commission to produce units fueled with strontium 90 for use in costal light buoys, and the Navy requested the Commission to develop similarly fueled units for automatic weather station power supplies.

The SNAP Experimental Reactor, a prototype of SNAP-2, achieved full power (50 thermal kilowatts, 1200°F) in November, 1959, and by July, 1960, had generated 150,000 thermal kilowatt hours at full power. The SNAP-2 turboelectric conversion equipment, designed to produce 3 electrical kilowatts at 40,000 revolutions per minute, has undergone endurance runs. SNAP-8 is a 30 electrical kilowatt unit with a turboelectric conversion system designed to meet requirements of the National Aeronautics and Space Administration. The AEC has the responsibility for development of the reactor. NASA selected Aerojet-General to develop conversion equipment for SNAP-8. Work was under way on the development of SNAP-10, which would generate electricity directly without moving parts. Critical experiments of the reactor core were initiated in July.

In the manned aircraft propulsion program, investigations were continued on two basic systems, the direct cycle and the indirect cycle. The General Electric Company was under contract to the Commission to develop reactors for the direct-cycle system at Evendale, Ohio, and at the National Reactor Testing Station in Idaho. Pratt & Whitney is under contract to the Commission to develop reactors for the indirect-cycle system at Middletown, Connecticut. In the direct-cycle system, compressed air is heated in a reactor core and is exhausted directly through an engine turbine and exhaust nozzle. No heat exchanger is used. In the indirect-cycle system, compressed air is heated as it passes through a heat-exchanger system containing, liquid-metal coolant from a reactor. In February, the Blaw-Knox Company was retained as architect-engineer for the development of indirect-cycle facilities that would be required at the National Reactor Testing Station.

The Commission's Oak Ridge National Laboratory provided general support for both the direct and indirect cycle programs, with emphasis on shielding problems. In September, the new Tower Shielding Reactor at Oak Ridge became operable for obtaining shielding data and for testing an indirect-cycle shield.

General Dynamics Corp., Convair Division, Fort Worth, Texas, was continuing to provide airframe design support to contractors for both propulsion systems.

DEFENSE AIR TRANSPORTATION ADMINISTRATION

DURING 1960, the Defense Air Transportation Administration, in consultation and cooperation with the Office of Civil and Defense Mobilization, continued its planning and programming for mobilization of civil aviation resources, both domestic and international to meet wartime needs.

New program features initiated included revision of the Civil Reserve Air Fleet (CRAF) on a quarterly basis, thereby insuring the availability of the most modern long-range aircraft fleet to meet military requirements; updating of studies reflecting apportionment of civil air transport capacity available to meet the needs of the civil wartime economy (WASP); revision of the National Emergency Defense Airlift (NEDA) Plan, to reflect the merging of Federal Civil Defense Administration and Office of Civil and Defense Mobilization and to provide flexibility of operations at all levels; formulation of plans for expansion of the interim binder program to make available non-premium insurance to those CRAF carriers under contract to the Department of Defense and to those American carriers entering into certain agreements with the Department of State; and consummation of indemnity agreements with the Department of Defense and State, approved by the President, providing for repayment by such Departments to Commerce of any amounts paid under non-premium insurance.

FISH AND WILDLIFE SERVICE used planes

FEDERAL COMMUNICATIONS COMMISSION

DURING 1960, the Federal Communications Commission continued administrative control over those portions of the radio spectrum which had been allocated for non-government use in aviation radio communication, aeronautical radio navigation, and to satisfy other safety and operational communications requirements of the aviation industry.

At the close of July, there were 93,421 authorizations for commercial and private radio operation; of these, 73,999 were in the aircraft group, 3,971 in the aeronautical and fixed group, 423 in the aviation auxiliary group, 370 in aviation radionavigation land and 14,658 in Civil Air Patrol.

After making the necessary frequency bands available, the Commission prescribed the manner in which they should be used, developed methods for better frequency utilization, prepared for, attended and followed up on international and domestic aeronautical and radio telecommunications conferences, reviewed and revised its rules governing the use of radio for civil aviation, and processed all applications covering radio facilities in the aviation services.

The Aviation Services section of FCC included both aircraft and ground stations. By classes, these were: air carrier aircraft, private aircraft, aeronautical enroute, aeronautical fixed, operational fixed, aeronautical advisory, aeronautical utility mobile, airdrome control, flight test, flying school, radio navigation, aeronautical public service aircraft, aeronautical

like the Grumman Goose in waterfowl survey.

search and rescue mobile, and civil air patrol.

In administering the non-government aviation services, coordination was maintained by the Commission throughout the year with such technical and policy-making groups as the Radio Technical Commission for Aeronautics, the Air Coordinating Committee (terminated in October, 1960) and, internationally, through the International Civil Aviation Organization (ICAO) and the International Telecommunication Union (ITU).

During the year, a major reallocation of aviation frequencies resulted in 5 mc of radio spectrum being relinquished by non-government and military users for government air traffic control. In consequence, about 800 non-government ground stations were being reassigned frequencies and relicensed. The change required close coordination with licensees and the Federal Aviation Agency nationally as well as the Canadian Department of Transport, internationally, in order to avoid interference in congested areas along the border.

One problem that faced the Commission at year-end was the announcement by FAA that the frequencies available for operation of the air route structure would soon become saturated and that by 1963 there would be a definite shortage of available radio channels. This meant that extensive effort would be needed to fulfill the demands for additional air traffic communications capabilities. The solution to the problem might involve more extensive frequency sharing or the reallocation of frequencies currently in use by other services, or both.

FISH AND WILDLIFE SERVICE
Department of Interior

DURING 1960, Fish and Wildlife Service used aircraft in enforcing federal fish and wildlife laws, taking waterfowl inventories, big game surveys, aerial hunting to control large predators, developmental work on national wildlife refuges such as aerial seeding and spraying, collection of fishery statistics, aerial reconnaissance of wildlife areas, and hauling supplies and personnel to and from isolated field stations.

The Service operated a fleet of 40 aircraft composed of 13 Cessnas (1 170 and 12 180's), 9 Grumman Gooses, 17 Pipers (Pacers and Supercubs), and 1 Navion. The majority of these aircraft were used in Alaska. The total number was reduced from 1959 due to transfers of equipment to the new state.

The maintenance of Service aircraft, with the exception of those in Alaska, was handled on a contract basis through commercial shops. The aircraft in Alaska were maintained in the Service's own repair shops, with some work being handled on a commercial basis.

In 1960, the Fish and Wildlife Service had 90 employees holding the Letter of Flight Authority. These pilots were all Civil Service qualified as Game Management Agents, Refuge Managers, Fishery or Wildlife Biologists, Animal Control Biologists, and in a few instances in Alaska as Pilot-Mechanics. Practically all Service pilots were trained wildlife or fishery personnel. The use of aircraft provided these men with additional speed and mobility so they could better handle the job of protecting and managing the country's wildlife resources.

FOREST SERVICE
Department of Agriculture

THE FOREST SERVICE in 1960 continued to expand its use of aircraft in the protection and management of the 181 million acres of National Forests located in 39 States and Puerto Rico. Aircraft were used extensively in fire detection and suppression, detection and control of forest insects and diseases, range and forest reseeding projects, and aerial surveys and map making.

New techniques of aerial attack by helicopter and air fire tankers enabled the Forest Service to expand the use of aircraft in its fire control operations. In 1959, fixed wing aircraft flew 26,030 hours and helicopters 6,716 hours compared to 22,923 hours and 4,106 hours, respec-

FROM TOP to bottom, Sikorsky XR-4 Helicopter, first to make an extended cross-country flight from Bridgeport, Connecticut to Wright-Patterson AFB, 1942; (L) scale models of Fighters and Scouts of World War I; (R) Inflight mounting of the Bell X-1. Planes on display in National Air Museum.

tively, in 1958. All aircraft carried 35,723 passengers and 1,297,247 pounds of cargo. Commercial and privately owned aircraft accounted for 82 percent of hours flown. In hours flown, reconnaissance of going fires increased 40 percent and air tanker use 117 percent over 1958. Air tankers dropped 3,360,000 gallons of fire retardant on 507 fires compared with 1,506,000 on 322 fires in 1958. The record for 1960 was even greater. During the summer of 1960 aircraft was used extensively on the big fires in the western states of Oregon, Washington, California, Idaho, Montana, Nevada, Utah, Arizona and Wyoming. At the peak of fire-fighting activities during the last two weeks of July more than 300 aircraft were used.

The Forest Service organized a stepped-up program of fire control for the National Forests in 1960 which involved 14 air bases and additional air tanker base equipment, aircraft, radios and other needed facilities.

In forest pest control, aircraft were used in detecting outbreaks of destructive insects and some diseases and in combating foliage destroying insects. Many millions of acres of forest lands were surveyed in 1959 by aerial observers who looked for and reported on abnormal insect activity. Certain tree diseases were also detected by aerial observers, such as oak wilt and dwarf mistletoe. Under cooperative arrangements by the Forest Service with state and private agencies, aerial application of DDT was made to suppress spruce budworm on 134,121 acres. This was one of the smallest budworm control operations in recent years. DDT was also aerially applied on 47,261 acres to check outbreaks of Tussock moth, jack pine budworm, elm spanworm, Saratoga spittlebug, pine sawfly, and pine weevil.

Aircraft, as in recent years, was used as an aid in range management during 1960. Over 82,000 acres of national-forest western rangeland were sprayed with herbicides to control undesirable plants.

The use of aerial photography for mapping and other forest resource planning and utilization continued to grow. In fiscal year 1960, the Forest Service initiated coverage of 56,086 square miles to aid in timber management and mapping.

During the year helicopters were used in the furtherance of wildlife habitat management work on the national forests. Ranger and wildlife biologists in Alaska used helicopters to assist them in counting Alaskan Brown bears. The men were shuttled in pairs to the heads of river drainages within the brown bear's range by helicopter. They then hiked down the drainages, tallying the bears seen along the way, and were picked up by the helicopter at the river's mouth and moved to the top of the next drainage.

Forest Service wildlife management biologists and foresters were also using helicopters on an experimental basis to photograph and map key big game winter ranges in western Montana. The low altitude aerial photographs thus obtained were then checked and calibrated on the ground for use in determining range conditions and trends.

NATIONAL AIR MUSEUM SMITHSONIAN INSTITUTION

AFTER BEING CLOSED to the public for eight months, the remodeled Aircraft Building of the National Air Museum, with new and different exhibits was opened on April 15. This was merely a token exhibit since only a small fraction of the items in the national aeronautical collection could be displayed in the small area. However, public reaction was favorable to the many new exhibits such as original Goddard Rockets, recovered space-age equipment, aircraft displayed in flight positions and wall panels showing the chronology of aviation history in proper sequence, using graphics dioramas, and specimens.

Pre-planning for the new building continued in anticipation of appropriations for the authorized plans and specifications.

In addition, the year was marked by the further improvement of the Preservation and Restoration Division located at Silver Hill, Maryland. At year-end the Museum had fourteen steel buildings filled with stored aircraft, engines, and other aviation materials. The largest one was used as a "factory" for the restoration of famous aircraft in the national collection. After considerable research to determine authentic original condition, each plane was completely disassembled, preserved, and restored in preparation for exhibition. All available sources of information on each airplane, including original drawings, technical orders, and so on are exhaustively studied so that when the restoration is completed, the plane then represents an historically and technically accurate exhibit.

Examples of outstanding accessions received by the National Air Museum during the year were: the nose cone, space capsules and cradles used in the first successful attempt to recover living animals (the monkeys Able and Baker) after a 1500 mile flight, 300 miles out into space—a transfer from the Army; fourteen equiscale models of aircraft used since the beginning of Braniff Airways; three original oil portraits of World War I aviators, painted by the French artist, Henri Farré; sixty-six medals, awards and certificates from General James H. Doolittle; a full size Atlas ICBM launch vehicle surmounted with a General Electric Mark II nose cone—a transfer from the Air Force; and 1400 volumes of rare and historically significant aviation books covering the period 1700 through World War I—a gift of the National Aviation Club.

POST OFFICE DEPARTMENT

APPROXIMATELY one and one-third billion pieces of airmail and air parcel post were handled in the domestic airmail service during Fiscal Year 1960, according to preliminary figures of the Post Office Department. The weight of this airmail exceeded 102 million pounds.

Some $46 million in service mail payments were made to 45 air carriers for the transportation of over 111 million mail ton-miles in the domestic service. There were nine carriers engaged exclusively in Alaskan operations and two carriers operating entirely within the new state of Hawaii. In addition to the service mail pay, subsidy mail payments were made to certain air carriers by the Civil Aeronautics Board.

First class mail transported by air totaled almost 20 million mail ton-miles. Payment to the airlines involved in this program amounted to more than $3.5 million during fiscal year 1960.

An increase of approximately eight percent over previous year figures was recorded in the volume of foreign airmail. This included mail from the United States to and from U.S. possessions and territories, and to and from U.S. military post offices located in foreign countries.

Approximately 13 percent of the total foreign airmail from the United States to other countries, except Canada, was transported by foreign flag carriers. Separate figures were maintained with respect to dispatch of airmail destined to Canada and they revealed that about 62 percent was transported by Canadian flag carriers.

DEPARTMENT OF COMMERCE WEATHER BUREAU

THE MODERNIZATION of the aviation weather service of the Weather Bureau continued in 1960, with gains in the fields of weather measurements, analysis, forecasts, warnings, and weather communications facilities.

With approximately 3,600,000 surface observations, 80,000 radiosonde and rawinsonde probes of the upper atmosphere, 400,000 radar observations and a large increase in the number of pilots' in-flight weather reports, the atmosphere was kept under closer surveillance than ever before.

Approximately 1,400,000 aviation forecasts were prepared by 28 Flight Advisory Weather Service (FAWS) Centers in the 50 states. The areas served by these Centers were realigned during 1960 to approximately equal size, coincident with the realignment of the public weather forecast service. The aviation and public forecast centers were combined.

Weather briefings were provided for 210,000 international flights and for over 6,500,000 domestic flights. Additional pilots were served by the continuous transcribed aviation weather broadcasts on FAA L/MF radio facilities at 19 locations serving areas of 125 mile radius. The material for these broadcasts was provided routinely by the Weather Bureau. By the end of 1961, the program of 87 such broadcasts was expected to be in operation, with country-wide coverage.

Success was achieved in the initiation of a greatly expanded pilots' weather reporting program. The weather as seen from the cockpit was rapidly summarized and disseminated to other aircraft in flight and to flight planning locations on the ground. It supplemented the continuous ground watch of changing weather conditions which served as the basis for issuance of advisory messages, by FAWS Centers, of weather potentially hazardous to aircraft in flight. The advisories were given immediate wide distribution by teletypewriter and aeronautical radio facilities.

Greater radar coverage was provided by the progressive installation of the powerful new WSR-57 weather radars, with 250-mile radius of coverage. With 20 sets in operation and more to be installed, this weather eye continuously surveyed weather blind spots between observing stations and detected the development and movement of squall lines, thunderstorms, tornadoes and other conditions of concern to aviation. FAWS Centers received radar reports by teletypewriter to assist in their continuous weather watch.

Sophisticated automatic weather observation stations were installed at several places. Development work continued on these automated weather observers, which provide a continuous record of wind, pressure, temperature and other elements at airports.

In the field of weather briefing, the Weather Bureau's service of making avialable its observations, forecasts and warnings to pilots planning flights was augmented by an agreement with the FAA to utilize the services of their Flight Service Specialists to answer air-ground requests for weather information and to handle preflight weather briefings at their facilities. The Weather Bureau provided the necessary observations, forecasts, advisories and warnings for this purpose, and train, examine and certified the FSS personnel. Inquiries involving forecast capability were referred to FAWS Centers.

Weather briefing was made more readily available by further installations of Weather Bureau Automatic Telephone Answering Systems which provide pilots with taped briefings on area weather conditions at 28 locations.

Improved equipment for upper air soundings resulted in increased height and accuracy of upper wind reports—a special benefit for the now-common high-level turbine-powered aircraft flights, for which a special High Altitude Forecast Service was maintained.

Weather communications improvement in 1960 included the expansion of the Weather Bureau's national weather facsimile network to a number of additional Weather Bureau offices, and increase in transmission speed from 60 to 120 scans per minute.

In an area of marked interest to aviation, the success of the weather satellite, Tiros I drew wide attention. During the three months, from its launching on April 1, 1960, to the termination of picture transmission on June 30, Tiros provided almost 24,000 photographs, from 400 miles up, of broadscale weather situations. An operational program will provide forecast offices on a current basis with facsimile depiction of the photographic weather surveillance provided by the next weather satellite.

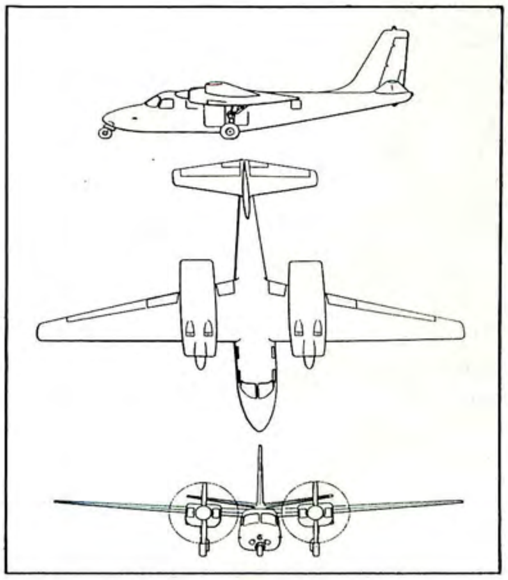
A Project Mercury Weather Support Group was established by the Weather Bureau to concentrate on the forecasting and research needed for the Man-in-Space program. Weather and sea conditions in the probable recovery area, and around the world beneath the planned orbit, would be closely watched. Units would be located at the National Meteorological Center, Cape Canaveral and the National Hurricane Center at Miami.

Action was initiated during 1960 to study the weather support problems that will arise by 1970 in connection with supersonic civil air transport aircraft. The relation of the sonic boom to atmospheric conditions, the winds and turbulence at the projected 80,000 foot cruising level, and the need to avoid hail and other hazards during high-speed climb and descent will be studied.

Study was also commenced on a more immediate problem—the forecasting of clear air turbulance at jet transport levels, with the object of developing successful methods of identifying and forecasting synoptic weather situations that coincide with instances of severe and extreme clear air turbulance. ■


N385AA
AMERICAN

AIRCRAFT IN PRODUCTION



AERO COMMANDER 500A

AERO COMMANDER, INC., Bethany, Oklahoma

SPECIFICATIONS

Span 49 ft. 6 in.; Length 35 ft. 1¼ in.; Height 14 ft. 6 in.; Empty Weight 4255 lb.; Wing Loading 24.5 lb. per sq. ft.; Power Loading 12.01 lb. per bhp; Engines 2 Continental IO-470-M fuel injection; 260 hp normal rated, or 260 hp at 2625 rpm takeoff; Fuel Capacity 156 gal.; Propeller Hartzell, 2 blade, full feathering; Wing Area 255 sq. ft.; Aileron Area 20.52 sq. ft.; Flap Area 21.20 sq. ft.; Fin Area 24.00 sq. ft.; Rudder Area 15.4 sq. ft.; Stabilizer Area 33.06 sq. ft.; Elevator Area 20.54 sq. ft.

PERFORMANCE

Maximum Speed 228 mph at sea level; Cruise Speed 217 mph at 70 percent power at 10,000 ft.; Landing Speed 100 mph; Rate of Climb 1510 fpm at sea level; Service Ceiling 23,200 ft.; Range with Maximum Payload 1800 mi.; Range with Maximum Fuel Load 1800 mi.; Grosses 6250 lbs.

AERO COMMANDER 500B

AERO COMMANDER, INC., Bethany, Oklahoma

SPECIFICATIONS

Span 49 ft. 6 in.; Length 35 ft. 1¼ in.; Height 14 ft. 6 in.; Empty Weight 4300 lb.; Wing Loading 26.47 lb. per sq. ft.; Power Loading 11.63 lb. per bhp; Engines 2 Lycoming IO-540-B1A fuel injection, 290 hp normal rated, or 290 hp at 2575 rpm takeoff; Fuel Capacity 156 gal.; Propeller Hartzell, 3 blade, full feathering; Wing Area 255 sq. ft.; Aileron Area 20.52 sq. ft.; Flap Area 21.20 sq. ft.; Fin Area 24.00 sq. ft.; Rudder Area 15.4 sq. ft.; Stabilizer Area 33.06 sq. ft.; Elevator Area 20.54 sq. ft.

PERFORMANCE

Maximum Speed 228 mph at sea level; Cruise Speed 218 mph at 70 percent power at 10,000 ft.; Landing Speed 100 mph; Rate of Climb 1450 fpm at sea level; Service Ceiling 20,500 ft.; Range with Maximum Payload 1250 mi.; Range with Maximum Fuel Load 1250 mi.; Grosses 6750 lbs.

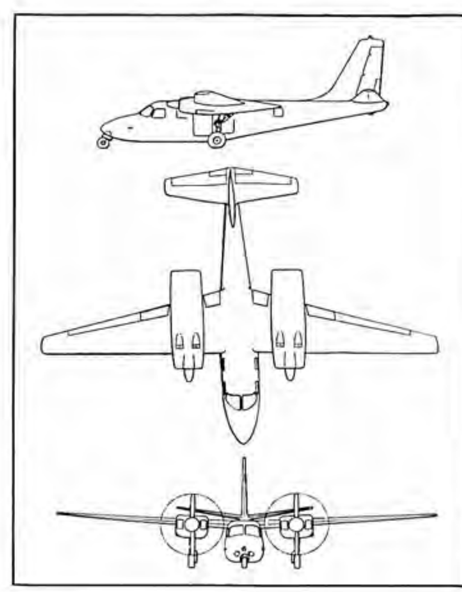
AERO COMMANDER 560F

SPECIFICATIONS

Span 49 ft. 6 in.; Length 35 ft. 1¼ in.; Height 14 ft. 6 in.; Empty Weight 4650 lb.; Wing Loading 29.41 lb. per sq. ft.; Power Loading 10.71 lb. per bhp; Engines 2 Lycoming IGO 540 fuel injection, 340 hp normal rated, or 350 hp at 3400 rpm takeoff; Fuel Capacity 223 gal.; Propeller Hartzell, 3 blade, full feathering; Wing Area 255 sq. ft.; Aileron Area 20.52 sq. ft.; Flap Area 21.20 sq. ft.; Fin Area 24.00 sq. ft.; Rudder Area 15.4 sq. ft.; Stabilizer Area 33.06 sq. ft.; Elevator Area 20.54 sq. ft.

PERFORMANCE

Maximum Speed 248 mph at sea level; Cruise Speed 232 mph at 70 percent power at 10,000 ft.; Landing Speed 100 mph; Rate of Climb 1720 fpm at sea level; Service Ceiling 21,900 ft.; Range with Maximum Payload 1500 mi.; Range with Maximum Fuel Load 1500 mi.; Grosses 7500 lbs.



AERO COMMANDER 680F

SPECIFICATIONS

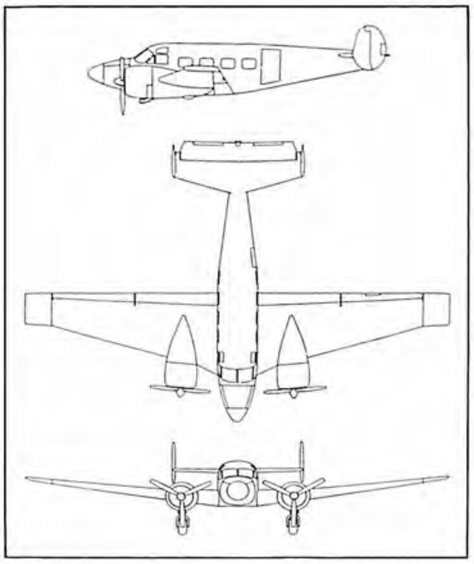
Span 49 ft. 6 in.; Length 35 ft. 1¼ in.; Height 14 ft. 6 in.; Empty Weight 4800 lbs.; Wing Loading 31.37 lb. per sq. ft.; Power Loading 10.51 lb. per bhp.; Engines 2 Lycoming IGSO-540 fuel injection, 380 hp normal rated, or 380 hp at 3400 rpm takeoff; Fuel Capacity 223 gal.; Propeller Hartzell, 3 blade, full feathering; Wing Area. 255 sq. ft.; Aileron Area 20.52 sq. ft.; Flap Area 21.20 sq. ft.; Fin Area 24.0 sq. ft.; Rudder Area 15.4 sq. ft.; Stablizer Area 33.06 sq. ft.; Elevator Area 20.54 sq. ft.

PERFORMANCE

Maximum Speed 290 mph at 15,500 ft.; Cruise Speed 244 mph at 70 percent power at 10,000 ft.; Landing Speed 105 mph; Rate of Climb 1660 fpm at sea level; Service Ceiling 28,500 ft.; Range with Maximum Payload 1400 mi.; Range with Maximum Fuel Load 1400 mi.; Grosses 8000 lbs.

BEECHCRAFT SUPER 18

BEECH AIRCRAFT CORP., Wichita I, Kansas



REMARKS

The eight-place Super G18 is an improved and larger version of the standard Model 18, first put on the market in 1937. Current models feature external drag reduction plus interior refinements. More than 6,943 units in commercial and military configurations of the Model 18 series have been built to date. Equipping the Super 18 with three-blade Hartzell propellers, coupled with other alterations, increases allowable gross weight to 9,700 pounds, which permits a 500-pound increase in useful load, and improves the rate of climb. The Super 18 was also produced with two-blade Hamilton-Standard propellers in a 9300-pound gross weight version. A standby power increase of 22.2 percent is gained by the addition of optional Aerojet Jr. JATO units, which provide 500 pounds of thrust for a duration of 15 seconds. Weather-avoidance radar is optional.

SPECIFICATIONS

Span 49 ft. 8 in.; Length 35 ft. 2½ in.; Height 9 ft. 8 in.; Empty Weight 5950 lb.; Gross Weight 9700 lb.; Wing Loading 26.9 lb. per sq. ft.; Power Loading 10.78 lb. per bhp.; Engines Two Pratt & Whitney R-985 AN-14B 450 hp at 2300 rpm takeoff; Fuel Capacity 395 gal.; Propeller Hartzell hydromatic 3-blade, all-metal, full feathering; Gear conventional; Wing Area 360.7 sq. ft.; Aileron Area 17.48 sq. ft.; Flap Area 28.12 sq. ft.; Fin Area 20.08 sq. ft.; Rudder Area 13.50 sq. ft.; Stabilizer Area 49.58 sq. ft.; Elevator Area 22 sq. ft.

PERFORMANCE

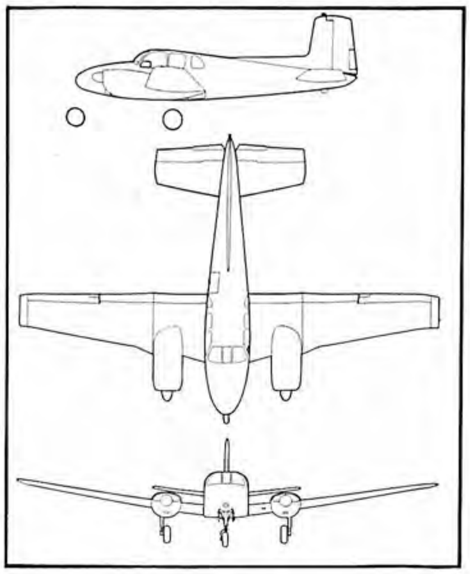
Maximum Speed 233 mph at 450 hp at 2300 rpm at 4500 ft.; Cruise Speed 214 mph at 300 hp at 2000 rpm at 10,000 ft.; Landing Speed 84 mph; Rate of Climb 1410 fpm at Sea Level at 9700 lb. gross; Range with Maximum Payload 1585 mi. at 10,000 ft., 200 hp; 45 min. reserve.

BEECHCRAFT TWIN-BONANZA

BEECH AIRCRAFT CORP., Wichita 1, Kansas

REMARKS

The Model H50 Twin-Bonanza, a six-place executive transport, is equipped with supercharged engines and fuel injection for improved performance. Increasing the Model H50's gross weight limit to 7,300 pounds is accomplished while increasing both service ceiling and maximum range. The Model D50C Twin-Bonanza, with high-compression 295 horsepower engines, was also in production. Both versions of the Twin-Bonanza may be equipped with optional standby rocket power through installation of Aerojet-General Jr. JATO. Optional equipment includes weather-avoidance radar installation.

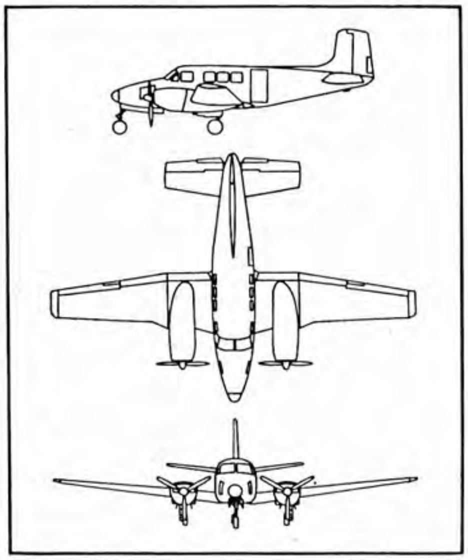


SPECIFICATIONS

Span 45 ft. 11⅜ in.; Length 31 ft. 6½ in.; Height 11 ft. 4 in.; Empty Weight 4480 lb.; Gross Weight 7300 lb.; Wing Loading 26.4 lb. per sq. ft.; Power Loading 11.4 lb. per bhp; Engines Two Supercharged Lycoming IGSO-480-A1 A6 with fuel injection, 320 hp normal rating, or 340 hp at 3400 rpm takeoff; Fuel Capacity 230 gal. with optional tanks; Propeller Hartzell, 3-blade constant speed, hydraulically operated, full feathering; Wing Area 277.06 sq. ft.; Aileron Area 13.89 sq. ft.; Flap Area 37.80 sq. ft.; Fin Area 14.25 sq. ft.; Rudder Area 12.77 sq. ft.; Stabilizer Area 47.25 sq. ft.; Elevator Area 17.49 sq. ft.

PERFORMANCE

Maximum Speed 235 mph at 3200 rpm at 12,000 ft.; Cruise Speed 223 mph at 238 hp at 2750 rpm at 15,200 ft.; Landing Speed 82.5 mph; Rate of Climb 1270 fpm at Sea Level; Service Ceiling 28,000 ft.; Range with Maximum Fuel Load 1650 mi.



BEECHCRAFT L-23F COMMAND TRANSPORT

BEECH AIRCRAFT CORP., Wichita 1, Kansas

REMARKS

Designed to meet a military requirement for a larger multi-purpose transport in the L-23 series, the prototype six-seven place Army L-23F first flew August 28, 1959. First units entered Army service in 1959. The Federal Aviation Agency and Japan's Civil Aviation Bureau also operate L-23Fs. The L-23F was ordered in substantial quantities by the U. S. Army in 1960.

SPECIFICATIONS

Span 45 ft. 10.5 in.; Length 33 ft. 4 in.; Height 14 ft. 2 in.; Empty Weight 4740 lb.; Gross Weight 7700 lb.; Wing Loading 27.6 lb. per sq. ft.; Power Loading 12 lb. per bhp; Engines Two Lycoming IGSO-480-A1A6 supercharged, with fuel injection, 320 hp normal rated; Fuel Capacity 230 gal.; Propeller Hartzell three-blade, hydraulic controlled constant speed, full feathering; Wing Area 280 sq. ft.; Aileron Area 13.8 sq. ft.; Flap Area 29.3 sq. ft.; Fin Area 14.25 sq. ft.; Rudder Area 12.77 sq. ft.; Stabilizer Area 47.25 sq. ft.; Elevator Area 17.87 sq. ft.

PERFORMANCE

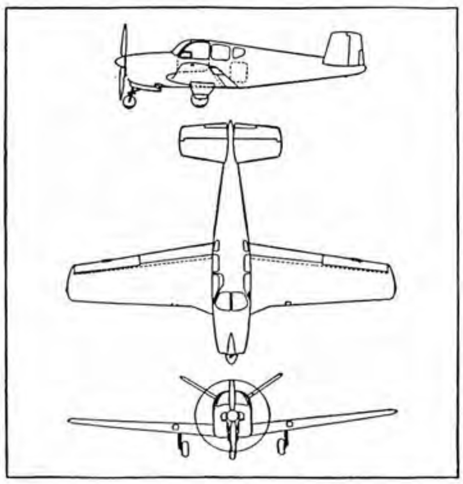
Maximum Speed 239 mph at 320 hp at 3200 rpm at 12,000 ft.; Cruise Speed 214 mph at 224 hp at 2750 rpm at 15,200 ft.; Landing Speed 80 mph; Rate of Climb 1300 fpm at Sea Level; Service Ceiling 27,000 ft; Absolute Ceiling 28,500 ft.; Range with Maximum Payload 1445 mi.; Range with Maximum Fuel Load 1445 mi.

BEECHCRAFT M35 BONANZA

BEECH AIRCRAFT CORP., Wichita 1, Kansas

REMARKS

The four-place Bonanza was first flown December 22, 1945. More than 6,400 of the high performance Bonanzas have been manufactured since that date. Popular with the business executive, the Bonanza also has had a successful feederline operational history. The Model M35 offers optional autopilot, auxiliary wing tanks, air conditioner, rotating beacon and Cagle brake units.



SPECIFICATIONS

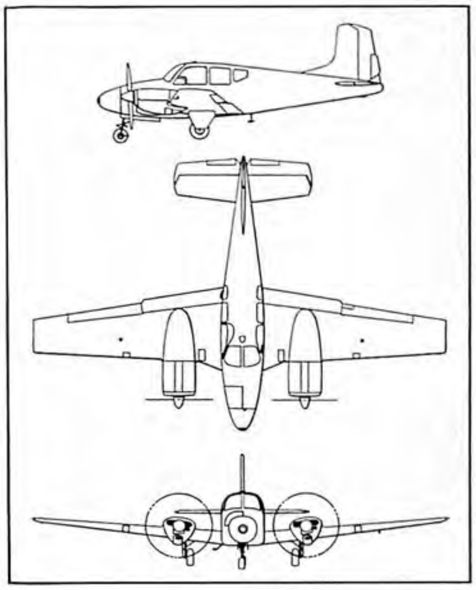
Span 33 ft. 5½ in.; Length 25 ft. 2 in.; Height 6 ft. 6½ in.; Empty Weight 1832 lb.; Gross Weight 2950 lb.; Wing Loading 16.3 lb. per sq. ft.; Power Loading 11.8 lb. per bhp; Engine (standard) Continental IO-470-C with fuel injection, 250 hp at 2600 rpm, all operations; Fuel Capacity 49 gal. (68 gal. with auxiliary tank); Propeller Beech hydraulically controlled, variable pitch; Gear tricycle, fully retractable; Wing Area 181.0 sq. ft.; Fin-Stabilizer Area 23.8 sq. ft.; Rudder-Elevator Area 12 sq. ft.

PERFORMANCE

Maximum Speed 210 mph at 250 hp at 2600 rpm at Sea Level; Cruise Speed 200 mph at 187.5 hp at 2450 rpm at 7000 ft.; Landing Speed 59 mph; Rate of Climb 1170 fpm at Sea Level; Service Ceiling 20,000 ft.; Maximum Range 1245 mi. at 10,000 ft. at 180 mph.

BEECHCRAFT TRAVEL AIR

BEECH AIRCRAFT CORP., Wichita 1, Kansas



REMARKS

First flown on August 6, 1956, the Travel Air marked Beechcraft's entry into the four-place, twin-engine business airplane field. In three years of utilization as an executive transport, the four-five place Travel Air has become noted for its quiet flight, ease of handling and operational economy. An additional 17 cubic feet of cabin area, improved visibility, higher gross weight and restyled empennage were incorporated in the Model B95 Travel Air.

SPECIFICATIONS

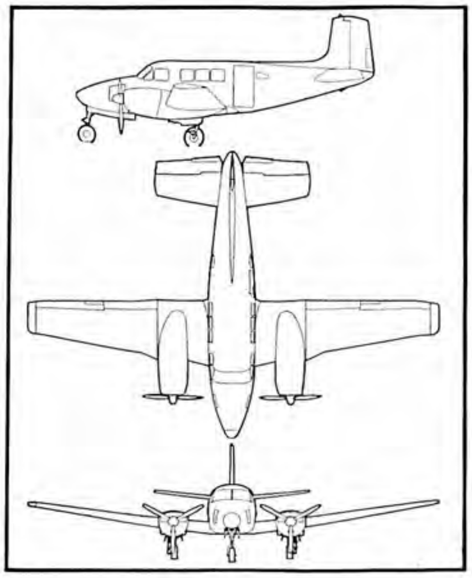
Span 37 ft. 10 in.; Length 25 ft. 4 in.; Height 9 ft. 6 in.; Empty Weight 2635 lb.; Gross Weight 4100 lb.; Wing Loading 20.6 lb. per sq. ft.; Power Loading 11.4 lb. per bhp; Engines Two Lycoming 0-360-A1A, 180 hp normal rates; Fuel Capacity 112 gal.; Propeller 72 in. 2-blade Hartzell, hydraulically controlled, continuously variable pitch, full feathering; Wing Area 199.2 sq. ft.; Aileron Area 11.5 sq. ft.; Flap Area 21.3 sq. ft.; Fin Area 16.97 sq. ft.; Rudder Area 6.63 sq. ft.; Stabilizer Area 27.4 sq. ft.; Elevator Area 15.0 sq. ft.

PERFORMANCE

Maximum Speed 210 mph at 180 hp at 2700 rpm at Sea Level; Cruise Speed 200 mph at 135 hp at 2450 rmp at 7500 ft.; Landing Speed 70 mph; Rate of Climb 1300 fpm at Sea Level; Service Ceiling 18,700 ft.; Absolute Ceiling 20,300 ft.; Range with Maximum Fuel Load 1410 mi.

BEECHCRAFT QUEEN AIR

BEECH AIRCRAFT CORP., Wichita I, Kansas



REMARKS

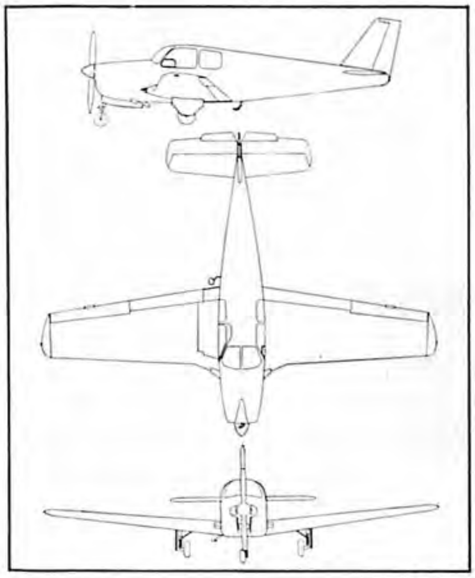
Introduced in 1960 was the Beechcraft Model 65 Queen Air, a completely new six-to-eight-place, twin-engine executive transport. A selection of custom interior arrangements designed to match the individual passenger comfort features of the large, modern airliner is offered. During its first year of production, the Queen Air was acquired by many United States corporations and both government and civilian customers of 10 nations in Europe, South America and Asia. Weather-avoidance radar is available, as well as Jr. JATO standby rocket power .

SPECIFICATIONS

Span 45 ft. 10.5 in.; Length 33 ft. 4 in.; Height 14 ft. 2 in.; Empty Weight 4,740 lb.; Wing Loading 27.8 lb. per sq. ft.; Power Loading 12.03 lb. per bhp; Engines Two Lycoming Six Cylinder Fuel Injection IGSO-480-A1A6 Supercharged; 340 hp at 3,400 rpm takeoff; Fuel Capacity 230 gal.; Propeller Two Hartzell 3-blade, full-feathering Aluminum alloy, constant speed, hydraulically controlled; Wing Area 277.06 sq. ft.; Aileron Area 13.8 sq. ft.; Flap Area 29.3 sq. ft.; Fin Area 14.25 sq. ft.; Rudder Area 12.77 sq. ft.; Stabilizer Area 47.25 sq. ft.; Elevator Area 17.87 sq. ft.

PERFORMANCE

Maximum Speed 239 mph at 320 hp at 3200 rpm at 12,000 ft.; Cruise Speed 214 mph at 224 hp at 2750 rpm at 15,200 ft.; Landing Speed 80 mph; Rate of Climb 1300 fpm at Sea Level; Service Ceiling 27,000 ft.; Absolute Ceiling 28,500 ft.; Range with Maximum Payload 1445 mi. (45 min. reserve); Range with Maximum Fuel Load 1445 mi. (45 min. reserve).



BEECHCRAFT DEBONAIR

BEECH AIRCRAFT CORP., Wichita 1, Kansas

REMARKS

Model 33, Debonair, is an executive aircraft which is available with optional auto-pilot, auxiliary wing fuel tanks, rotating beacons, third side window and radio combinations.

SPECIFICATIONS

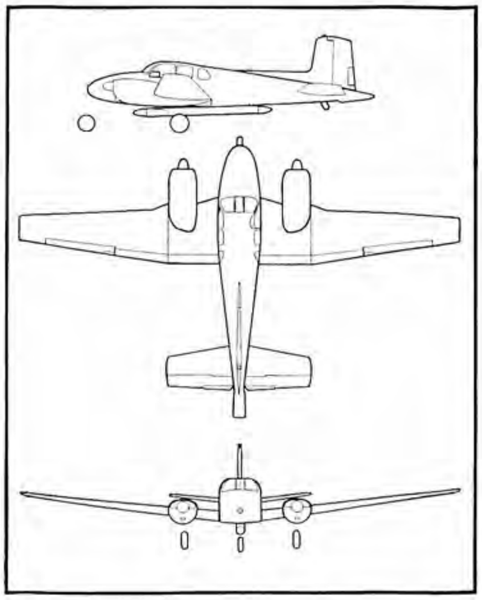
Span 32 ft. 10 in.; Length 25 ft. 6 in.; Height 8 ft. 3 in.; Empty Weight 1720 lb.; Wing Loading 16.3 lb. per sq. ft.; Power Loading 12.9 lb. per bhp; Engines Continental Six-Cylinder Fuel Injection IO-470-J, 225 hp normal rated; Fuel Capacity 70 gal.; Propeller Hartzell 84 in., hydraulically controlled, continuously variable pitch; Wing Area 177.6 sq. ft.; Aileron Area 11.5 sq. ft.; Flap Area 21.3 sq. ft.; Fin Area 9.1 sq. ft.; Rudder Area 4.6 sq. ft.; Stabilizer Area 12.16 sq. ft.; Elevator Area 15 sq. ft.

PERFORMANCE

Maximum Speed 195 mph at 225 hp at 2600 rpm at Sea Level; Cruise Speed 185 mph at 169 hp at 2450 rpm at 7000 ft.; Landing Speed 60 mph; Rate of Climb 1010 fpm at Sea Level; Service Ceiling 19,800 ft.; Absolute Ceiling 22,000 ft.; Range with Maximum Payload 1160 mi.; Range with Maximum Fuel Load 1160 mi.

BEECHCRAFT U. S. ARMY RL-23D

BEECH AIRCRAFT CORP., Wichita I, Kansas



REMARKS

The United States Army ordered both new units and modified L-23D units of the SLAR (side-looking airborne radar)-equipped Beechcraft RL-23D in 1960. Beech produced several versions of the RL-23D to accommodate different Army SLAR equipment.

SPECIFICATIONS

Span 50 ft. 3 in.; Lengths 31 ft. 11 in.; Height 11 ft. 6 in.; Empty Weight 5954 lb.; Engines Two Lycoming GSO-480-B1B6, 340 hp normal rated; 3400 rpm takeoff; Fuel Capacity 168 gal.; Wing Area 293.9 sq. ft.

PERFORMANCE

Maximum Speed 215 mph at 9000 ft.; Landing Speed 84 mph; Rate of Climb 1463 fpm at (initial); Service Ceiling 23,800 ft.

BELL 47G-2A; H-13H SIOUX (ARMY)

BELL HELICOPTER COMPANY, Fort Worth 1, Texas

REMARKS

Model 47G-2A is 1961 version of the 47G-2, most widely-used commercial helicopter in the world. Utilizing longer main rotor blades and longer fuselage, plus increased horsepower, the 47G-2A can carry 325 pounds more payload than the 47G-2.

The new model features spacious cabin comfort for pilot and two passengers, is rugged, dependable and has low operating cost. It's ideal for crop-dusting, surveying, powerline patrol, offshore oil work, ranching, law-enforcement, mapping and many other jobs.

Military version of the 47G-2A's predecessor 47G-2 is the Army's H-13H Sioux, used for evacuation, observation, reconnaissance, training and other duties.

SPECIFICATIONS

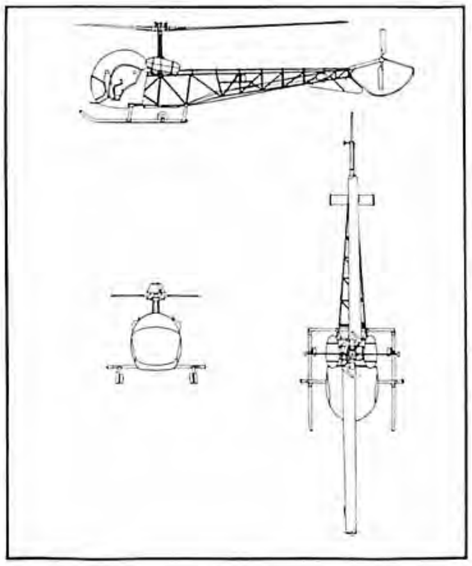
Main Rotor Diameter 37 ft. 2 in.; Length 31 ft. 7 in.; Height 9 ft. 4 in.; Empty Weight 1638 lbs.; Maximum Gross Weight 2850 lbs.; Useful Load 1212 lbs.; Engine One Lycoming VO-435, 250 hp at 3200 rpm; 240 hp takeoff; 220 hp maximum continuous; Fuel Capacity 43 gal.

PERFORMANCE

Maximum Speed (VNE) 105 mph at Sea Level; Maximum Recommended Cruise Speed at 3000 ft.: 95 mph (at 2050 lbs. gross wt.) and 86 mph (at 2850 lbs. gross wt.); Service Ceiling 17,200 ft. (at 2050 lbs.) and 9000 ft. (at 2850 lbs.); Hovering Ceiling IGE 13,000 ft. (at 2050 lbs.) and 4500 ft. (at 2850 lbs.); Range with no reserve 243 miles (at 2050 lbs.) and 202 miles (at 2850 lbs.)

BELL 47G-3

BELL HELICOPTER COMPANY, Fort Worth 1, Texas



REMARKS

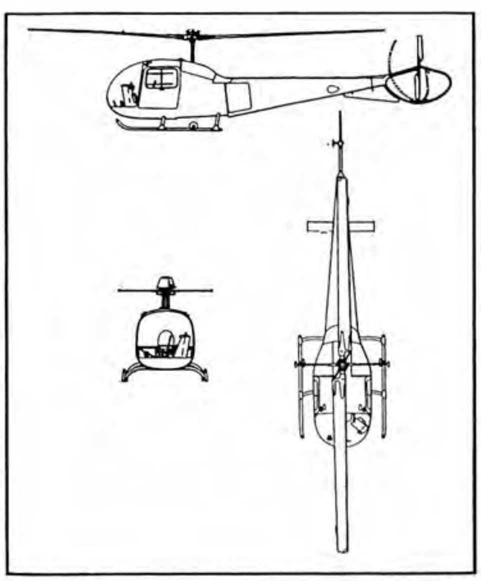
The 47G-3 made world-wide aviation news in 1959 with extensive tests atop Pikes Peak, but its versatility makes it a high-performance ship at sea level and intermediate altitudes. The three-place ship can hover at more than 15,000 feet density altitude with 1,100 pounds and can do the many other jobs for which the Bell 47 Series commercial helicopters are famous.

SPECIFICATIONS

Main Rotor Diameter 37 ft. 2 in.; Length 31 ft. 7 in.; Height 9 ft. 4 in.; Empty Weight 1609 lbs.; Maximum Gross Weight 2650 lbs.; Useful Load 1041 lbs.; Engine One Franklin 6VS-335, 225 hp at 3200 rpm; 225 hp takeoff; 220 hp maximum continuous; Fuel Capacity 41 gal.

PERFORMANCE

Maximum Speed (VNE) 105 mph (at 5000 ft.); Maximum Recommended Cruise Speed (at 5000 ft.) 98 mph at 1950 Gross Wt. and 91 mph at 2650 Gross Wt.; Service Ceiling 26,800 ft. at 1950 Gross Wt. and 19,600 ft. at 2650 Gross Wt.; Hovering Ceiling IGE 23,300 ft. at 1950 Gross Wt. and 15,400 ft. at 2650 Gross Wt.; Range with no reserve 228 miles at 1950 Gross Wt. and 200 miles at 2650 Gross Wt.



BELL 47J-2 RANGER; H-13J (AIR FORCE); HUL-1 (NAVY AND COAST GUARD)

BELL HELICOPTER COMPANY, Fort Worth 1, Texas

REMARKS

The 47J-2 Ranger is a deluxe, four-place ship, plushest commercial helicopter in the world. Aside from its beauty and comfort, the Ranger, since it went on the civilian market in 1957 as the 47J, has proved its high performance capabilities throughout the world on jobs ranging from executive transport in metropolitan centers to gruelling work in isolated polar regions and equatorial jungles. President Eisenhower was the first U. S. chief executive to fly by helicopter when he rode the Air Force version of the Ranger (H-13J) in 1957. Navy and Coast Guard models of the Ranger (HUL-1) are used as utility helicopters.

SPECIFICATIONS

Main Rotor Diameter 37 ft. 2 in.; Length 32 ft. 5 in.; Height 9 ft. 4 in.; Empty Weight 1730 lbs.; Maximum Gross Weight 2850 lbs.; Useful Load 1120 lbs.; Engine One Lycoming VO-540, 305 hp at 3200 rpm; 260 hp takeoff; 220 hp maximum continuous; Fuel Capacity 48 gal. (with optional larger tanks).

PERFORMANCE

Maximum Speed (VNE) 105 mph; Maximum Recommended Cruise Speed (at 5000 ft.) 103 mph at 2220 lbs. Gross Wt. and 93 mph at 2850 lbs. Gross Wt.; Service Ceiling 17,800 ft. (at 2220 lbs. Gross Wt.) and 12,100 ft. (at 2850 lbs. Gross Wt.); Hovering Ceiling IGE 15,400 ft. (at 2220 lbs. Gross Wt.) and 9,100 ft. (at 2850 lbs. Gross Wt.); Range with no reserve 288 miles (at 2220 lbs. Gross Wt.) and 260 miles (at 2850 lbs. Gross Wt.).

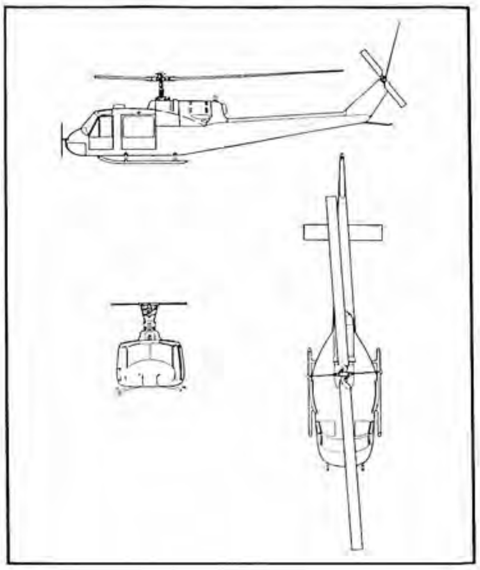
BELL HU 1-A IROQUOIS (ARMY)

BELL HELICOPTER COMPANY, Fort Worth 1, Texas

REMARKS

The HU-1 Iroquois Series Bell makes for the U. S. Army has made more rotary-wing news since its inception than any other model in helicopter history. It won industry-wide design competition in 1955, was the Army's first production-line turbine-powered helicopter and in 1960 shattered three Russian-held world rotary-wing marks and claimed four other universal records with headline-making performances under adverse conditions in Texas summer temperatures.

The Iroquois features speed, easy field maintenance and ruggedness. It has been called the most thoroughly-tested helicopter model in the world, having survived the torture of prolonged sub-zero maneuvers in the Arctic and in 120-degree Arizona desert heat. The Army has awarded Bell multi-million-dollar contracts for undisclosed numbers of the Iroquois, which can outclimb some World War II fighter planes. It now is operational with the Army. Designed as a six-place ship originally, the Army has hauled as many as 10 combat troops on maneuvers. The Iroquois now has advanced to HU-1A and HU-1B Models, and Bell introduced to the world market late in 1960 a commercial version, the 204B.



SPECIFICATIONS

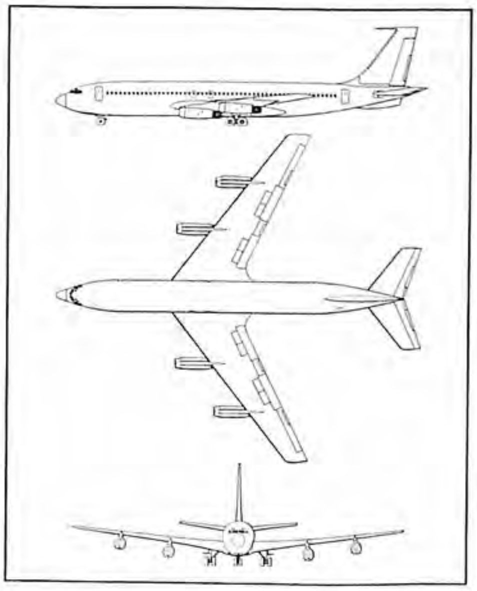
Rotor Diameter 44 ft.; Length 42 ft. 8 in.; Height 11 ft. 4 in.; Engine—HU-1A One Lycoming T53-L-1A, 860 hp at 6400 rmp; HU-1B One Lycoming T53-L-5, 960 hp at 6400 rpm; 204B One Lycoming T53-L-9, 1100 hp at 6600 rpm; Maximum Gross Weight HU-1A, 7200 lb.; HU-1B and 204B, 8500 lb.; Useful Load HU-1A, 3261 lb.; HU-1B, 4131 lb.; 204B, 4182 lb.; Empty Weight HU-1A, 3939 lb.; HU-1B, 4369 lb.; 204B, 4318 lb.

PERFORMANCE

Maximum Recommended Cruise Speed: HU-1A, 121 mph; HU-1B and 204B, 128 mph; Maximum Speed VNE: HU-1A, 121 mph; HU-1B, 139 mph; 204B, 145 mph; Service Ceiling: HU-1A, 13,600 ft.; HU-1B, 14,400 ft.; 204B, 16,900 ft. NRP; Hovering Ceiling IGE: HU-1A, 15,000 ft.; HU-1B, 15,400 ft.; 204B, 17,400 ft. MRP; Range (no reserve) In Statute Miles: HU-1A, 248; HU-1B and 204B, 288; Fuel Tank Capacity: HU-1A, 155 gal.; HU-1B and 204B, 165 gal.

BOEING 707 MODEL 120 JET TRANSPORT

BOEING AIRPLANE COMPANY, Seattle 24, Washington



REMARKS

The first production airplane of the Boeing 707 commercial jet series made its maiden flight December 20, 1957, with Pan American World Airways putting the airplane into trans-oceanic service October 26, 1958, and American Airlines following with transcontinental service January 25, 1959.

The prototype jet airliner, built as a private venture by Boeing at a cost of more than $16,000,000, amassed more than 1000 hours in its four years of flight testing, while the first three of the production airplanes used for Civil Aeronautics Administration certification testing raised the overall total to more than 1650 hours. In addition, the new jet transports benefited by the thousands of hours of flight time logged by their military counterpart, the Boeing KC-135 jet multipurpose tanker-transports which went into service in 1957.

Including the prototype, there are eight Boeing jet airliners; the others are the 707-120, the 707-120B, the 707-220, the 707-320, the 707-420, the 720 and the 720B. Weighing in at 248,000 pounds as compared with the prototype's 190,000, the -120 is principally intended for continental use. The -220 is identical in airframe and body size to the -120, but is powered by Pratt & Whitney JT4 turbojet engines, larger and of greater thrust than the JT3. The "B" airplanes use Pratt & Whitney JT30 turbofan engines.

SPECIFICATIONS (-120)

Span 130 ft. 10 in.; Height 42 ft.; Length 144 ft. 6 in.; Engines Four Pratt & Whitney JT3C-6 turbojet, more than 10,000 lb. thrust; Gear tricycle, main undercarriage units, four-wheel trucks, dual nose wheels.

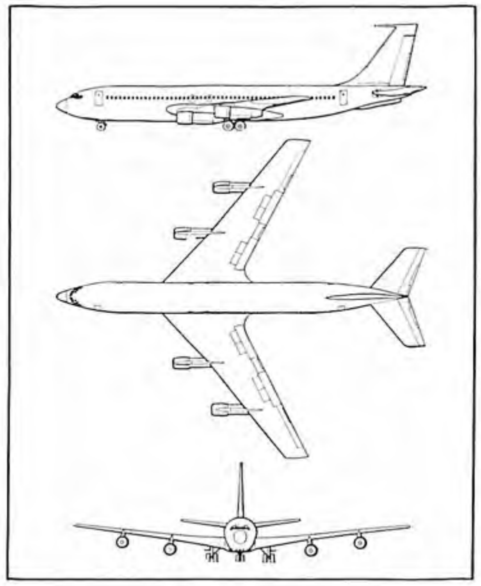
PERFORMANCE

Cruise Speed 591 mph; Cruising Altitude 25,000 to 40,000 ft.

BOEING 707 INTERCONTINENTAL JET TRANSPORT

BOEING AIRPLANE COMPANY, Seattle 24, Washington

REMARKS



The -320 and the -420 are the Intercontinental 707s, which partially fulfill the growth potential Boeing designed into the basic 707 series. Weighing more than 295,000 pounds, they are 8 feet, 5 inches longer overall than the -120, -220, and 720, have 11 feet 7 inches more wingspan, and 500 square feet of additional wing area. Fuselage diameter, 148 inches, is the same in all models. Only difference between the -320 and -420 is the engines, the former using Pratt & Whitney JT4s and the latter Rolls-Royce "Conways."

SPECIFICATIONS (INTERCONTINENTAL)

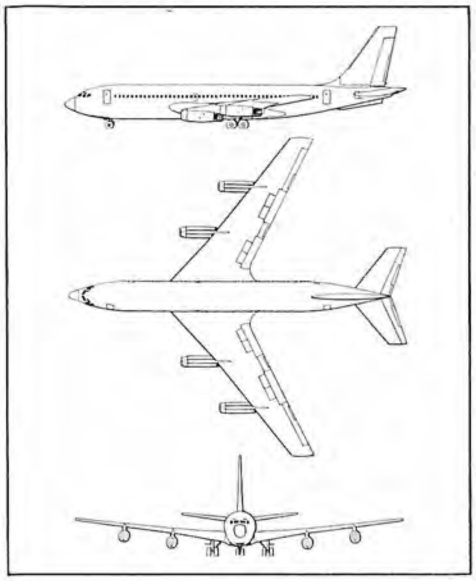
Span 142 ft. 5 in.; Height 42 ft.; Length 152 ft. 11 in.; Engines Four Pratt & Whitney JT4 or Rolls Royce Conway turbojets, more than 10,000 lb. thrust; Gear tricycle, main undercarriage units, four-wheel trucks, dual nose wheels.

PERFORMANCE

Cruise Speed 591 mph; Cruising Altitude 25,000 to 40,000 ft.

BOEING 720 JET TRANSPORT

BOEING AIRPLANE COMPANY, Seattle 24, Washington



REMARKS

Designed to operate profitably in the medium range area, the Boeing 720 combines low cost with excellent operational flexibility. Associated with its capability to operate over existing route segments is the ability of the 720 to utilize present runways and terminal facilities throughout the entire airline system. The 720 offers a high level of safety, ease of maintenance and inspection, long life, minimum structural weight and reliability based on experience and extensive test programs. The seats are mounted on continuous tracks recessed in the floor, allowing use of four, five and six-abreast seating. In less than ten minutes each row of seats and its accompanying overhead service unit can be repositioned or replaced. Windows are spaced at 20-inch intervals to insure an unobstructed view regardless of seat spacing. This flexibility permits a choice of seating combinations ranging from the luxurious four-abreast interior to the six-abreast, 149-passenger tourist arrangement.

SPECIFICATIONS

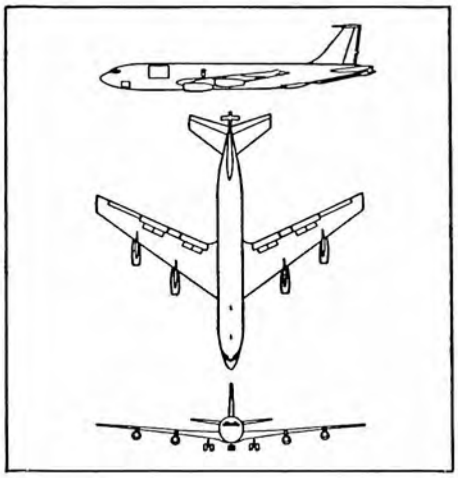
Span 130 ft. 10 in; Length 136 ft. 2 in.; Height 41 ft. 6.5 in.; Empty Weight 103,145 lb.; Engines Four Pratt & Whitney JT3C-7; Fuel Capacity 11,500 gal.; Wing Area 2433 sq. ft.

PERFORMANCE

Maximum Speed more than 600 mph; Maximum Range 3300 mi.; Cruising Altitude 15,000 to 40,000 ft.

BOEING KC-135 JET TANKER-TRANSPORT

BOEING AIRPLANE COMPANY, Seattle 24, Washington



REMARKS

KC-135s are now in service with the Air Force, replacing the KC-97 as the Air Force's standard multi-purpose aerial refueling tanker-transport. The last of 888 KC-97s built by Boeing at Renton was rolled out only moments before the first appearance of the KC-135. The high-speed Flying Boom refueling equipment with which the KC-135 is equipped was flight-tested earlier on the Boeing 707 prototype. Soon after being placed in operational status with SAC, the KC-135 set a series of new records. More than 400 have been delivered to the Strategic Air Command.

SPECIFICATIONS

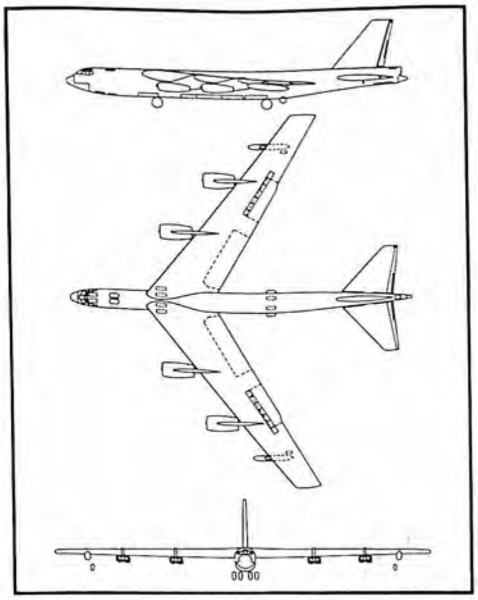
Span 130 ft. 10 in.; Length 136 ft. 3 in.; Sweepback 35 deg.; Height 38 ft. 5 in.; Weight more than 250,000 lb.; Engines Four Pratt & Whitney J57 turbojet, 10,000 lb. thrust class; Gear tricycle, main undercarriage units, four-wheel trucks, dual nose wheels.

PERFORMANCE

Speed more than 600 mph; Ceiling more than 35,000 ft.; Range more than 4000 mi.

BOEING B-52G MISSILE PLATFORM BOMBER

BOEING AIRPLANE COMPANY, Seattle 24, Washington



REMARKS

The first production model of the B-52G was rolled from the Boeing plant in Wichita, Kansas, July 23, 1958.

The new Stratofortress can span oceans and return to bases in the United States without refueling, and will carry two GAM-77 "Hound Dog" air-to-surface missiles which can be released hundreds of miles from their targets. The missiles are in addition to the Stratofort's prime bomb load which can be saved for still another target.

A new fuel system and new type of engine enable the B-52G to fly at sustained speeds in excess of 650 miles an hour without the range-limiting fuel efficiency penalty associated with bombers capable of brief supersonic dashes. Principal feature of the fuel system is the wing in which integral tank construction forms virtually one huge fuel tank of the entire wing.

The B-52F was phased out in 1959. Production on the "G" continued through 1960 when it was replaced by the new "H" model, the first of which was rolled out late in the year. The "H" model will have all of the capabilities of the "G", plus other advancements, including Pratt & Whitney TF33 turbofan engines which will stretch the bomber's unrefueled range of "more than 9000 miles" by a good margin.

SPECIFICATIONS

Span 185 ft.; Length 157 ft. 6.9 in.; Sweepback 35 deg.; Height 40 ft. 8 in.; Weight more than 450,000 lb.; Engines Eight Pratt & Whitney J57-43W turbojet, more than 10,000 lb. thrust class; Gear eight main wheels in tandem with single outrigger wheels near wing tips.

PERFORMANCE

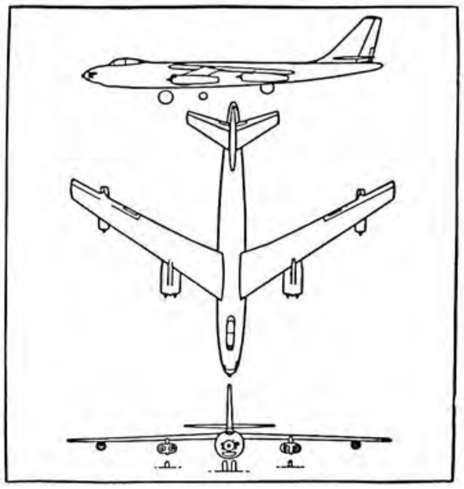
Very high-speed, long-range heavy bomber with a service ceiling over 50,000 feet, speed more than 650 miles per hour, and unrefueled range of more than 6,000 miles.

BOEING RB-47E MEDIUM BOMBER

BOEING AIRPLANE COMPANY, Seattle 24, Washington

REMARKS

The first XB-47 flight took place December, 1947, and more than 1300 have been built. The RB-47E differs from the standard model in having a longer nose, more windows, and air-conditioned camera compartment in place of bomb bay. Crew for this model are pilot, copilot riding in tandem, and observer-photographer. Among the features of the B-47 are the thin flexible wings which have a drooped appearance on the ground changing to a slight dihedral in flight. A B-47 set a new jet endurance record during 1954 with a 21,000 mile flight in 47 hours and 35 minutes with the aid of aerial refueling. Crew: three.

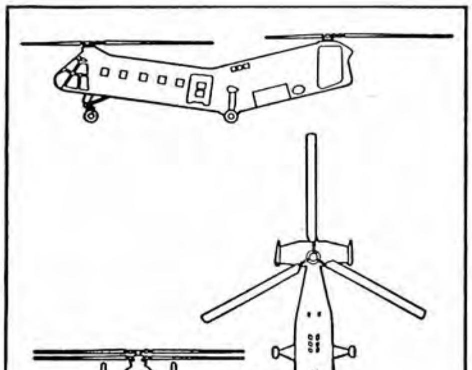


SPECIFICATIONS

Span 116 ft.; Sweepback 35 deg.; Length 107 ft.; Height 28 ft.; Gross Weight more than 200,000 lb.; Normal Bomb Load more than 20,000 lb.; Engines Six General Electric J47, 6000 lb. thrust normal rated; Provisions for 33 external ATO units, 1000 lb. each and water injection systems providing 17 percent power increase; Gear dual main wheels in tandem with a single outrigger under each inboard pod.

PERFORMANCE

Maximum speed more than 600 mph; Service Ceiling over 40,000 ft.; Range more than 3000 mi.



VERTOL MODEL 44

VERTOL DIVISION, BOEING AIRPLANE CO., Morton, Pennsylvania

REMARKS

The Vertol Model 44 transport helicopter is an improved version of the H-21 type helicopter being offered for military and commercial operations. It is available in three basic cabin interiors: the Model 44A for utility, cargo and military use, which permits transport of 19 passengers; the Model 44B airliner capable of carrying 15 passengers; and the Model 44C, for deluxe executive transport in business and industry. It has a useful load of 5420 pounds, a cruising speed of 101 miles per hour. The tandem configuration eliminates balance problems in the placement of cargo and allows passengers to sit anywhere in the cabin. Five airline versions of the Vertol 44 now are operated by New York Airways. Utility versions of this type of aircraft are in service with the Japanese Army, the German Army, the Swedish Navy, and with Spartan Air Services, under contract with the Royal Canadian Air Force.

SPECIFICATIONS

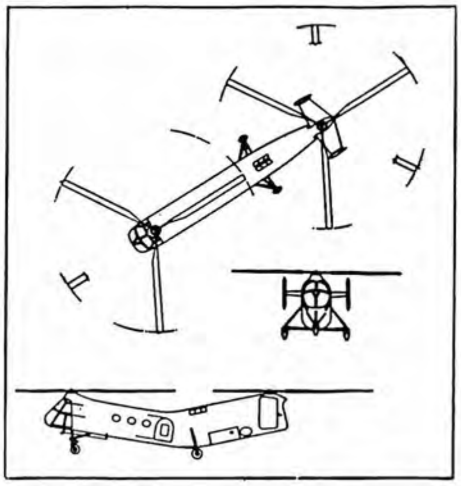
Main Rotor Diameter 44 ft.; Length 52 ft. 6 in.; Height 15 ft. 5 in.; Empty Weight 8980 lb.; Useful Load 5420 lb.; Engine Wright 1820-103, 1275 hp normal rates, or 1425 hp at 2700 rpm takeoff; Fuel Capacity 300 gal.

PERFORMANCE

Maximum Speed 127 mph; Cruise Speed 101 mph; Service Ceiling 10,600 ft.; Range with Maximum Fuel Load 360 statute mi.

VERTOL H-21 WORKHORSE TRANSPORT

VERTOL DIVISION, BOEING AIRPLANE CO., Morton, Pennsylvania



REMARKS

The H-21B is the Air Force and RCAF model in this series, and is similar to the Army H-21C. The fuselage is of all metal stressed skin, semi-monocoque construction. The cockpit has side-by-side seating with the pilot on the right and complete hydraulic controls. The main entrance door is located on the left side at the rear of the cabin. Twin-turbine powered versions of this aircraft have been extensively flight tested.

SPECIFICATIONS

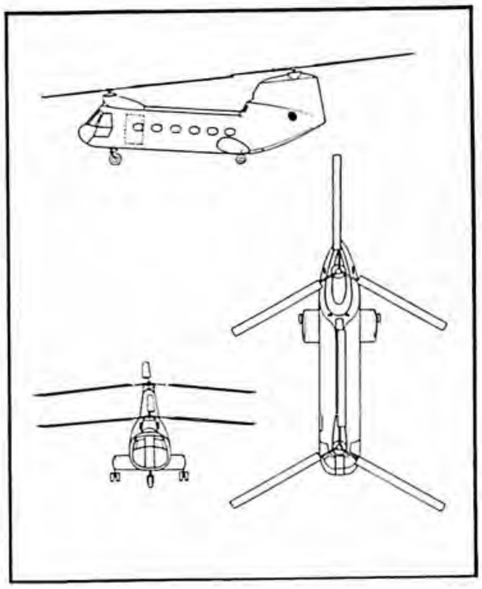
Rotor Diameter 44 ft.; Length 52 ft. 6 in.; Height 16 ft.; Empty Weight 8500 lb.; Gross Weight 13,300 lb.; Overload Gross Weight 15,200 lb.; Engine Wright R1820-103, 1425 hp, military; Fuel Capacity 300 gal.; Gear fixed tricycle.

PERFORMANCE

Maximum Speed 135 mph at Sea Level; Cruise Speed 98 mph at Sea Level; Rate of Climb 1100 fpm; Service Ceiling 10,000 ft.; Range over 450 mi.

VERTOL 107

VERTOL DIVISION, BOEING AIRPLANE CO., Morton, Pennsylvania



REMARKS

The company-developed Vertol 107 prototype, first of a new family of multi-turbine powered helicopters capable of all-weather flying, flew for the first time in April 1958. Following an extensive demonstration tour of U.S. and Canadian military bases that year, it was introduced to commercial operations in May 1959. The following month it was shipped to Europe where it began a 2,500 mile tour, beginning with the Salon de L'Aeronautique in Paris.

In October 1959 at Aberdeen Proving Grounds, Md., the 107 prototype demonstrated for the first time the important role the helicopter can play as an integral part of the Army's newest weapons systems. A Little John launching crew, and complete equipment, was carried to the demonstration area, unloaded, set up, fired, the launching equipment returned to the helicopter, and take-off accomplished in 11 minutes and 57 seconds after landing.

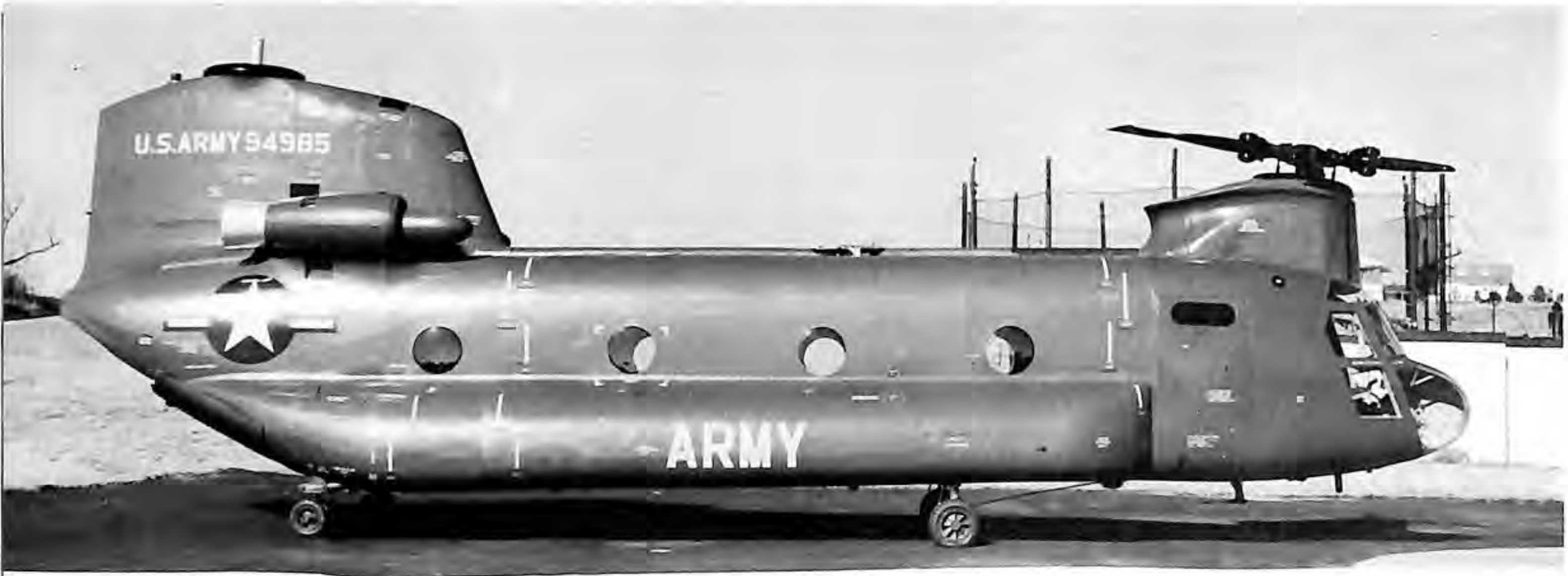
In April 1960 the 107 prototype began a demonstration tour to all military services and commercial operators in Japan. By the time it returned to the U.S., the aircraft had made a total of 811 flights and had flown more than 8,000 miles. This was accomplished in 339 flight hours. It had carried more than 3,325 passengers, made 182 water landings, and visited a total of 50 cities and military bases.

SPECIFICATIONS

Main Rotor Diameter 48 ft. 4 in.; Length 44 ft. 3.6 in.; Height 17 ft.; Gross Weight 15,500 lb.; Engines Two Lycoming T53 or Two General Electric T58.

PERFORMANCE

Classified.



VERTOL MODEL YHC-1A

VERTOL DIVISION, BOEING AIRPLANE CO., Morton, Pennsylvania

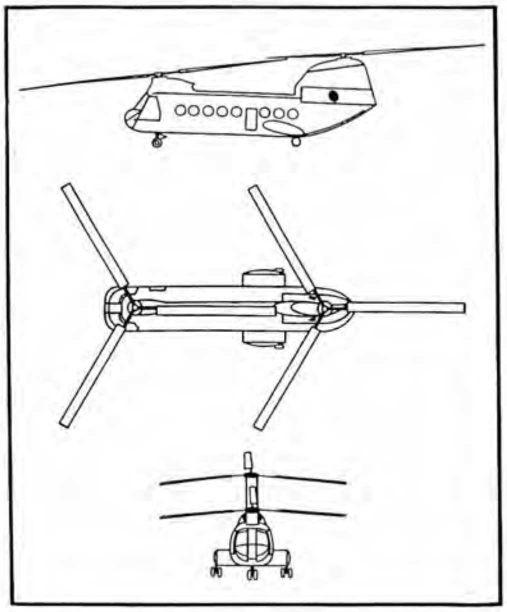
REMARKS

The Vertol 107 resulted from an 18-month research program to determine the best aircraft configuration to meet world-wide requirements for a medium transport helicopter for the new turbine-engine era of the 1960's.

Results of this investigation led Vertol Division Boeing to incorporate many new features into the 107's design. These include multi-engine reliability, instrument flight capability, capacity for 26 to 30 passengers or troops, indiscriminate cargo and passenger loading, a rear-loading ramp with straight-in loading, high cruise speeds, engines located completely away from the cabin, low seat-mile and ton-mile cost, flotation capability, and exceptionally low vibration and noise level.

Powered by two General Electric T58 shaft turbine engines, the Vertol 107 has a gross weight of 18,450 lbs. The 107 can land and take off from the water without special boat-hull design or flotation gear added. This feature is requiréd for emergency landing in commercial operations and also makes possible rescue or recovery missions at sea.

For commercial operations, a removable mobile baggage unit has been designed to fit into the rear cabin area, rolling out like a drawer for rapid baggage handling. The first order received for the airliner was from New York Airways, which is scheduled to put the first 107 airliner into operation in mid-1961.



SPECIFICATIONS

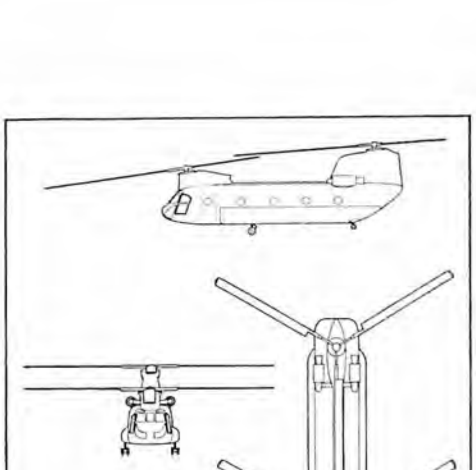
Height 16 ft. 10 in.; Length 44 ft. 7 in.; Rotars: two counter-rotating metal rotors in tandem, each 50 ft. in diameter and each having three articulated blades; Gross Weight 18,450 lb.; Payload (115 statute miles range with 10 percent reserve) 7,612 lb.; Engine Two General Electric T-58 shaft turbines.

PERFORMANCE

Rate of Climb (Sea Level) Vertical 1240 fpm; Forward Rate 1700 fpm; Cruising Speed 150 mph; Service Ceiling 13,700 ft.

VERTOL YHC-1B CHINOOK

VERTOL DIVISION, BOEING AIRPLANE CO., Morton, Pennsylvania



REMARKS

The Vertol YHC-1B Chinook is an advanced member of the Vertol developed Model 107 family of turbine-powered, tandem-rotor helicopters. In March, 1959, it won the U.S. Army design competition for a helicopter able to carry up to three tons of payload on normal 100-mile missions and slightly less than eight tons on alternate missions.

The Army selected the Chinook as a primary vehicle for battle-field mobility to replace its current fleet of piston-engine powered transport helicopters. Despite the Chinook's tremendous carrying capacity, its fuselage is only 51 feet long. Powered by two 2200 shp Lycoming T55 turbines, the Vertol YHC-1B has a cruising speed of 150 m.p.h.

Cargo can be quickly and easily loaded through a rear-loading ramp which can be left open in flight, permitting elongated cargo to be carried.

In addition to providing battlefield mobility with tactical integrity, for fighting elements, the Chinook can perform many support or logistical roles in forward areas. It can transport certain missiles, nuclear warheads, liquid cargo, pipelines, area neutralization material, mechanical minelayer magazines and high density cargo—to name a few.

The YHC-1B accommodates 33 fully equipped troops or 24 litter patients. It has a gross weight of 33,000 lbs. and a maximum speed of 175 m.p.h.

SPECIFICATIONS

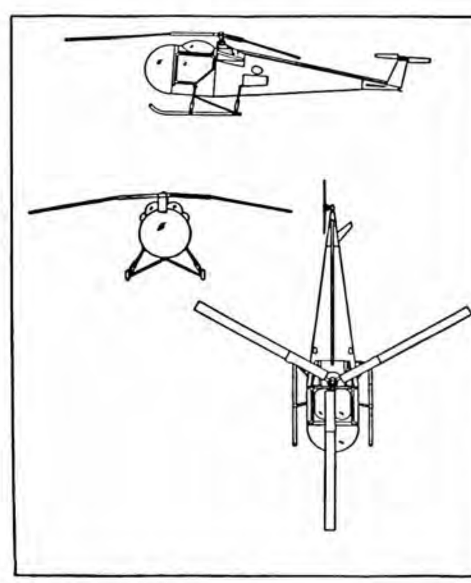
Height 18 ft. 6½ in.; Length 51 ft.; Rotors: Two three-bladed rotor (tandem configuration) each 59.1 ft. in diameter; Gross Weight 33,000 lb.; Useful Load 16,682 lb.; Empty Weight 16,318 lb.; Engines Two Lycoming T-55-L-5 each rated at 2200 shp (military power).

PERFORMANCE

Maximum Rate of Climb at Sea Level 2070 fpm; High Speed (Sea Level) 152 kts.; Cruising Speed 130 kts.; Range (with reserve) 220 n.miles; Service Ceiling 12,300 ft.

BRANTLY B-2

BRANTLY HELICOPTER CORP., Frederick, Oklahoma



REMARKS

Type certificate 2H2 was awarded to the Brantly Helicopter Corporation, Frederick, Oklahoma, on April 27, 1959. 15 Model B-2 helicopters had been delivered at year end.

SPECIFICATIONS

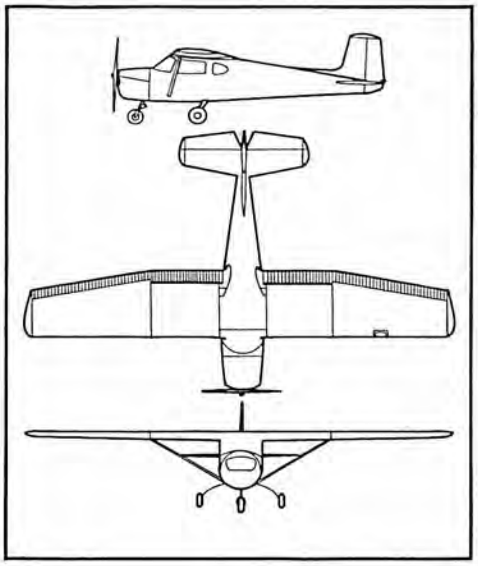
Length 21 ft. 9.1 in.; Height 6 ft. 11.75 in.; Empty Weight 990 lb.; Rotor Diameter 23.9375 ft.; Power Loading 9.04 lb. per bhp; Engines One Lycoming VO-360-A1B, 177 hp normal rated; Fuel Capacity 31 gal.

PERFORMANCE

Maximum Speed 100 mph at 138 hp at 471 Rotor rpm at Sea Level; Cruise Speed 90 mph at 110 hp at 471 Rotor rpm at Sea Level; Rate of Climb 1580 fpm at Sea Level; Service Ceiling 9600 ft.; Absolute Ceiling 10,300 ft.; Range with Maximum Payload 230 mi.; Range with Maximum Fuel Load 300 mi.

CESSNA 150

CESSNA AIRCRAFT CO., Wichita, Kansas



REMARKS

The 1961 Cessna Model 150, with an increased number of "big plane" features, points up Cessna's desire to increase utility, comfort and performance in its low price range aircraft. The 150, whose sales reached the 1,000 mark since its introduction two years ago, is an all-metal, two-place aircraft offered in standard, trainer and inter-city commuter versions. For 1961, the 150 features a new functionally designed instrument panel, relocated main landing gear, increased visibility, optional individual adjustable seats and completely restyled interiors and exteriors. The 150 is also available as a patrol aircraft with patroller wings that provide additional fuel capacity, Plexiglas door panels and message chute.

SPECIFICATIONS

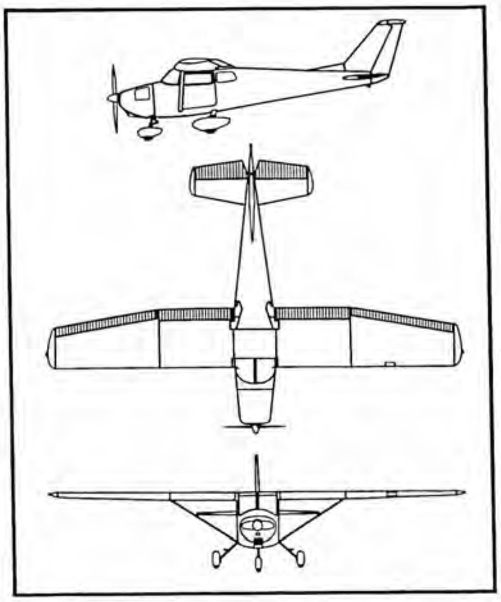
Span 33 ft. 4 in.; Length 21 ft. 6 in.; Height 6 ft. 11 in.; Empty Weight 946 lb.; Wing Loading 9.4 lb. per sq. ft.; Power Loading 15 lb. per bhp; Engine One Continental O-200-A (4-cylinder), 100 hp Max. or continuous, or 100 hp at 2750 rpm takeoff; Fuel Capacity 26 gal.; Propeller Sensenich M69CK-52; Wing Area 160 sq. ft.; Aileron Area 17.88 sq. ft.; Flap Area 17.24 sq. ft.; Fin Area 7.79 sq. ft.; Rudder Area 6.32 sq. ft.; Stablizer Area 17.38 sq. ft.; Elevator Area 11.14 sq. ft.

PERFORMANCE

Maximum Speed 124 mph at 100 hp at 2750 rpm at Sea Level; Cruise Speed 121 mph at 70 percent hp at 2650 rpm at 9000 ft.; Landing Speed 54 mph flaps up—50 mph flaps down; Rate of Climb 740 fpm at Sea Level; Service Ceiling 15,300 ft.; Range with Maximum Fuel Load 520 mi. at max. Cruise; range 630 mi. using 43 percent power at 10,000 ft. (economy cruise).

CESSNA 172
CESSNA AIRCRAFT CO., Wichita, Kansas

REMARKS
More than 4,800 Cessna 172's have been sold since the model was introduced in late 1955. During the 1960 model year, the 172, with unit sales totalling 992, outsold all other business aircraft on the market. The all metal, four passenger 172 is equipped with Cessna "Land-O-Matic" tricycle gear that simplifies landing and take-off and with large "Para Lift" flaps that provide ease of operation in and out of short or rough fields. The 1961 version features a new fuselage, an outside baggage door, increased range, restyled landing gear of lower design and new exterior and interior styling.



SPECIFICATIONS
Span 36 ft.; Length 26 ft. 5.5 in.; Height 8 ft. 8 in.; Empty Weight 1252 lb.; Gross Weight 2200 lb.; Wing Loading 12.6 lb. per sq. ft.; Power Loading 15.2 lb. per bhp. Engine Continental O-300-C (six cylinder), 145 hp; Fuel Capacity 42 U.S. gal.; Propeller McCauley all-metal fixed pitch; Wing Area 174 sq. ft.

PERFORMANCE
Maximum Speed 139 mph at 145 hp at Sea Level; Cruise Speed 130 mph at maximum recommended cruise, 8000 ft. at 70 percent power; Rate of Climb 730 fpm at Sea Level; Service Ceiling 15,100 ft.; Range with Maximum Payload 565 mi. or 4.4 hours at 130 mph true air speed; Range with Maximum Fuel Load 790 mi. or 7.9 hrs. with true air speed of 100 mph.

CESSNA SKYHAWK

CESSNA AIRCRAFT CO., Wichita, Kansas

REMARKS

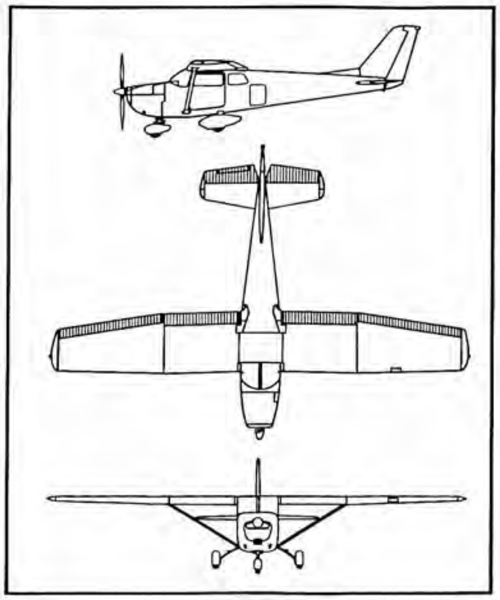
A new addition to the Cessna line for 1961, the Skyhawk is a fully equipped prestige companion model to the Cessna 172. Standard equipment on the Skyhawk includes electric push button starter, engine driven vacuum system, wheel speed fairings, wing strut fairings, landing and taxi light, sun visors, tow bar and navigation light flasher, turn and bank indicator, rate of climb, sensitive altimeter, clock and outside air temperature gauge. The Skyhawk is finished with an all-over paint design offered in six different color selections.

SPECIFICATIONS

Span 36 ft.; Length 26 ft. 5.5 in.; Height 8 ft. 8 in.; Empty Weight 1330 lb.; Wing Loading 12.6 lb. per sq. ft.; Power Loading 15.2 lb. per bhp; Engines One Continental 0-300-D, 145 hp at 2700 rpm takeoff; Fuel Capacity 42 gal.; Propeller McCauley fixed pitch; Wing Area 174 sq. ft.; Aileron Area 18.30 sq. ft.; Flap Area 21.23 sq. ft.; Fin Area 10.76 sq. ft.; Rudder Area 7.28 sq. ft.; Stabilizer Area 19.80 sq. ft.; Elevator Area 14.87 sq. ft.

PERFORMANCE

Maximum Speed 140 mph at 145 hp at sea level; Cruise Speed 131 mph 8000 ft.; Rate of Climb 730 fpm at sea level; Service Ceiling 15,100 ft.; Range with Maximum Payload 790 mi. at 10,000 ft. with 39 gal. useable fuel; Range with maximum Fuel Load 790 mi. at 10,000 ft. with 39 gal. useable fuel.



CESSNA MODEL 175

CESSNA AIRCRAFT CO., Wichita, Kansas

REMARKS

Introduced for the first time in 1958 as a step up airplane for business pilots desiring additional power and performance, the Model 175 is a four-place all-metal high-wing monoplane. The 1961 version of the 175 has many new features including new cabin and carburetor "Blend Temp" heating system, reclining front seats, and completely new internal and external styling. New magnetic fuel level gauges, a new fuel strainer drain valve and simplified starter activation through rerouting of the starter control are among other new features on the 1961 model. The Skylark is a prestige companion model to the Cessna 175. It is offered with many items usually considered optional equipment, including speed fairings, landing and taxi lights, navigation light flasher, sun visors, sensitive altimeter, electric clock, horizon and directional gyros, rate of climb and has an overall paint design. The Skylark has an all electric pushbutton starter as standard equipment.

SPECIFICATIONS

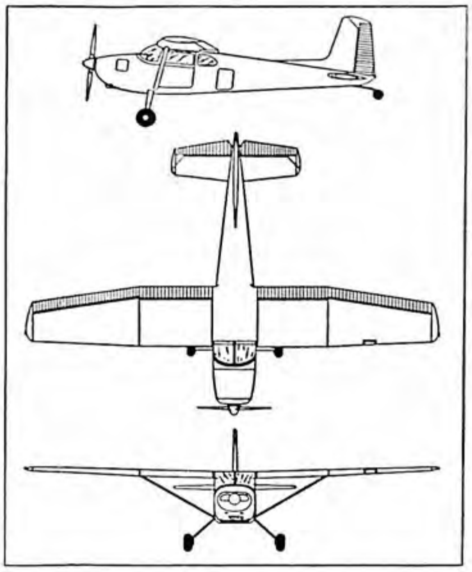
Span 36 ft.; Length 26 ft. 4 in.; Height 8 ft. 8 in.; Empty Weight 1325 lb.; Wing loading 13.5 lb. per sq. ft.; Power Loading 13.4 lb. per bhp; Engine One Continental GO-300-C six-cylinder, 175 hp at 3200 rpm takeoff; Fuel Capacity 52 gal.; Propeller McCauley FC 8467; Wing Area 175 sq. ft.; Aileron Area 18.30 sq. ft.; Flap Area 21.23 sq. ft.; Fin Area 10.76 sq. ft.; Rudder Area 7.28 sq. ft.; Stablizer Area 19.72 sq. ft.; Elevator Area 14.87 sq. ft.

PERFORMANCE

Maximum Speed 147 mph at 175 hp at 3200 rpm at Sea Level; Cruise Speed 140 mph at 70 percent hp at 10,000 ft.; Landing Speed 53 mph flaps down—62 mph flaps up; Rate of Climb 850 fpm at Sea Level; Service Ceiling 15,900 ft.; Range at max. cruise speed 590 mi.; Range at economy cruise (max. range) 39 percent power at 10,000 ft. 755 mi.

CESSNA MODEL 180

CESSNA AIRCRAFT CO., Wichita, Kansas



REMARKS

Highlighting new features incorporated in the 1961 Model 180 are a redesigned instrument panel, key ignition system, restyled interior and exterior plus many new passenger and pilot comfort and convenience items. The 180, which was first introduced in 1953, is an all-metal, four passenger airplane popular in both domestic and export markets for rough terrain operation as a passenger and cargo carrier. Equipped with conventional landing gear and certified for operation on standard or amphibious floats and skis, the 180 has accounted for more than 3,800 unit sales since its introduction.

SPECIFICATIONS

Span 36 ft.; Length 26 ft. 6 in.; Height 7 ft. 6 in.; Empty Weight 1530 lb.; Gross Weight 2650 lb.; Wing Loading 15.1 lb. per sq. ft.; Power Loading 11.5 lb. per bhp; Engine Continental O-470-L, 230 hp at 2600 rpm; Fuel Capacity 65 gal.; Propeller All-Metal constant speed; Wing Area 174 sq. ft.

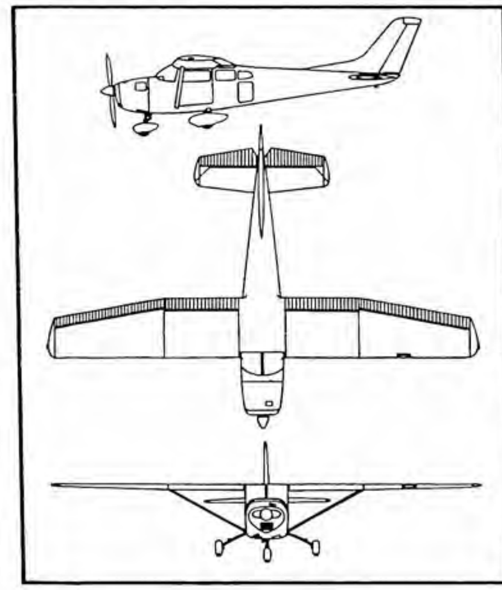
PERFORMANCE

Maximum Speed at Sea Level 170 mph; Cruise Speed 160 mph; Rate of Climb 1130 fpm at Sea Level; Cruising Range 675 mi.; Service Ceiling 21,500 ft.; Maximum Range 845 mi.

CESSNA 182
CESSNA AIRCRAFT CO., Wichita, Kansas

REMARKS

Introduced in 1956 as an "easy to fly" airplane for business pilots desiring increased power and performance, the 182 is an all-metal, four place airplane. The 1961 Model 182 features redesigned instrument panel, a key ignition system, restyled interior and exterior, plus many new comfort and convenience items. Nose and main gear of the 182 have been lowered four inches which results in better ground handling characteristics, a four pound increase in useful load and a more streamlined appearance. Other new features include the use of Camlock cowling fasteners to reduce cowl removal time, a lever type cowl flap control and a new nosewheel fork to provide a stronger and more durable nose gear. Introduced in 1958 as a companion model to the Cessna 182, the Skylane is equipped with a full panel, overall three-color paint design, wheel speed fairings, and tinted glass as standard equipment. The 1961 model has the same new features incorporated in the 1961 Model 182 plus increased performance due to the addition of speed fairings.

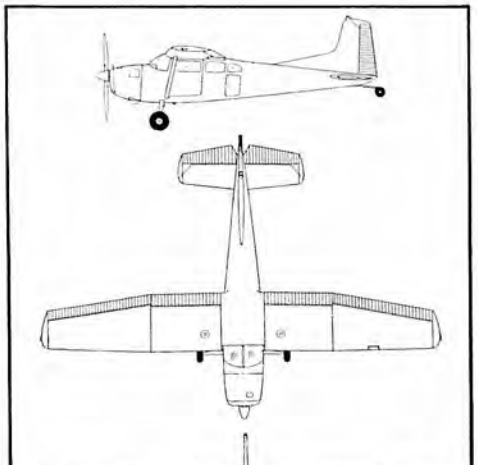


SPECIFICATIONS

Span 36 ft.; Length 27 ft. 1 in.; Height 9 ft. 5 in.; Empty Weight 1615 lb.; Wing Loading 15.1 lb. per sq. ft.; Power Loading 11.5 lb. per bhp; Engine One Continental O-470-L six-cylinder, 230 hp at 2600 rpm takeoff; Fuel Capacity 65 gal.; Propeller Hartzell or McCauley all-metal constant speed; Wing Area 174 sq. ft.; Aileron Area 18.30 sq. ft.; Flap Area 21.23 sq. ft.; Fin Area 11.20 sq. ft.; Rudder Area 6.95 sq. ft.; Stabilizer Area 20.94 sq. ft.; Elevator Area 13.18 sq. ft.

PERFORMANCE

Maximum Speed 170 mph at 230 hp at 2600 rpm at Sea Level; Cruise Speed 160 mph at 70 percent hp at 8000 ft.; Landing Speed 62 mph flaps up—56 mph flaps down; Rate of Climb 1030 fpm at Sea Level; Service Ceiling 19,800 ft.; Range at Maximum cruise 70 percent power at 8000 ft. 675 mi.; Maximum Range 845 mi.



CESSNA 185

CESSNA AIRCRAFT CO., Wichita, Kansas

REMARKS

A new addition to the Cessna line for 1961, the Model 185 is a six-place single-engine utility plane for packing heavy pay loads and certified for standard gear, ski and float operations. Delivery of the first production models is scheduled to begin in March, 1961. Equipped with conventional gear the 185 is ideally suited for passenger, charter and feeder line work, cargo hauling, agricultural work and long range mapping operations. The 185 is available in five different interior arrangements to meet individual mission requirements.

SPECIFICATIONS

Span 36 ft.; Length 26 ft. 2 in.; Height 7 ft. 6.5 in.; Empty Weight 1520 lb.; Wing Loading 18.4 lb. per sq. ft.; Power Loading 12.3 lb. per bhp; Engines one Continental IO-470-F fuel injection, 260 hp at 2625 rpm takeoff; Fuel Capacity 65 gal. standard, 84 gal. optional; Propeller constant speed; Wing Area 174 sq. ft.

PERFORMANCE

Maximum Speed 176 mph at sea level; Cruise Speed 165 mph at 70 percent power at 8000 ft.; Rate of Climb 1000 fpm at sea level; Service Ceiling 17,300 ft.; Range with Maximum Payload 1160 mi. at 10,000 ft. with 81 gals. useable fuel; Range with Maximum Fuel Load 1160 mi. at 10,000 ft. with 81 gals. useable fuel.

CESSNA 310F

CESSNA AIRCRAFT CO., Wichita, Kansas

REMARKS

First introduced in late 1954, the Model 310 is a five passenger, twin-engine business transport of high performance and advanced design. The 1961 version, the 310F, has advanced styling of nose cap, wing tip tanks and prop spinners to complement Cessna's "flight sweep" design. A new third window has been added on each side for increased passenger visibility, new Scintilla retard magnetos, simplified pilot procedure for starting, interior and exterior design changes and refinements for perfecting performance and simplified maintenance have been incorporated in the "F" model. Noted for its single engine performance, the airplane will climb at the rate of 440 feet per minute on one engine with a full passenger and baggage load.

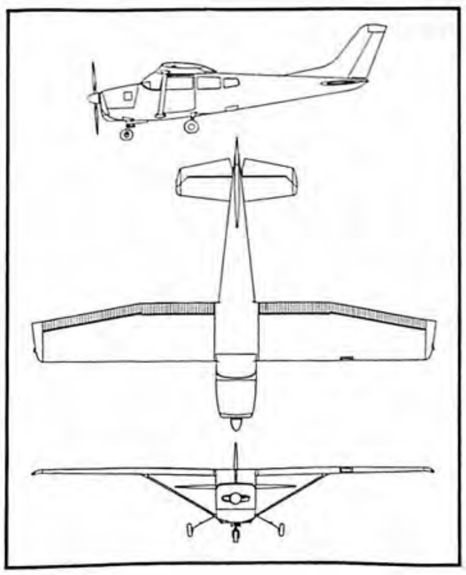
SPECIFICATIONS

Span 36 ft.; Length 29.5 ft.; Height 9.93 ft.; Empty Weight 3040 lb.; Gross Weight 4830 lb.; Wing Loading 27.6 lb. per sq. ft.; Power Loading 9.3 lb. per bhp; Engines Two Continental IO-470-Ds 260 hp with fuel injection rated at 2625 rpm; Fuel Capacity 102 gals. carried in wing tip tanks, with auxiliary tanks, 133 gals.; Propeller constant speed full feathering; Gear tricycle; Wing Area 175 sq. ft.

PERFORMANCE

Maximum Speed at Sea Level 242 mph; Cruise Speed 220 mph; Rate of Climb 1800 fpm; Service Ceiling 21,300 ft.; Range with Maximum Payload 825 mi.; Maximum Range with Auxiliary Fuel 1440 mi.

CESSNA 210
CESSNA AIRCRAFT CO., Wichita, Kansas



REMARKS
The Cessna Model 210 is a four place, high performance aircraft with retractable landing gear. It is unique in that it is the first high-wing, single engine aircraft with retractable landing gear offered on the commercial market. The 210, which outsold other single engine retractable gear aircraft following its introduction in 1960, has many new and improved features for 1961. Among these features will be a restyled instrument panel, increased visibility through the addition of two more rear side windows, increased headroom, key ignition starter, new heating and ventilating system and new interior and exterior styling.

SPECIFICATIONS
Span 36.5 ft.; Length 27 ft. 4 in.; Height 8.15 ft.; Empty Weight 1740 lb.; Wing Loading 16.5 lb. per sq. ft.; Power Loading 11.2 lb. per bhp; Engine Continental IO-470-E (fuel injection), 260 hp at 2625 rpm takeoff; Fuel Capacity 65 gal., 84 gals. optional; Wing Area 175.5 sq. ft.; Aileron Area 18.30 sq. ft.; Flap Area 21.23 sq. ft.; Fin Area 11.20 sq. ft.; Rudder Area 6.95 sq. ft.; Stabilizer Area 20.94 sq. ft.; Elevator Area 15.13 sq. ft.

PERFORMANCE
Maximum Speed 199 mph at 260 hp at 2625 rpm at Sea Level; Cruise Speed 190 mph at 75 percent power at 7000 ft.; Landing Speed 59 mph; Rate of Climb 1300 fpm at Sea Level; Service Ceiling 20,700 ft.; Absolute Ceiling 22,400 ft.; Range at Maximum Cruise 755 mi.; Maximum Range with auxiliary fuel 1365 mi.

CESSNA T-37B

CESSNA AIRCRAFT CO., Wichita, Kansas

REMARKS

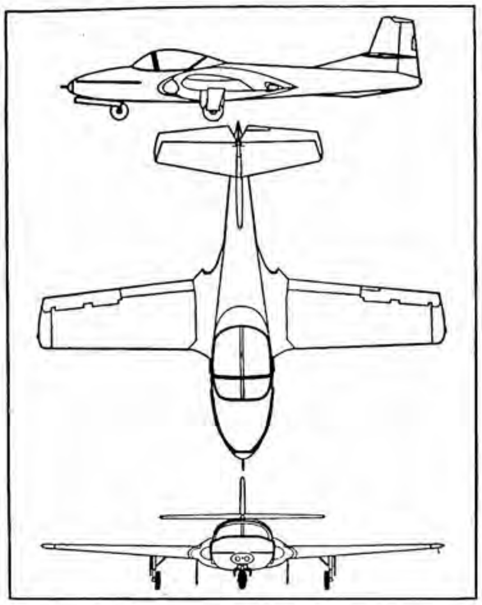
The Cessna T-37 twin-jet intermediate trainer is in use at Air Force Training schools throughout the United States, and has been instrumental in introducing jets into the earliest phases of flight training. The aircraft features side-by-side seating of student and instructor, a feature which has had notable effects of speeding training, increasing effectiveness and building confidence. The T-37B, with higher thrust engines and increased communication and navigation equipment, entered Air Force service in November, 1959.

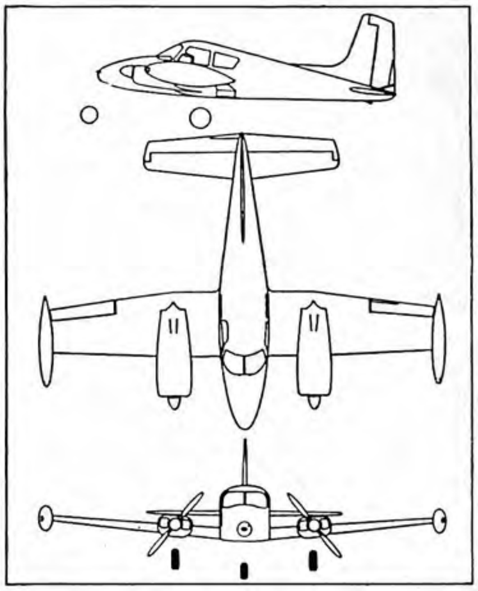
SPECIFICATIONS

Span 33 ft. 10 in.; Length 29 ft. 4 in.; Height 9 ft. 3 in.; Empty Weight 4056 lb.; Wing Loading 35.7 lb. per sq. ft.; Power Loading 3.2 lb. per lb. of thrust; Engines Two Continental J69-T25s, 880 lb. thrust normal rated, or 1025 lb. thrust at 21,730 rpm takeoff; Fuel Capacity 321 gal.; Wing Area 183.9 sq. ft.; Aileron Area 11.3 sq. ft.; Flap Area 15.1 sq. ft.; Fin Area 11.5 sq. ft.; Rudder Area 6.2 sq. ft.; Stabilizer Area 34.9 sq. ft.; Elevator Area 11.6 sq. ft.

PERFORMANCE

Maximum Speed 408 mph at Military Power at 21,730 rpm at 35,000 ft.; Cruise Speed 368 mph at normal rated power at 20,700 rpm at 35,000 ft.; Gross Weight Landing Speed 85 mph; Rate of Climb 3200 fpm at S. L.; Service Ceiling 39,200 ft.; One-half fuel Absolute Ceiling 44,000 ft.; Range with Maximum Payload 796 mi.; Range with Maximum Fuel Load 796 mi.





CESSNA U-3A

CESSNA AIRCRAFT CO., Wichita, Kansas

REMARKS

The U-3A is an off-the-shelf version of the Cessna Model 310 and was purchased by the Air Force to meet the need for low-cost and low-maintenance administrative and light cargo transportation. Air Force has received 160 of the light twins and has 35 additional airplanes on order.

SPECIFICATIONS

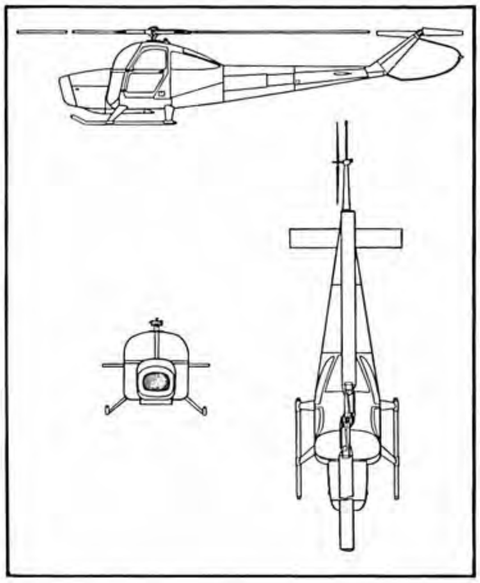
Span 36 ft.; Length 26 ft.; Height 10 ft. 6 in.; Empty Weight 3146 lb.; Gross Weight 4830 lb.; Wing Loading 27.6 lb. per sq. ft.; Power Loading 10.05 lb. per bhp; Engines Two Continental O-470-M, 240 hp at 2600 rpm takeoff; Fuel Capacity 130 gal.; Propeller Two-bladed Hartzell full feathering, constant speed; Wing Area 175 sq. ft.; Aileron Area 13.4 sq. ft.; Flap Area 22.9 sq. ft.; Fin Area 14.08 sq. ft.; Rudder Area 11.78 sq. ft.; Stabilizer Area 32.15 sq. ft.; Elevator Area 22.1 sq. ft.

PERFORMANCE

Maximum Speed 230 mph at 240 hp at 2600 rpm at Sea Level; Cruise Speed 210 mph at 70 percent hp at 2300 rpm at 8000 ft.; Landing Speed 95 mph (single-engine go around); Rate of Climb 1590 fpm at Sea Level; Service Ceiling 20,000 ft.; Absolute Ceiling 21,300 ft.; Range with Maximum Fuel Load 1125 st. mi.

CESSNA SKYHOOK

CESSNA AIRCRAFT CO., Wichita, Kansas



REMARKS

The first rotary-wing aircraft in aviation history to be supported by a world-wide organization providing readily available parts and service is the Skyhook, a new addition to the company's line of aircraft for 1961. The Skyhook is a four-place rotary-wing craft with a maximum gross weight of 3100 pounds. The aircraft's stability, comparable to that of a fixed wing aircraft, greatly simplifies handling characteristics. Mechanical simplicity, with a minimum of moving parts throughout the drive system, along with a simplified Cessna design rotor head, are key features of the Skyhook. In June, 1960, the FAA certified an instrument version of the Skyhook for IFR operation.

SPECIFICATIONS

Overall Length 42.5 ft.; Fuselage Length 29.4 ft.; Height 8 ft. 4 in.; Empty Weight 2080 lb.; Rotor Diameter 35 ft.; Engines One Continental FSO 526A, 270 hp at 3000 and 3200 rpm takeoff; Fuel Capacity 60 gal. standard, 90 gal. with auxiliary tanks.

PERFORMANCE

Maximum Speed 122 mph at sea level; Cruise Speed 90 to 120 mph; Rate of Climb 1030 fpm at 8000 ft.; Service Ceiling 16,200 ft.; Range with Maximum Payload 260 mi.; Range with Maximum Fuel Load 400 mi.

CHAMPION CHALLENGER

CHAMPION AIRCRAFT CORP., Osceola, Wisconsin

SPECIFICATIONS

Span 34.45 ft.; Length 22.08 ft.; Height 6.87 ft.; Engine O-320-A (Continuous) 150 hp; Wing Loading 9.18 lb. per sq. ft.; Power Loading 11.0 lb. per hp; Wing Area 170.22 sq. ft.; Gross Weight 1650 lb.; Empty Weight 1050 lb.; Useful load 600 lb.; Service Ceiling 17,500 ft.; Absolute Ceiling 19,150 ft.

PERFORMANCE

Cruise Speed 125 mph; Rate of Climb 1145 fpm; Range at 75 percent power at 8000 ft. 510 mi.

CHAMPION TRI-TRAVELER

SPECIFICATIONS

Span 33 ft. 5 in.; Length 21 ft. 8 in.; Height 8 ft. 8 in.; Empty Weight 968 lb.; Gross Weight 1450 lb.; Useful Load 482 lb.; Baggage 50 lb.; Wing Loading 8.8 psf; Power Loading 16.50 php.

PERFORMANCE

Maximum Speed 135 mph; Cruising Speed 108 mph; Landing Speed 42 mph; Rate of Climb 900 fpm; Cruising Range 500 miles; Fuel Capacity 26 gal.

CHAMPION TRI-CON ''95''

SPECIFICATIONS

Span 33 ft. 5 in.; Length 21 ft. 8 in.; Height 7 ft. 6 in.; Engine Continental C-90-12F, 95 hp; Wing Loading 8.8 psf; Power Loading 16.5 php; Gross Weight 1450 lb.; Useful Load 482 lb.

PERFORMANCE

Maximum Speed 138 mph; Cruise Speed 108 mph; Rate of Climb 900 fpm; Landing Speed 42 mph; Cruising Range 500 mi.

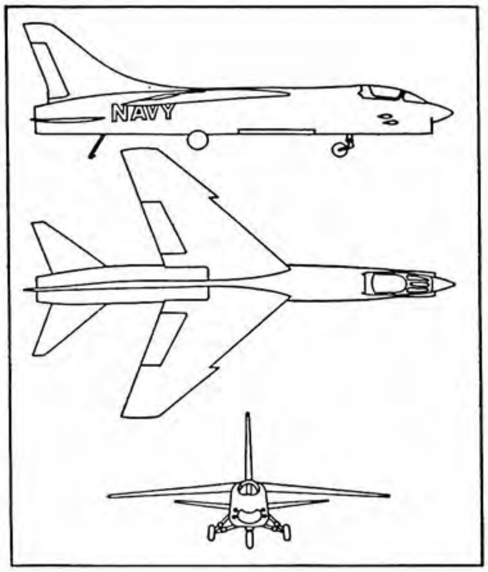
CHANCE VOUGHT F8U-2

CHANCE VOUGHT CORP., Dallas, Texas

REMARKS

The first production model F8U-2 made its initial flight at the Chance Vought Corporation plant at Dallas on August 20, 1958. Capable of speeds approaching Mach 2, the F8U-2 is an advanced version of the F8U-1 Crusader, but has a more powerful engine and improved fire control and radar systems. Two fixed low-aspect-ratio fins have been added under the tail section and two small afterburner airscoops have been mounted atop the tail cone. Like the F8U-1, the carrier-based F8U-2 has a two position wing, making it possible for the fighter to achieve very high speeds and yet land on a small area of carrier deck. Armament consists of Sidewinder guided missiles, four 20-millimeter cannons and 32 2.75-inch rockets. The F8U-2 is operational in Fleet units.

The 1,000-mile-an-hour-plus F8U-1 Crusader currently is operating with Fleet squadrons both on land and at sea. The high-performance aircraft saw service in both the Lebanon and Formosan areas. First flight of the high-wing fighter was on March 25, 1955. Armament consists of Sidewinder missiles, four 20-millimeter cannon and 32 2.75-inch rockets.

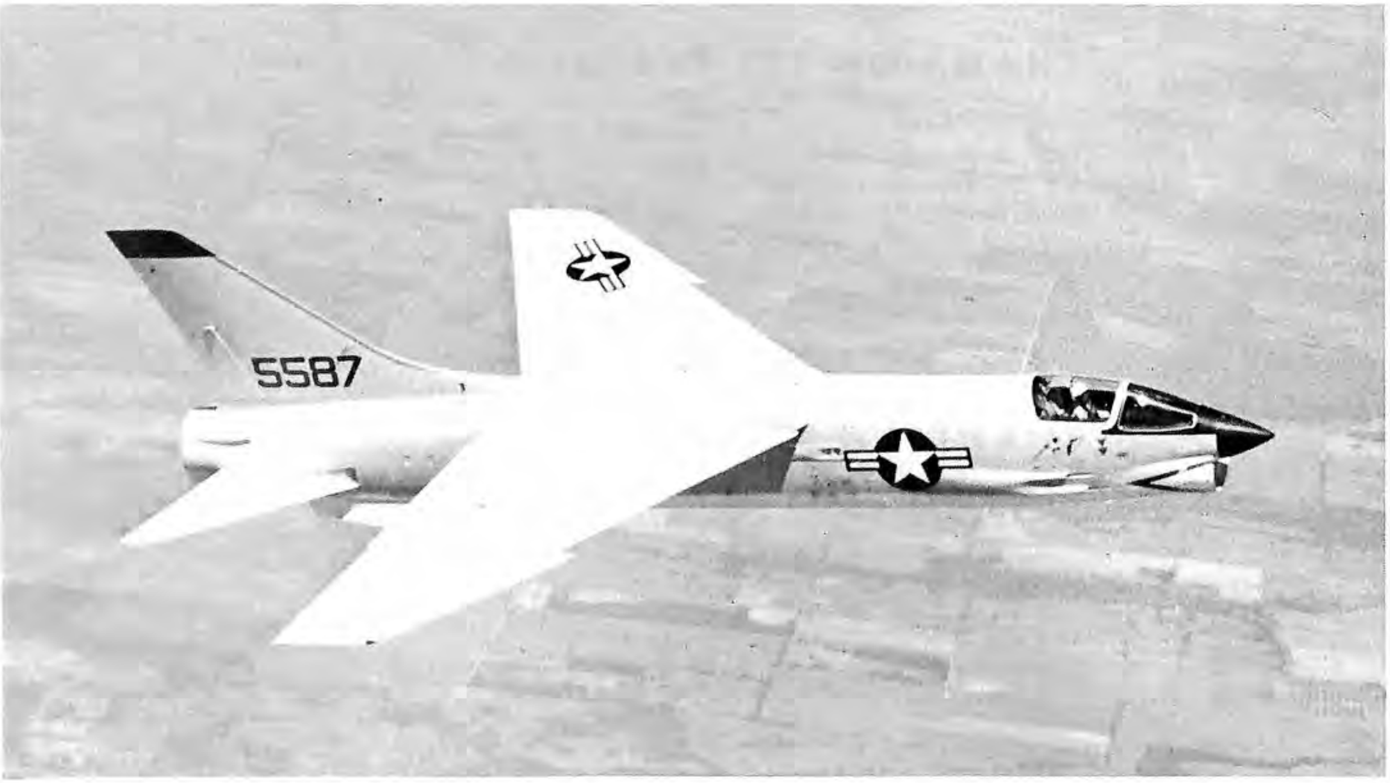


SPECIFICATIONS

Span 35 ft. 8 in.; Length 54 ft. 2.75 in.; Height 15 ft. 9.1 in.; Engine One Pratt & Whitney J-57-P-16.

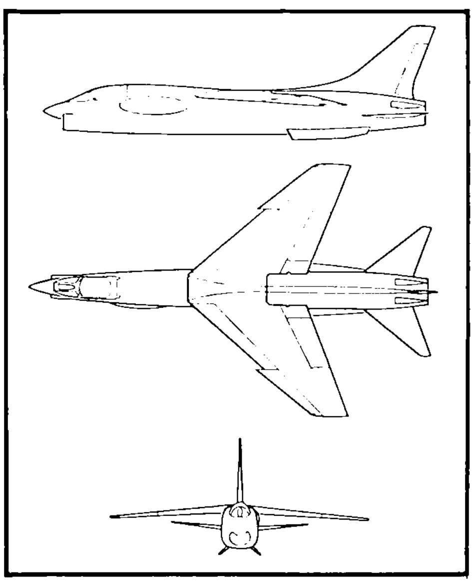
PERFORMANCE

Maximum speed approaching Mach 2.



CHANCE VOUGHT F8U-2N

CHANCE VOUGHT CORP., Dallas, Texas



REMARKS

Chance Vought Aircraft's F8U-2N Crusader, an all-weather interceptor capable of speeds twice that of sound and the latest in the series of record-breaking F8U aircraft, joined the Fleet late in 1960.

First flown in February, 1960, the "2N" is a more powerful aircraft than its F8U-1 and F8U-2 fighter predecessors and has an increased ability to detect and destroy targets at night or in bad weather.

The F8U-2N is powered by a Pratt & Whitney J-57-P20 engine with a thrust rating in excess of 15,000 pounds. It is armed with four Sidewinder guided missiles, 20 mm. cannon, and is equipped with an improved radar and fire control system. It also has provisions for additional armament and for advanced missiles now under development.

A Chance Vought-developed autopilot relieves the pilot of many routine flight tasks, and allows him to concentrate on his mission. Fuel capacity has been increased over that of the long-range F8U-2, which can remain aloft more than three hours without refueling. Other improvements include revised interior and exterior lighting systems and new instrumentation. Like the F8U-2, the "2N" has ventral fins mounted under the tail section to provide increased stability at the high speeds the aircraft is capable of reaching and a two-position wing.

Since the experimental version of the airplane—the XF8U-1—made its first flight March 25, 1955, Crusaders have set the first national speed record in excess of 1,000 miles an hour and become the first aircraft to span the nation faster than the speed of sound. They also won the Collier Trophy for outstanding aviation achievement and the first Certificate of Merit ever awarded by the former Navy Bureau of Aeronautics, now the Bureau of Naval Weapons.

SPECIFICATIONS

Span 35 ft. 8 in.; Length 54 ft. 2.75 in.; Height 15 ft. 9.1 in.; Engine One Pratt & Whitney J-57-P20.

PERFORMANCE

Maximum Speed Mach 2.

CONVAIR B-58 HUSTLER

CONVAIR, A DIVISION OF GENERAL DYNAMICS CORP., San Diego 12, California

REMARKS

Deliveries of Mach 2-plus B-58 Hustler bombers as officially operational weapon systems in Strategic Air Command highlighted the B-58 program at Convair-Fort Worth in 1960.

The B-58 was officially declared operational by strategic Air Command on August 1, 1960. Only 45 days later, the B-58 for the first time was entered in the Strategic Air Command 1960 Combat Competition at Bergstrom Air Force Base, Austin, Texas.

In competition against more experienced crews flying aircraft with years of operational missions behind them, the B-58 nevertheless scored fifth among the 13 top aircraft and top crews of Strategic Air Command.

In one important category–high and low-level bombing–the B-58 flown by a crew of the 43rd Bomb Wing, Carswell Air Force Base, Fort Worth, took first place. It was the first time in history that this event has been won by a newly operational airplane.

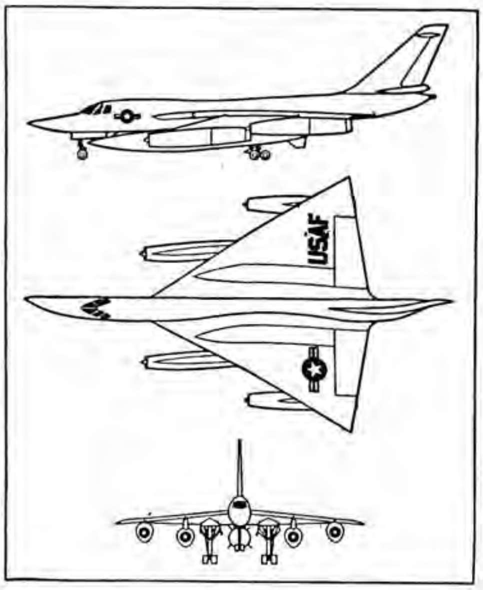
Operational B-58s continued to flow to Carswell to build up full strength of the 43rd Bomb Wing, first supersonic bomb wing in the nation's history. Air Force plans were for B-58s to go next to 305th Bomb Wing at Bunker Hill Air Force Base near Peru, Indiana.

Also going to the 43rd Bomb Wing were the first two of four TB-58s, trainer versions of the B-58 designed to facilitate transitional training of jet pilots already experienced in flying other aircraft, but who had not had previous experience with the delta-wing bomber. (See photo and remarks concerning TB-58.)

The B-58 was first flown on November 11, 1956. Developed by Convair for the Air Force, the bomber carries its strategic striking power in a missile-like pod beneath the fuselage. The original pod was in a single component. It 1960, Convair-Fort Worth completed design and production of a new two-component pod. The lower portion carries only fuel for the B-58's J-79 engines.

In combat, the lower component would be dropped when its fuel supply was exhausted. The airplane then would fly on to the target to drop the upper component, which carries both fuel and a nuclear weapon. Thus stripped of all excess poundage, the B-58 would have less weight and less drag to make for a speedier return to home base.

The Hustler embodies the Convair-pioneered delta wing for speed and stability both at low and high altitudes.



SPECIFICATIONS

Gross Weight over 160,000 lb.; Span 56 ft. 10 in.; Length 96 ft. 9 in.; Height 30 ft.; Engines Four General Electric J79-5A turbojet pod-mounted; Wing Area 1542 sq. ft.

PERFORMANCE

Maximum Speed over 1300 mph (Mach 2); Service Ceiling above 60,000 ft.; Range Intercontinental, with mid-air refueling; Design Bomb Load Nuclear; Crew Three; Fuel Capacity more than 15,000 gal.; Landing Gear tricycle (dual-wheel nose gear, eight-wheel truck main gear).

CONVAIR TB-58

CONVAIR, A DIVISION OF GENERAL DYNAMICS CORP., San Diego 12, California

REMARKS

New 1960 sight on flight lines at Carswell Air Force Base, Fort Worth, Texas, and at Convair-Fort Worth across the runway from Carswell are TB-58s, trainer versions of the Mach 2-plus B-58 Hustler supersonic bomber.

Just as the Air Force B-58 is the only supersonic bomber, so is the TB-58 the Air Force's only supersonic trainer bomber. First flight of the TB-58, produced by converting an earlier B-58, was on May 10, 1960. Like its sister ship, the TB-58 operates up to and beyond Mach 2. Its purpose is to provide jet transition and proficiency training for Air Force pilots due to fly supersonic bomber weapon system missions in Strategic Air Command.

The TB-58s, four of which have been ordered by the Air Force, enable the Air Force to train pilots for virtually any operation they may be called upon to perform in combat. This includes not only handling of flight controls, but also training in refueling techniques, as well as procedures for dropping the B-58's externally mounted disposable pod, containing the bomber's payload, on an enemy target.

Externally, the TB-58 is identical to the B-58 except for additional windows. These provide visibility adequate for the TB-58 to be flown either from the first crew station or from the second crew station immediately behind. Pilots may take off, fly and land the plane from either of the first two stations.

The pilot in training uses the forward station. The instructor pilot uses the second station, which is so arranged that the instructor literally may look over the should of the pilot in front. The third station may at the same time carry a qualified B-58 pilot who needs to renew or upgrade his skills. In flight, he may change places with the instructor pilot in the second station

SPECIFICATIONS

Gross Weight over 160,000 lb.; Span 56 ft. 10 in.; Length 96 ft. 9 in.; Height 30 ft.; Engines Four General Electric J79-5A turbojet pod-mounted; Wing Area 1542 sq. ft.

PERFORMANCE

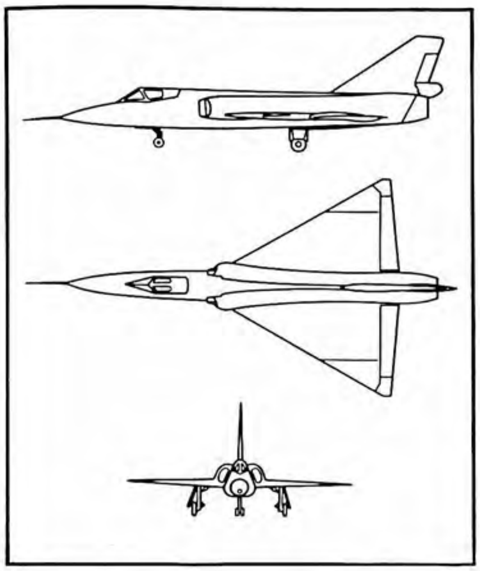
Maximum Speed over 1300 mph (Mach 2); Service Ceiling above 60,000 ft.; Range Intercontinental, with mid-air refueling; Crew Three; Fuel Capacity more than 15,000 gal.; Landing Gear tricycle (dual-wheeled nose gear, eight-wheel truck main gear).

CONVAIR F-106A ADVANCED ALL-WEATHER INTERCEPTOR

CONVAIR, A DIVISION OF GENERAL DYNAMICS CORP., San Diego 12, California

REMARKS

The single-seat F-106A carries Hughes Falcon GAR-3 and GAR-4 missiles and Douglas Genie MB-1 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.

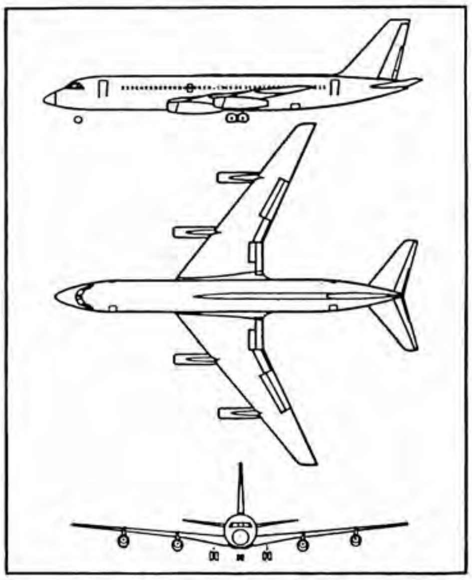


SPECIFICATIONS

Span 38 ft. 1.6 in.; Length 70 ft. 8.78 in.; Height 20 ft. 3.33 in.; Engine One Pratt & Whitney J75-P17 turbojet with afterburner 15,000 lb. thrust class; Wing Area 631.23 sq. ft.; Elevon aft on hinge line 66.60 sq. ft.; Rudder Area aft of hinge line 11.10 sq. ft.; Fin Area 93.90 sq. ft., including rudder.

PERFORMANCE

Maximum Speed 1,525.95 mph; Landing Speed 166.75 mph (All other details are classified); Ceiling above 50,000 ft.



CONVAIR 880

CONVAIR, A DIVISION OF GENERAL DYNAMICS CORP., San Diego 12, California

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 slightly increased range, fuel capacity, operating weights and slightly shorter runway requirements. It has wing leading edge slats, power boost rudder, and engines with increased thrust. Both Convair 880s can cruise at 615 miles an hour. Range of the basic 880 with first-class payload and normal fuel reserves is 3,200 statute miles. The 880-M with optional fuel tanks installed has a range of 3,750 statute miles. In a first-class, two-abreast seating arrangements as used by initial operators, the 880 carries 84 passengers. In a five-across coach configuration it will carry 110 persons. The basic 880 received its FAA air worthiness certificate May 1, 1960, and went into commercial airline service on May 15, 1960. The first flight of the 880-M was October 3, 1960 and FAA certification is planned in 1961.

SPECIFICATIONS

Span 120 ft.; Length 129 ft. 4 in.; Height 36 ft. 3.7 in.; Empty Weight 84,300 lb.; Wing Loading 92.95 lb. per sq. ft. at maximum to weight of 184,500 lb.; Engines four General Electric CJ805-3 turbojet, each with 11,200 lb. thrust; optional, General Electric CJ805-3B with 11,650 lb. static thrust; Fuel Capacity 10,770 gal.; With optional center fuel tanks 12,534 gal.; 880-M Maximum Takeoff Weight 191,000 lbs.; Wing Area 2000 sq. ft.; Rudder Area 82.4 sq. ft.; Elevator Area 88.3 sq. ft.; Horizontal Tail Area 395 sq. ft.; Vertical Tail Area 295 sq. ft.

PERFORMANCE

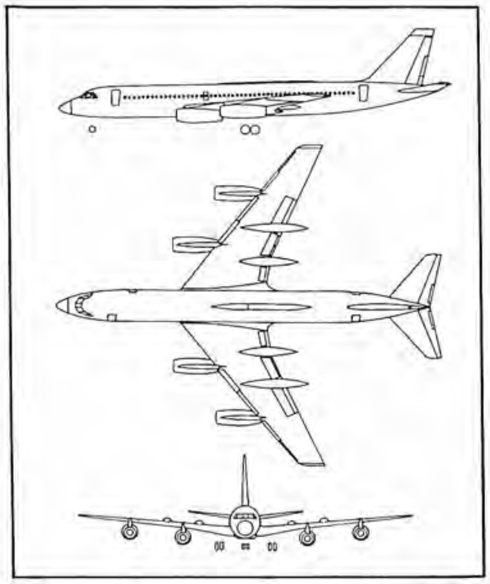
Maximum Speed 615 mph at maximum cruise thrust at 22,500 ft.; Cruise Speed 556 mph at Mach 0.84 at 35,000 ft.; Landing Speed 145 mph, 1.3 Stall Speed Landing Weight 121,000 lb.; Rate of Climb 3565 fpm at Sea Level; Service Ceiling 41,000 ft., 8000 ft. cabin altitude at 41,000 ft. airplane altitude, 8.2 psi cabin pressure differential; Range with Maximum Payload 3200 s. mi.; Range with Maximum Fuel Load 3200 statute mi., reserve fuel for 200 nautical mi. plus ¾ hr.

CONVAIR 990

CONVAIR, A DIVISION OF
GENERAL DYNAMICS CORP.,
San Diego 12, California

REMARKS

The Convair 990 (formerly Model 600) is a medium-range jet airlines with enough cruising speed and fuel capacity to fly nonstop transcontinental routes at near sonic speeds. The transport can fly both medium and long-range routes at premium speeds; and with full reserves, carries enough fuel for maximum-range trips of 4,300 miles or premium speed trips up to 2,860 miles. The CJ-805-23 engines, which power the 990, incorporate an additional turbine and fan. This aft-fan compresses air flowing around the basic engine and exhausts it throught a double jet nozzle at low velocity for improved engine efficiency. Also helping to make possible the tremendous speed of Model 990 is use of four "speed capsules." These capsules 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 990's large fuel capacity comes from the fact that these speed capsules also function as fuel tanks. The plane can seat 96 first-class passengers in the regular four-across, wide-aisle, deluxe version and in the six-place lounge. A five-across standard coach seating arrangement can accommodate 121 passengers. American Airlines has ordered 25 Convair 990 jet airliners and has taken an option on an additional 25. Swissair has ordered seven and SAS two. Real Aerovias has ordered three. Deliveries will begin in 1961.

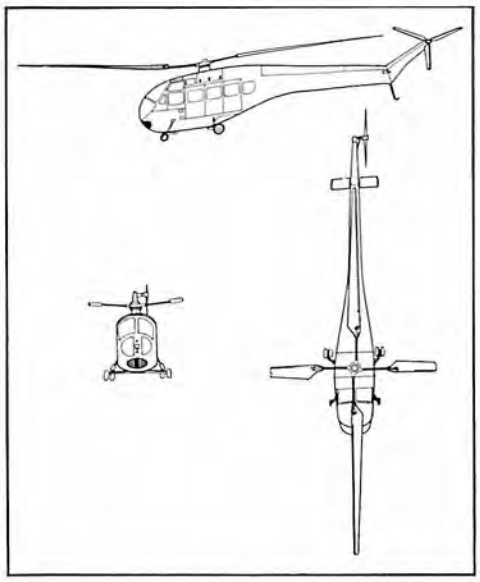


SPECIFICATIONS

Span 120 ft.; Length 139 ft. 5 in.; Height 39 ft. 6 in.; Empty Weight 110,750 lb.; Wing Loading 106 lb. per sq. ft. at maximum to weight 239,200 lb.; Engines Four General Electric CJ805-23 aft-fan turbojet, each with 16,100 lb. static thrust; Fuel Capacity 15,110 gal.; Wing Area 2250 sq. ft.; Rudder Area 82.4 sq. ft.; Elevator Area 98.0 sq. ft.; Horizontal Tail Area 426.5 sq. ft.; Vertical Tail Area 295 sq. ft.

PERFORMANCE

Maximum Speed 640 mph at maximum cruise thrust at 21,500 ft.; Cruise Speed 570 mph at Mach 0.86 at 35,000 ft.; Landing Speed 137 mph, 1.3 Stall Speed; Landing Weight 151,000 lb.; Rate of Climb 3250 fpm at Sea Level; Service Ceiling 41,000 ft., 8000 ft. cabin altitude at 41,000 ft. airplane altitude, 8.2 psi cabin pressure differential; Range with Maximum Payload 4300 mi.; Range with Maximum Fuel Load 4300 mi., reserve fuel for 200 nautical mi. plus ¾ hr.



DOMAN D-10

DOMAN HELICOPTERS, INC., Danbury, Connecticut

REMARKS

The Model D-10 is being produced in Italy by Aeronautica Sicula, S.p.A. under license. The D-10 features a simplified rotor system that is completely enclosed, self lubricated, and simple in fabrication, operation and maintenance. Blade flapping and drag hinges, dampers, and grease fittings, long employed in conventional rotors, are completely eliminated on the D-10. All moving parts, including controls, are located in the rotor head and are protected from the elements. No post flight maintenance is required.

SPECIFICATIONS

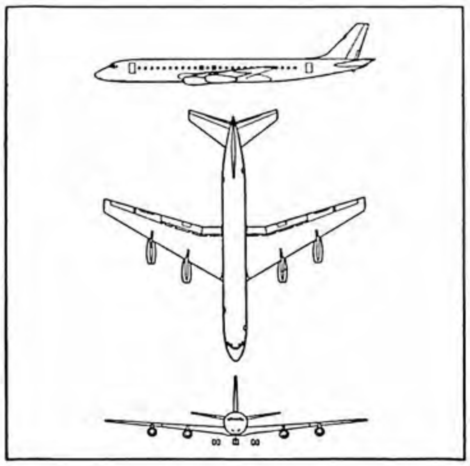
Length 38 ft.; Height 10 ft. 5 in.; Main Rotor Diameter 48 ft.; Tail Rotor Diameter 10 ft.; Engine Lycoming ISO-720-A1A, 525 hp at 3300 rpm takeoff; Fuel Capacity 119 gal.; Empty Weight 3327 lb.

PERFORMANCE

Maximum Speed 104 mph; Cruise Speed 95 mph; Range with Standard Fuel Load 354 mi.; Service Ceiling 21,000 ft.

DOUGLAS DC-8 JET TRANSPORT

DOUGLAS AIRCRAFT CO., INC., Santa Monica, Calif.



REMARKS

All models of the DC-8 have identical dimensions, differing only in weight, resulting from more fuel capacity and structural accommodations for the added fuel on intercontinental models. Four powerplants may be selected: Pratt & Whitney JT3C, JT3D and JT4A for domestic models and JT3D, JT4A and Rolls-Royce Conway for intercontinental versions. First flight was May 30, 1958; first delivery in June, 1959; certification August, 1959.

SPECIFICATIONS

Span 142.4 ft.; Over-All Length 150 ft. 6.362 in.; Height 42 ft. 3.589 in.; Manufacturing Empty Weight domestic 119,997 lb. for JT3C to 125,956 lb. for JT4A, overwater 126,400 lb.; T. O. Gross Weight domestic JT3C 265,000 lb. to 273,000 lb., JT4A 276,000 lb., intercontinental 300,000 lb. to 310,000 lb., extended range 315,000 lb.; Wing Loading 95.5-113.6 lb. per sq. ft.; Engines Four Turbojet; Fuel Capacity domestic 17,600 gal. or 118,950 lb., intercontinental 23,079 gal. or 156,750 lb.; Wing Area 2772.5 sq. ft.; Aileron Area 161.6 sq. ft.; Flap Area 456.9 sq. ft.; Fin Area 222.9 sq. ft.; Rudder Area 128.8 sq. ft.; Stabilizer Area 391.2 sq. ft.; Elevator Area 167.9 sq. ft.

PERFORMANCE

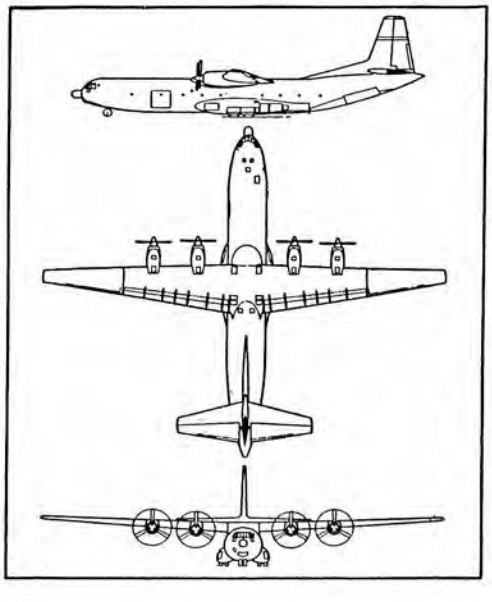
Speed 550 to 600 st. mph; Stall Speed at Maximum Landing Weight 114 to 118 st. mph; Design Landing Weight 189,000 to 199,500 lb.; Cruise Altitude 25,000 to 42,000 ft.; Take-off Distance 7600 to 10,200 ft.; Payload 32,000 to 40,000 lb.; Range 5690 to 6050 st. mi.

DOUGLAS C-133B HEAVY CARGO TRANSPORT

DOUGLAS AIRCRAFT CO., INC., Santa Monica, Calif.

REMARKS

The C-133A and C-133B are capable of transporting any missile in the United States arsenal, including intercontinental ballistic missiles. It also can carry virtually all of Army field force equipment. Costly disassembly of large vehicles and equipment is unnecessary, and vehicles are ready for use upon arrival. Two cargo entrances permit simultaneous front-and-rear loading into the 13,000-cubic-foot capacity cabin which is pressurized to maintain a sea level cabin 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 Air Transport Service, is produced at the Douglas Long Beach Division.



SPECIFICATIONS

Span 179 ft. 7.86 in.; Length 157 ft. 6.44 in.; Height 48 ft. 9 in.; Empty Weight 120,363 lb.; Wing Loading 107.0 lb. per sq. ft.; Power Loading 9.73 lb. per eshp; Engines T34-P-9W, 5650 eshp normal rated, or 7500 eshp at 11,000 rpm takeoff; Fuel Capacity 18,112 gal.; Propeller C-W CT735 S-B100, 1060-25C5-12 Electric, Full Feathering, Reversible; Wing Area 2673.1 sq. ft.; Aileron Area 142 sq. ft.; Flap Area 496.5 sq. ft.; Fin Area 354.3 sq. ft.; Rudder Area 182.4 sq. ft.; Stabilizer Area 459.2 sq. ft.; Elevator Area 341.5 sq. ft.

PERFORMANCE

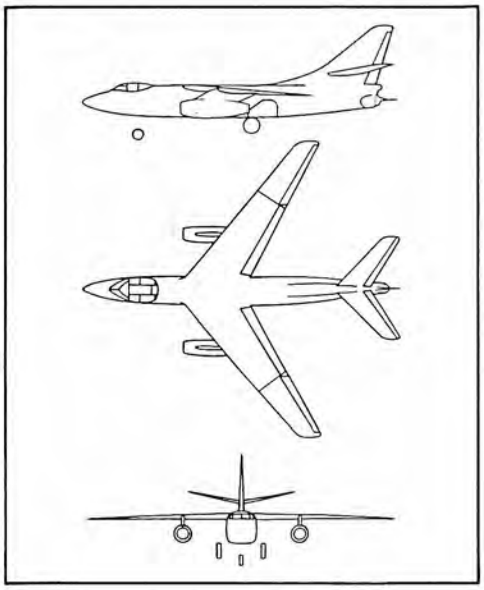
Maximum Speed 312 knots at Military Power at 286,000 lb. gr. wt. at 8700 ft.; Cruise Speed 284 knots at approximately 90 percent normal rated power at altitudes varying from 17,000 ft. at 280,000 lb. to 35,000 ft. at 130,000 lb.; Landing Speed 117 knots at 250,500 lb.; Rate of Climb 1280 fpm at S. L. MIL power, at 286,000 lb.; Service Ceiling 20,950 ft., at MIL power at 286,000 lb.; Absolute Ceiling 22,500 ft. at MIL power at 286,000 lb.; Range with Maximum Payload 1973 n. mi., 90,015 lb. cargo; Range with Maximum Fuel Load 3858 n. mi., 42,481 lb. cargo; Design Range 3500 n. mi., 51,200 lb. cargo.

DOUGLAS A3D-2 SKYWARRIOR ATTACK BOMBER

DOUGLAS AIRCRAFT CO., INC., Santa Monica, Calif.

REMARKS

The A3D-2 Skywarriors, which will be phased out of production in January, 1961, are now flying in carrier squadrons as the Navy's most potent single striking force. The twin-jet bomber, mightiest ever to operate from an aircraft carrier, first flew October 28, 1952. Rated in the 600-700 miles-per-hour class, the A3D flies long-range missions above 40,000 feet. Primarily designed to deliver nuclear weapons, it can also carry a huge variety of other armament on twelve bomb bay racks. An in-flight refueling system has been developed for installation at the squadron level to convert the bomber into a high-speed jet tanker. Permanent configurations of the Skywarrior include the A3D-2P, designed exclusively for photographic missions; the A3D-2Q, modified for electronic reconnaissance and countermeasures, and the A3D-2T, the Navy's first jet bomber-trainer. These configurations utilize the former bomb bay area to accommodate special equipment and additional personnel in a new pressurized cockpit and cabin. On March 21, 1957, a transcontinental speed record was broken when an A3D-1 completed a round trip from Los Angeles to New York and return in 9 hours 31 minutes 35.4 seconds (1 hour 46 minutes under the old record). Simultaneously, the east-to-west record was bettered. This was 5 hours 12 minutes 39.24 seconds, more than 11 minutes faster than the previous mark. (Both records were later topped.)

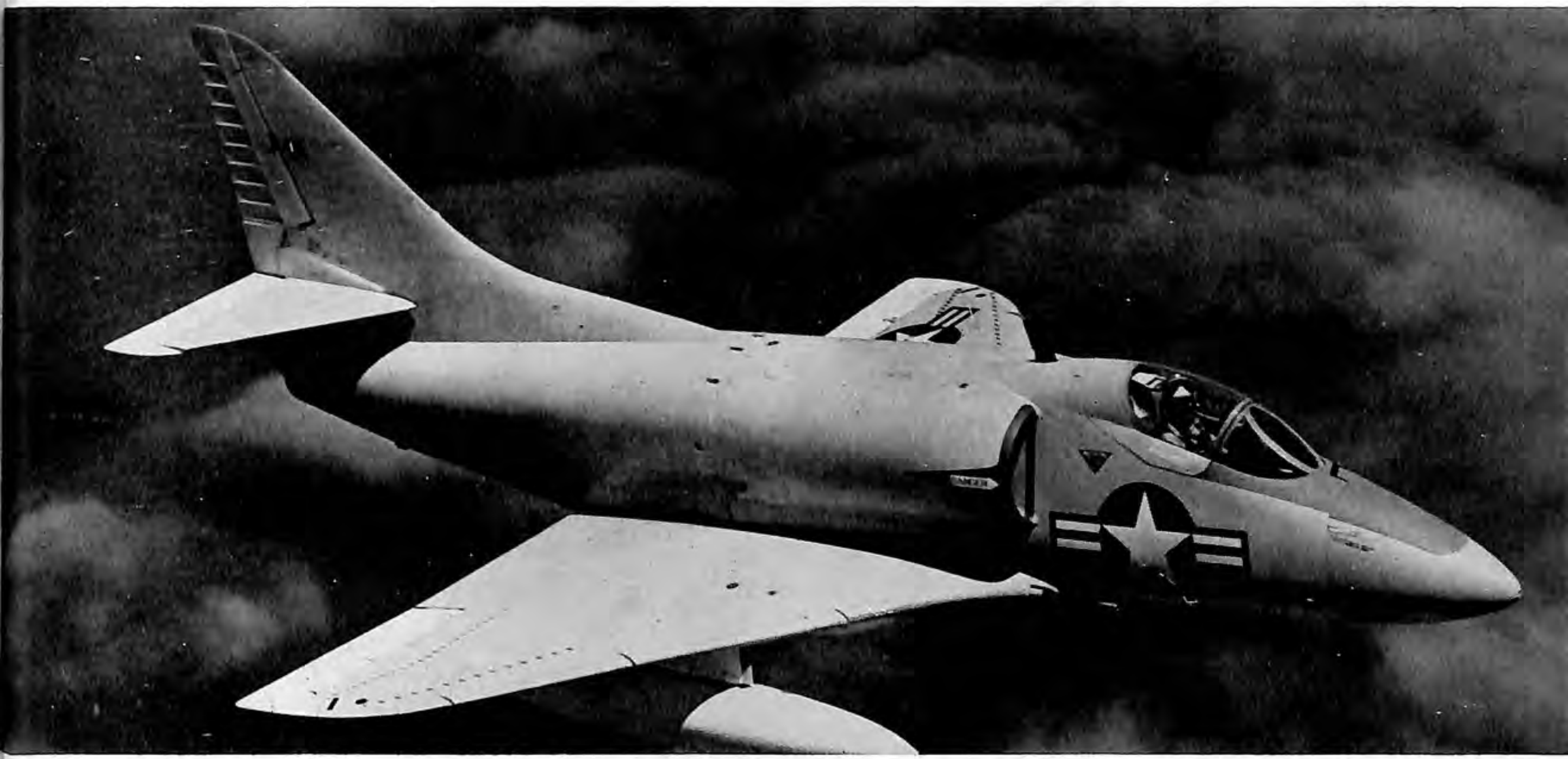


SPECIFICATIONS

Span 72 ft. 5 in.; Length 75 ft. 7 in.; Height 22 ft. 8 in.; Normal Gross Weight 70,000 lb.; Engines Two Pratt & Whitney J57s; Guns Two (auto. tail turret) 20 mm.; Crew Three (basic).

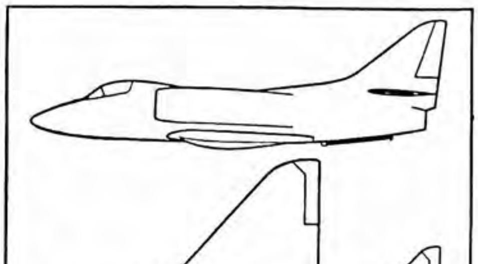
PERFORMANCE

Range more than 2500 n. mi. Other data classified.



DOUGLAS A4D-2 SKYHAWK ATTACK BOMBER

DOUGLAS AIRCRAFT CO., INC., Santa Monica, Calif.



REMARKS

The A4D Skyhawk was designed and built at the Douglas El Segundo Division. The first flight was made June 22, 1954, and fleet deliveries began in mid-1956, following carrier qualifications. The size of the A4D allows it to operate from carriers without folding wings, yet it is capable of carrying out long-range missions with nuclear weapons, missiles, bombs, rockets, guns, and other weapons. Skyhawks can be refueled from tanker aircraft and can also be converted into tankers themselves by carrying external fuel tanks on the wing and the Douglas In-Flight Fueling Store on the centerline rack. Operational with the Navy and Marine Corps are the A4D-1, A4D-2 and A4D-2N, equipped with advanced electronic instrumentation for all weather navigation and weapon delivery. The Navy has announced a newer version, the A4D-5, with an improved J-52 engine, will soon go into production at Douglas. Performance data on the new series of Skyhawks are classified.

SPECIFICATIONS

Span 27 ft. 5 in.; Length 39 ft. 4 in.; Height 15 ft.; Gross Weight 15,000 lb. Engine Wright J65; Guns Two 20 mm.; Bomb-rocket-missile capacity 5000 lb.

PERFORMANCE

Range Transcontinental; Speed 600-700 mph class; Climb comparable to fighters.

DOUGLAS MISSILEER

DOUGLAS AIRCRAFT CO., INC., Santa Monica, Calif.

REMARKS

A design contract for development of the Missileer, a launching aircraft for the Eagle long-range air-to-air guided missile, was awarded to Douglas Aircraft Company by the Bureau of Naval Weapons. The Missileer aircraft, a component of the Eagle-Missileer weapons system, will provide a more efficient launching aircraft with advantage of increased fire power, endurance and versatility. In this weapons system concept, long range and high performance are built into the missile rather than the aircraft.

SPECIFICATIONS

Engines Two TF30-T-2 Turbo Fan Pratt & Whitney. Other data classified.

DOWNER BELLANCA 260

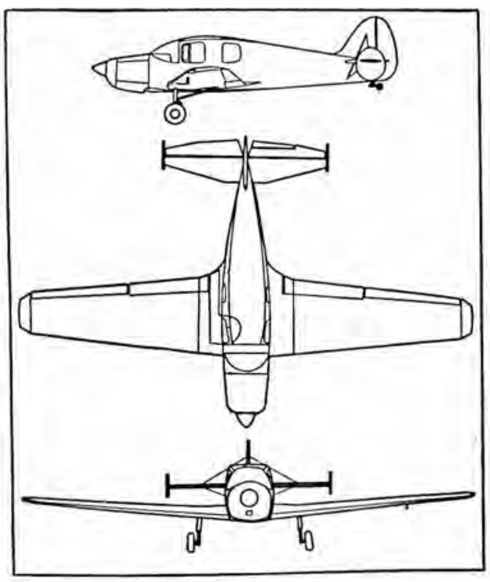
DOWNER AIRCRAFT INDUSTRIES, INC., Alexandria, Minnesota

REMARKS

The name of the company was changed from Northern Aircraft, Inc. to Downer Aircraft Industries, Inc., effective January 1, 1959. Production of the Bellanca 260 was begun March, 1950. First flight of the prototype was on November 16, 1958. FAA type certification was secured on February 20, 1959, and first production airplane was delivered March 6, 1959. Current production rate is three airplanes each week. The Bellanca 260 is the descendent of a long line of Bellanca airplanes dating back to 1918.

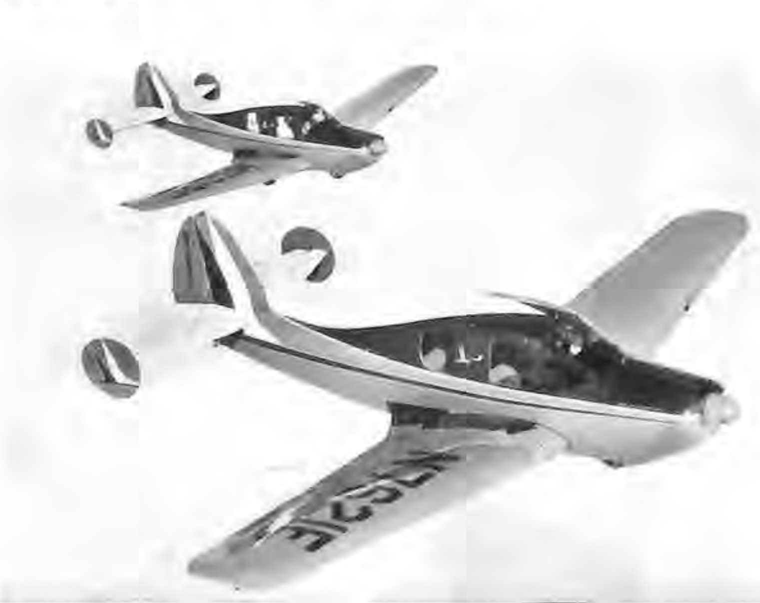
SPECIFICATIONS

Span 34 ft. 2 in.; Length 22 ft. 11 in.; Height 6 ft. 4 in.; Empty Weight 1690 lb.; Wing Loading 16.7 lb. per sq. ft.; Power Loading 10.4 lb. per bhp; Engine Continental IO-470-F, 260 hp normal rated, or 260 hp at 2625 rpm takeoff; Fuel Capacity 60 gal.; Propeller McCauley, Model B2A36C31/90M-8; or Hartzell Model HC-A2XF-1/8433-4; Wing Area 161.5 sq. ft.; Aileron Area 11.77 sq. ft.; Flap Area 16.16 sq. ft.; Tip Fin Area 4.4 sq. ft. total for two; Fin Area 5.67 sq. ft.; Rudder Area 6.28 sq. ft.; Stabilizer Area 17.21 sq. ft.; Elevator Area 12.20 sq. ft.



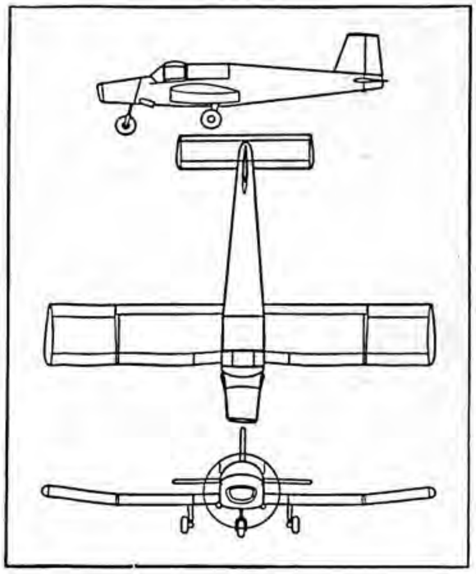
PERFORMANCE

Maximum Speed 208 mph at 260 (100%) hp at 2625 rpm at 9200 ft.; Cruise Speed 203 mph at 195 (75%) hp at 2450 rpm at 9200 ft.; Landing Speed 49 mph; Rate of Climb 1750 fpm at Sea Level; Service Ceiling 22,000 ft.; Absolute Ceiling 26,500 ft.; Range with Maximum Payload 880 mi.; Range with Maximum Fuel Load 880 mi.



FLETCHER FU-24 UTILITY

FLETCHER AVIATION CORP., El Monte, California



REMARKS

The Fletcher FU-24 Utility is designed to carry the pilot and four passengers or 1000 pounds of cargo and to accommodate a hopper, spreader, and other equipment required in dusting or fertilizing. The construction of this plane permits simple installation of special equipment to meet individual needs. Also used for hauling machinery and equipment, search and rescue work, transporting work crews and materials, or as a flying fire watcher.

SPECIFICATIONS

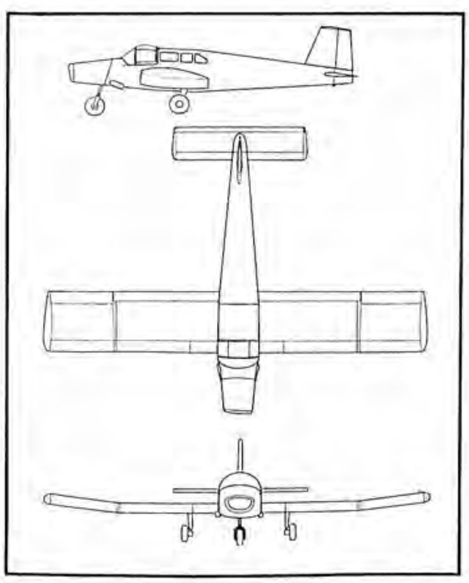
Span 42 ft.; Length 31 ft. 10 in.; Height 9 ft. 4 in.; Empty Weight 1890 lb.; Wing Loading 11.9 lb. per sq. ft.; Power Loading 15.5 lb. per bhp; Engine Continental O-470-N, 240 hp normal rates; Wing Area 294 sq. ft.

PERFORMANCE

Maximum Speed 141 mph at 260 hp at 2600 rpm at sea level; Cruise Speed 115 mph at 75 percent hp at sea level; Landing Speed 48 mph; Rate of Climb 745 fpm at sea level; Service Ceiling 14,700 ft.; Absolute Ceiling 17,000 ft.; Range with Maximum Payload 355 mi.

FLETCHER FU-24A

FLETCHER AVIATION CORP., El Monte, California



REMARKS

The FU-24A is a rugged six-place version of the FU-24, ideally suited for orientation flights, search and rescue, cargo hauling and agricultural flying.

SPECIFICATIONS

Span 42 ft.; Length 31 ft. 10 in.; Height 9 ft. 4 in.; Empty Weight 2000 lb.; Wing Loading 11.9 lb. per sq. ft.; Power Loading 15.5 lb. per bhp; Engine Continental O-470-N, 240 hp normal rated, or 240 hp at 2600 rpm takeoff; Fuel Capacity 48 gal.; Propeller Constant Speed Metal; Wing Area 294 sq. ft.; Aileron Area 20 sq. ft.; Flap Area 34 sq. ft.; Fin Area 13.6 sq. ft.; Rudder Area 6.9 sq. ft.; All Moveable Tail 48 sq. ft.

PERFORMANCE

Maximum Speed 141 mph at 260 hp at 2600 rpm at sea level; Cruise Speed 115 mph at 75 percent hp at sea level; Landing Speed 48 mph; Rate of Climb 745 fpm at S. L. ft.; Service Ceiling 14,700 ft.; Absolute Ceiling 17,000 ft.; Range with Maximum Payload 355 mi.

GOODYEAR ZPG-2W

GOODYEAR AIRCRAFT CORP., Akron 15, Ohio

REMARKS

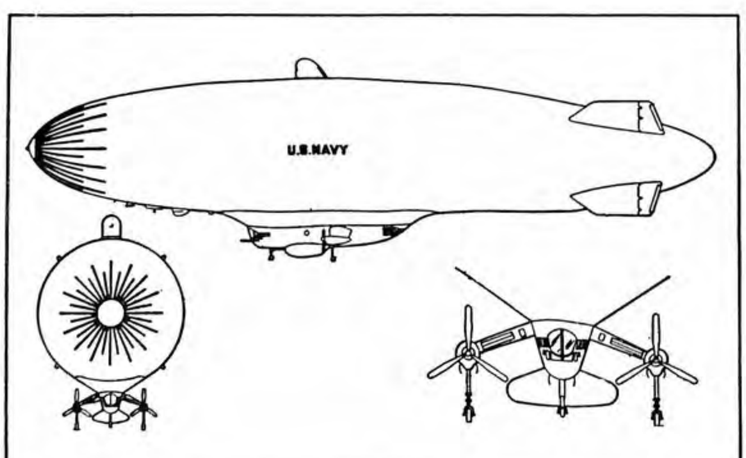
In early 1955, the Goodyear Aircraft-built Navy ZPG-2W was flown for the first time. The ship, a modified version of existing Goodyear ZPG-2 airships designed for antisubmarine warfare service, incorporates electronic features designed specifically for aircraft early warning missions. The blimp's most unusual visible feature is a radome mounted on top of the envelope. This bubble houses special electronic devices for aircraft detection.

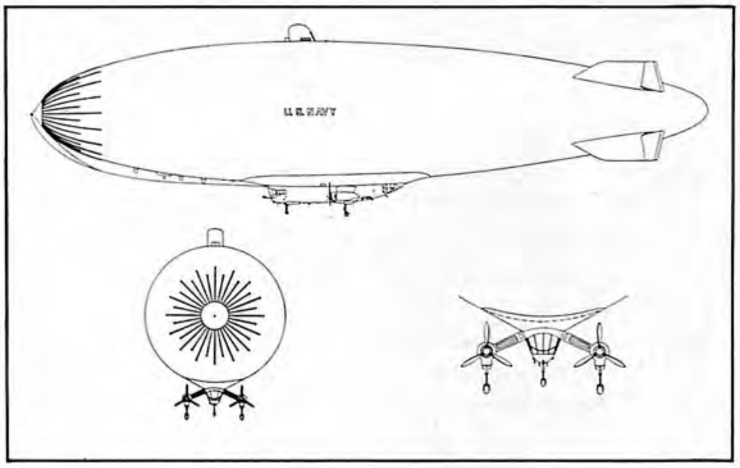
SPECIFICATIONS

Width 75 ft.; Length 343 ft.; Height 107 ft.; Weight Empty 47,800 lbs.; Engines Two Wright R1300, 700 hp normal rated, or 800 hp at 2600 rpm @ takeoff; Fuel Capacity 2025 gal. without auxiliary tanks; Propeller Curtiss Electric; Envelope Volume approx. 1,000,000 cu. ft.; Fin Area (Four) 2080 total sq. ft.; Ruddevator Area (Four) 952 sq. ft.

PERFORMANCE

Maximum Speed 70 knots; Cruise Speed 50 knots; Rate of Climb 2160 fpm at Sea Level to pressure height.





GOODYEAR ZPG-3W

GOODYEAR AIRCRAFT CORP., Akron 15, Ohio

REMARKS

First of a new and larger class of non-rigid airships built for Navy use in Airborne Early Warning (AEW) picket patrol as part of the North American Air Defense Command operation, the Goodyear ZPG-3W was flown for the first time on July 21, 1958. Delivery of the first ZPG-3W to the Navy was made June 19, 1959. The company has completed construction of four of the blimps. Equipped with latest electronic detection devices, the airship's huge envelope serves as a natural "radome" for a gigantic, internally-mounted radar antenna. Goodyear ZPG-3W is the largest non-rigid airship ever built.

SPECIFICATIONS

Width 85 ft.; Length 403 ft.; Height 118 ft.; Weight Empty 72,000 lbs.; Engines Two Wright R1820-88, 1275 hp at 2500 rpm normal rated, or 1525 hp at 2800 rpm takeoff; Propeller Curtiss Electric; Envelope Volume around 1,500,000 cu. ft.; Fin Area (Four) 2612 total sq. ft.; Ruddevator Area (Four), including tabs, 970 sq. ft.

PERFORMANCE

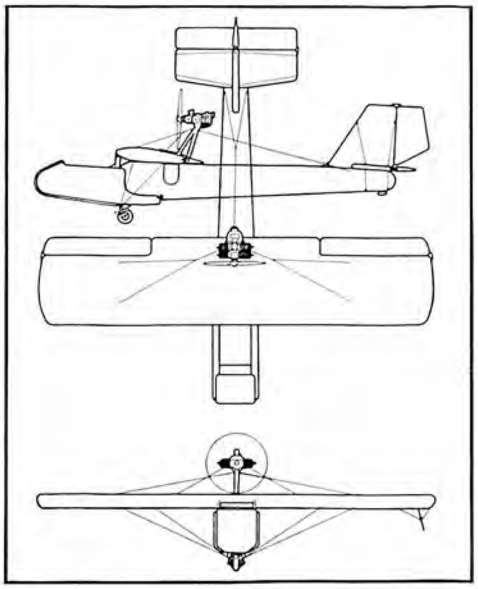
Cruise Speed 30-60 knots; Rate of Climb 2400 fpm at Sea Level.

GOODYEAR GA-468 INFLATOPLANE

GOODYEAR AIRCRAFT CORP., Akron 15, Ohio

REMARKS

The Inflatoplane was born of a need for special-purpose aircraft that are light in weight, have excellent packaging characteristics, are easily transported, and have a rapid package-to-flight time. Its debut confirms the first practical applications of fabric components to heavier-than-air craft. Because of the inherent buoyancy features of the structural material Airmat, the Inflatoplane equipped with a hydroski can also operate from small lakes and streams with equal facility. Internal air pressures are maintained constant through all altitudes and temperature changes by a continuously driven engine-mounted compressor. Both one and two-place configurations have been produced and delivered to the Office of Naval Research for Field Evaluation by the Navy and the Army.

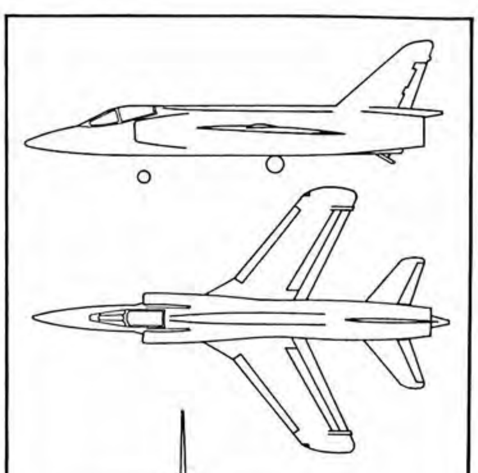


SPECIFICATIONS

Span 22 ft.; Length 19.7 ft.; Height 6.9 ft.; Package Size 3 ft.-by 3 ft.-by 3.5 ft.; Inflation Pressure 7 psi; Empty Weight 225 lb.; Gross Weight 550 lb.; Wing Loading 5 lb. per sq. ft.; Engine Nelson H-63 42 hp; Fuel Capacity 20 gal.; Propeller U. S. fixed pitch; Wing Area 110 sq. ft.; Landing Gear Unicycle or Hydroski.

PERFORMANCE

Package to Flight Time 5 minutes; Maximum Speed 72 mph; Cruise Speed 60 mph; Landing Speed 40 mph; Rate of Climb 550 fpm; Clear 50 ft. Obstacle 450 ft.; Service Ceiling 10,300; Absolute Ceiling 13,000; Takeoff Distance, sod, 250; Takeoff Distance, water, 300; Endurance 6½ hours.



GRUMMAN F11F-1 TIGER

GRUMMAN AIRCRAFT ENGINEERING CORP., Bethpage, Long Island, New York

REMARKS

Coupled with its extreme speed and altitude capabilities, the Super Tiger, designed primarily as a carrier-based aircraft, has excellent short-field and short-approach performance and can operate out of small unimproved land bases as well as from the most modern airstrips. The aircraft is both fighter-bomber and interceptor. It flew to an altitude of 76,828 feet (over 14½ miles) in April, 1958.

The Super Tiger, a modification of Grumman's F11F-1 Tiger, a jet fighter now in service with the Navy, is one of the smallest high performance aircraft built today. Overall length measures under 50 feet. General Electric's J79 engine gives the airplane a basic thrust of approximately 15,000 pounds (with afterburner) placing the Super Tiger in a Mach-2 category. Like its predecessor, the F11F-1, the Super Tiger features an area-ruled or "coke-bottle" fuselage.

SPECIFICATIONS

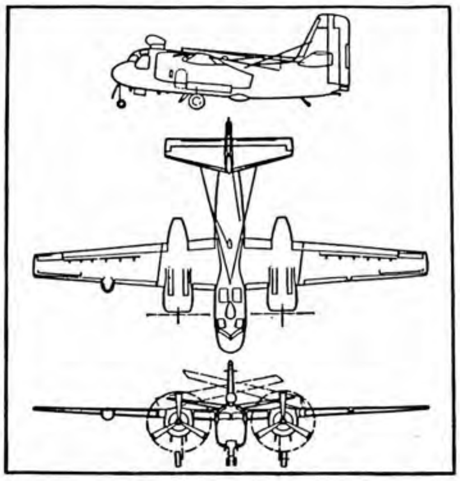
Span 31 ft. 7.5 in.; Length 47 ft. 9 in.; Height 14 ft. 5 in.; Engines J79-GE-7, over 15,000 lb. thrust; Wing Area 250 sq. ft.

PERFORMANCE

All data are classified.

GRUMMAN S2F-3 TRACKER

GRUMMAN AIRCRAFT ENGINEERING CORP., Bethpage, Long Island, New York



REMARKS

Already delivered to the U. S. Navy, the S2F-3 Tracker is a later version of the S2F-1, still in general use as the main carrier-based, anti-submarine warfare aircraft of U. S. Navy fleet units. The "dash 3" will eventually replace the S2F-1. The new Tracker has basically the same air frame as the S2F-1 but carries greatly improved search and detection equipment. The Tracker performs both the "hunter" and "killer" mission for fleet units.

SPECIFICATIONS

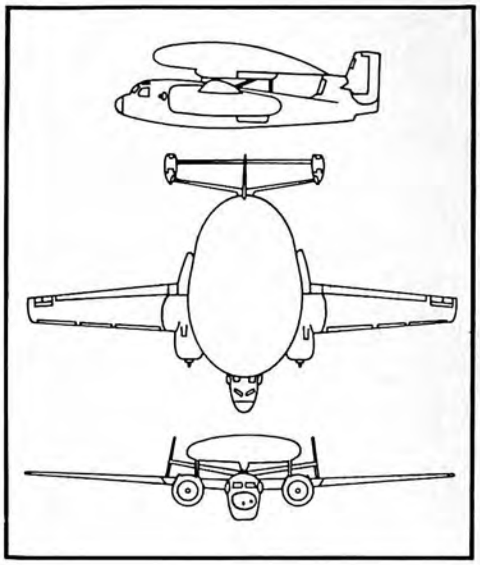
Span 69 ft. 8 in.; Length 42 ft. 3 in.; Height 16 ft. 3 in.; Engines Two Wright R1820-82, 1525 hp takeoff.

PERFORMANCE

All data are classified.

GRUMMAN WF-2 TRACER EARLY WARNING AIRCRAFT

GRUMMAN AIRCRAFT ENGINEERING CORP., Bethpage, Long Island, New York



REMARKS

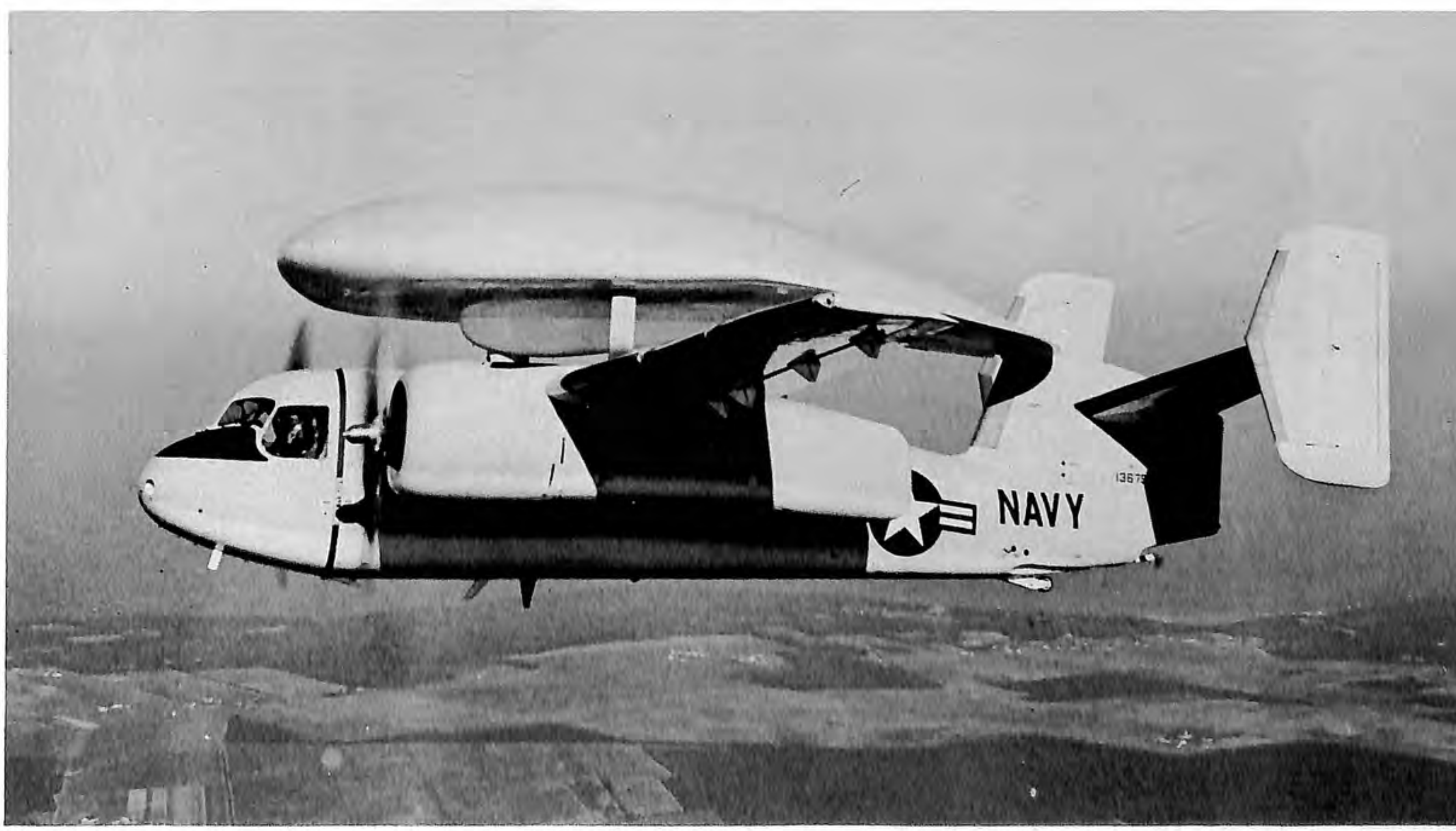
The "saucer-topped" WF-2 Tracer, designed to fill one of the Navy's most important roles in the national defense picture by providing early warning to fleet units of impending attacks by enemy air and sea forces, is a modification of Grumman's S2F Tracker and TF-1 Trader, the three airplanes having basically the same airframe structure. The airplane's huge radome, largest yet designed for a carrier-based aircraft, houses long-range detection equipment. As a direct descendent of the TF-1 Trader, major modification—beyond the attachment of the radome—was required in the design of the Tracer's tail assembly. A dual-fin arrangement was decided on to reduce possible radome wake effects on vertical surfaces. In addition, wing fold assembly was changed from more conventional vertical or overhead folding to a "sto-wing" system similar to that used on Grumman's famous World War II Avenger.

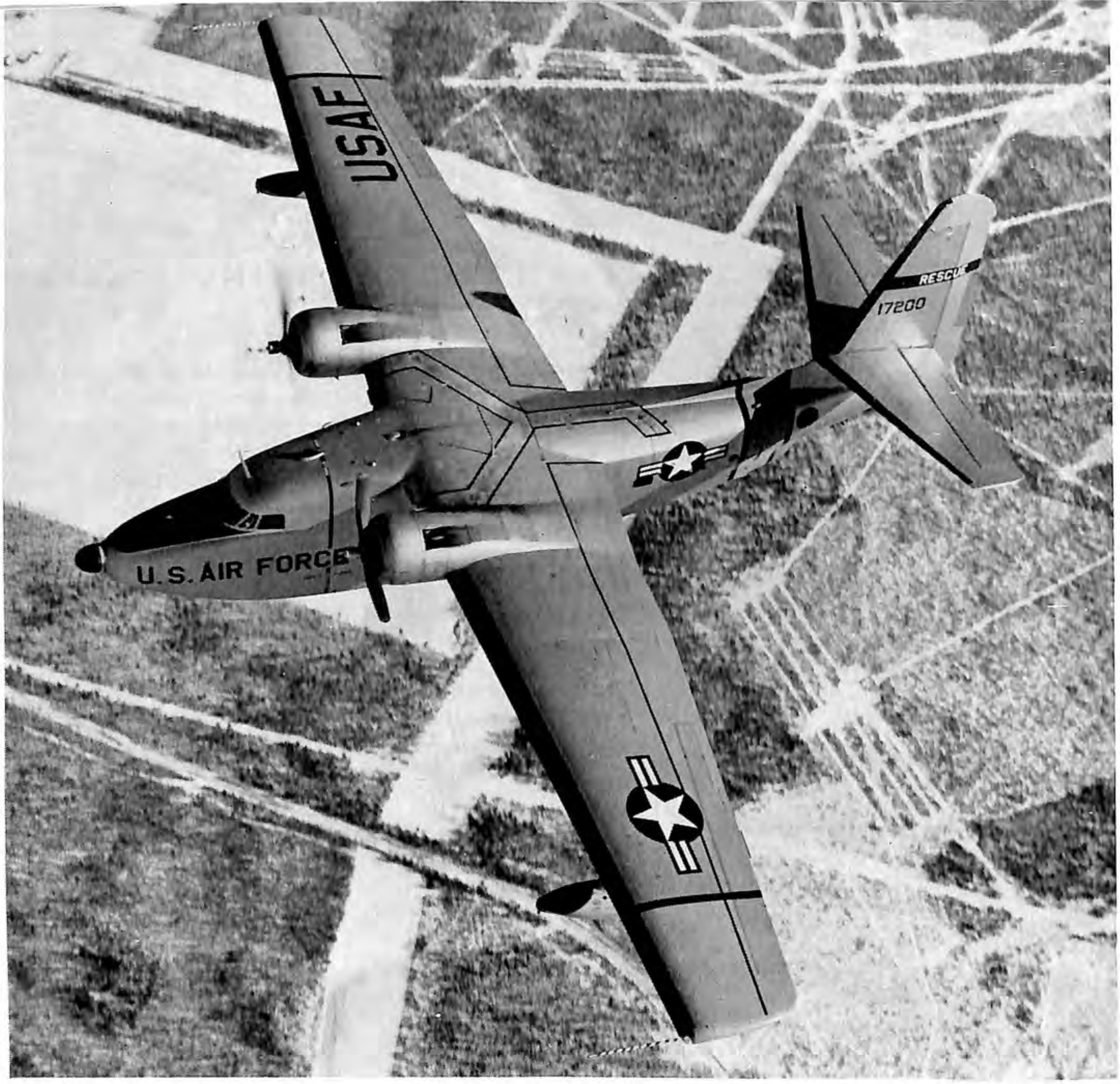
SPECIFICATIONS

All data are classified.

PERFORMANCE

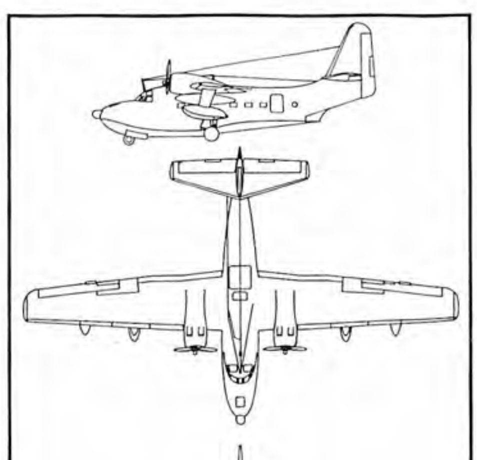
All data are classified.





GRUMMAN SA-16B ALBATROSS

GRUMMAN AIRCRAFT ENGINEERING CORP., Bethpage, Long Island, New York



REMARKS

The Albatross, Grumman's largest amphibian, is used by the Air Force, Navy, and Coast Guard as a general utility aircraft capable of performing as a hospital plane or for air-sea rescue, cargo, transport or photographic duty. On active service with every Air Force Rescue Squadron throughout the world. Crew: 6. The SA-16B, a long-range, faster version (pictured), has a greater wingspan and larger horizontal and vertical surfaces than the SA-1A, and is being integrated into Air Force, Coast Guard and Navy service.

SPECIFICATIONS

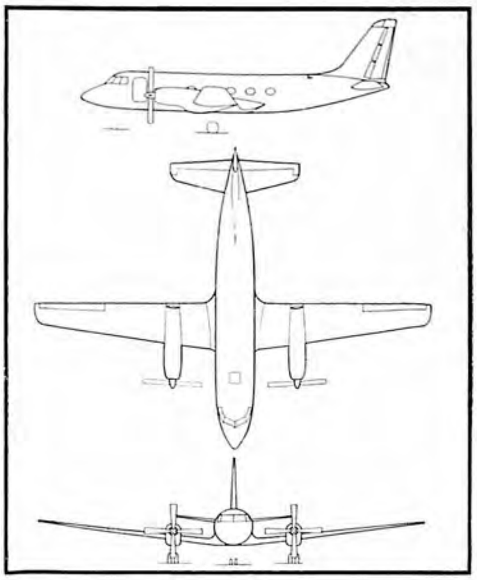
Span 96 ft. 8 in.; Length 61 ft. 4 in.; Height 25 ft. 10 in.; Engines Two Wright R-1820-76, 1425 hp takeoff.

PERFORMANCE

Maximum Speed Military Power-Sea Level 236 mph; Cruise Speed Normal 207 mph.

GRUMMAN GULFSTREAM EXECUTIVE TRANSPORT

GRUMMAN AIRCRAFT ENGINEERING CORP., Bethpage, Long Island, New York



REMARKS

The Gulfstream marks Grumman's return to the commercial aviation market it abandoned at the outset of the Korean conflict. A propjet designed specifically for executive operation, it carries from ten to nineteen passengers (the latter a high-density version), the Gulfstream can operate from runways under 4000 feet long and has a range of 2200 miles, plus a reserve of 200 miles and 45 minutes fuel. Both number one and number two production models have undergone tests to obtain certification under CAR category 4b and SR422A regulation. The first airplane was delivered June 23, 1959.

SPECIFICATIONS

Span 78 ft. 6 in.; Length 64 ft.; Height 22 ft. 9 in.; Engines Two Rolls-Royce Dart RDa 7/2 propjets, 2190 eshp at 15,000 rpm takeoff; Fuel capacity 1540 gal.; Propeller Rotol.

PERFORMANCE

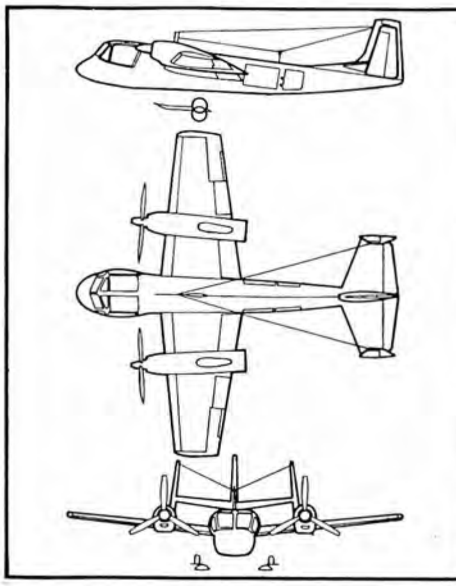
Maximum Speed 350 mph at 14,400 rpm at 30,000 ft.; Cruise Speed 340 mph at 14,000 rpm at 25,000 ft.; Service Ceiling 36,000 ft.; Range with Maximum Payload of 4880 lb. 1310 mi.; Range with Maximum Fuel Load 2200 mi.

GRUMMAN MOHAWK

GRUMMAN AIRCRAFT ENGINEERING CORP., Bethpage, Long Island, New York

REMARKS

Designed to operate from small unimproved fields, the Mohawk will be used by the Army for purposes of tactical observation; its "bug-eye" canopy offering exceptional visibility to its two-man crew. Featuring a 55-knot stall speed and relatively the same short takeoff and landing capabilities as the Army's present light-weight, single-engine airplanes, the Mohawk will be able to virtually "live" with the Army in the field.



SPECIFICATIONS

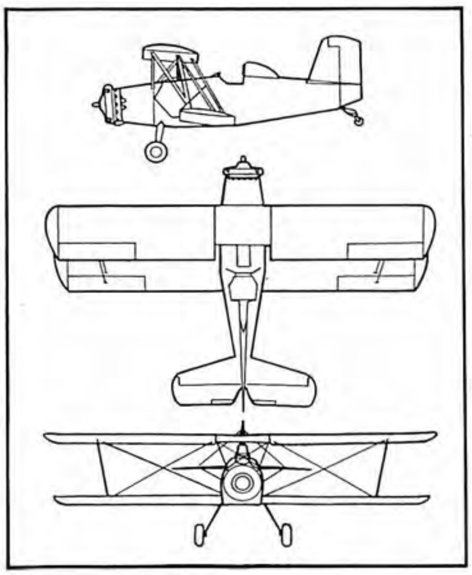
Span 42 ft.; Length 41 ft.; Height 12 ft. 8 in.; Wing Loading 35 lb. per sq. ft.; Power Loading 6 lb. per shp; Engines Two Lycoming T-53-L-3s, 865 eshp normal rated, or 1005 eshp at 1678 (prop) rpm takeoff; Fuel Capacity 292 gal.; Propeller Ham. Std. 53C51; Wing Area 330 sq. ft.; Aileron Area 22.7 (total) sq. ft.; Flap Area 43.6 (total) sq. ft.; Fin Area 12.0 (outb'd), 17.8 (center) sq. ft.; Rudder Area 9.5 ea. (outb'd), 8.0 (center) sq. ft.; Stabilizer Area 66 sq. ft.; Elevator Area 19.0 (total) sq. ft.

PERFORMANCE

Maximum Speed 325 mph at 1484 (total) shp at 1672 (prop) rpm at 13,000 ft.; Cruise Speed 207 mph at 670 (total) shp at 1320 (prop) rpm at 5000 ft.; Landing Speed 76 mph; Rate of Climb 2950 fpm at S. L.; Service Ceiling 33,000 ft.; Absolute Ceiling 33,500 ft.; Range with Maximum Payload 774 mi.; Range with Maximum Fuel Load 1557 mi.

GRUMMAN AG-CAT

GRUMMAN AIRCRAFT ENGINEERING CORP., Bethpage, Long Island, New York



REMARKS

The Ag-Cat was designed as a biplane to provide a maximum wing area, or lift-surface, with minimum wing span, a combination which permits making a continuous 1.5 "G"-turn at dusting speed and at maximum gross weight. Upper and lower wings are interchangeable. Each is torsionally stiffened with a minimum of external wires, a factor which greatly reduces rigging time.

All performance figures shown above, are for a maximum certificated weight of 3700 pounds. Slight differences exist depending on external equipment, i.e., whether equipped as a duster or sprayer.

Both the airspeed indicator and the engine tachometer have been placed on a separate panel forward of the cockpit in the pilot's flying line of vision, recognition having been given the fact that during dusting or spraying operations pilots have little time to look inside the cockpit. Other features of the Ag-Cat include maintenance-free, spring-steel landing gear, instant changeability from duster to sprayer, corrosion-proofed metal surfaces, interchangeability of all four ailerons, and a "sloping" nose which affords excellent visibility in normal flight attitude.

SPECIFICATIONS

Span 35 ft. 8 in.; Length 24 ft. 6 in.; Height 10 ft. 9 in.; Empty Weight 2127 lb.; Wing Loading 11.3 lb. per sq. ft.; Power Loading 16.8 lb. per bhp; Engines Continental 220, Radial, 220 hp normal rated, or 220 hp at 2075 rpm takeoff; Fuel Capacity 34 gal.; Propeller McCauley; Wing Area 326 sq. ft.; Aileron Area 31.5 sq. ft.; Fin Area 9.0 sq. ft.; Rudder Area 12.0 sq. ft.; Stabilizer Area 22.8 sq. ft.; Elevator Area 22.2 sq. ft.

PERFORMANCE

Maximum Speed 114 mph at 220 hp at 2075 rpm at Sea Level; Cruise Speed 80 mph at 1800 rpm at 2500 ft.; Landing Speed 61 mph; Rate of Climb 490 fpm at Sea Level; Range with Maximum Payload 205 mi.; Range with Maximum Fuel Load 240 mi.; Design Agricultural Load 1200 lb.

GRUMMAN W2F-1 HAWKEYE

GRUMMAN AIRCRAFT ENGINEERING CORP., Bethpage, Long Island, New York

REMARKS: W2F-1 HAWKEYE

Hawkeye's greatly improved radar, computers, and high speed data relay system provide the U. S. Navy with an unprecedented early-warning-of-attack and intercept-control capability. The coordinated effort of Hawkeye's crew of five and this speedy information collection, evaluation, and relaying equipment is called ATDS (Airborne Tactical Data System). The nerve center of this vertible flying brain, the system provides fleet headquarters with the lead time necessary for offensive action in nullifying high mach number attacking aircraft. Powered by two Allison T-56 A8 turbo-prop engines, Hawkeye will be able to remain airborne for prolonged periods.

SPECIFICATIONS

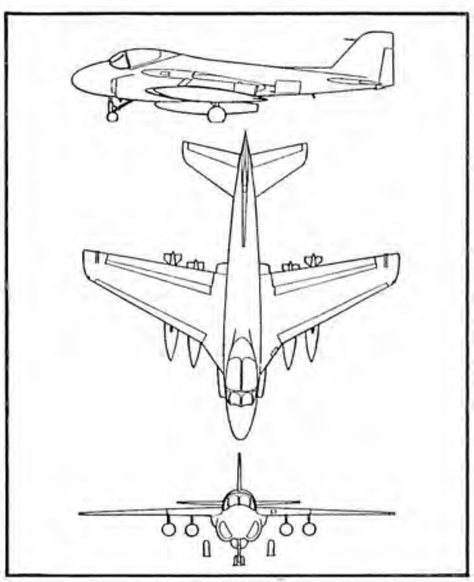
Span 80 ft. 7 in.; Length 56 ft. 4 in.; Height 16 ft. (to top of radome); Engines Allison T56-A8, 4050 hp normal rated.

APPLICATIONS

Early warning of attack and intercept control aircraft.

GRUMMAN A2F-1 INTRUDER

GRUMMAN AIRCRAFT ENGINEERING CORP., Bethpage, Long Island, New York



REMARKS: A2F-1 INTRUDER

Versatility of mission was the aim of Grumman designers of the A2F-1 Intruder, the Navy's first low altitude jet-powered attack aircraft. Truly an all-weather aircraft, the Intruder can fly long distances to deliver its nuclear punch or provide close support for tactical ground troops with conventional weapons. The aircraft can carry the broadest spectrum of current or programmed missiles. Key to the two-place, carrier-based aircraft's versatility is the aircraft's "integrated display system." Regardless of obscuring weather or darkness of night, this system enables cockpit occupants to "see" targets or the environment surrounding the aircraft by means of visual displays presented on viewing screens.

SPECIFICATIONS

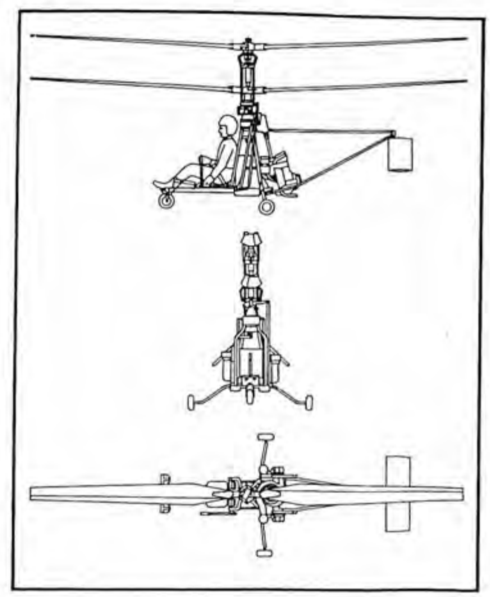
Wing span 53 ft.; Length 53 ft. 3 in.; Height 15 ft. 1 in. (to tip of tail); Engines two J-52-P6 Pratt & Whitney, rated at 8,500 lbs. of thrust each.

PERFORMANCE

All data are classified.

GYRODYNE YRON-1 ROTORCYCLE

GYRODYNE COMPANY OF AMERICA, INC., St. James, Long Island, New York



REMARKS

The YRON-1 is a one-man carrying rotary wing aircraft being evaluated by the Marines for the many tactical uses of which it is capable: liaison, reconnaissance, aerial photography, mine detection, wire laying, resupply and other combat tasks. This helicopter, fully loaded with pilot and fuel, weighs about 700 pounds and has an endurance of over one hour. The Rotorcycle incorporates the coaxial type of rotor system developed and perfected by Gyrodyne. This type of rotor system gives the vehicle outstanding flying qualities and reduces pilot check-out time because of the simplicity of the pilot's task. The Gyrodyne Company has initiated discussions with the Federal Aviation Agency regarding certification of the Rotorcycle for commercial use. Because of the priority of military requirements, however, it is not expected that the commercial version will be available until late 1961.

SPECIFICATIONS

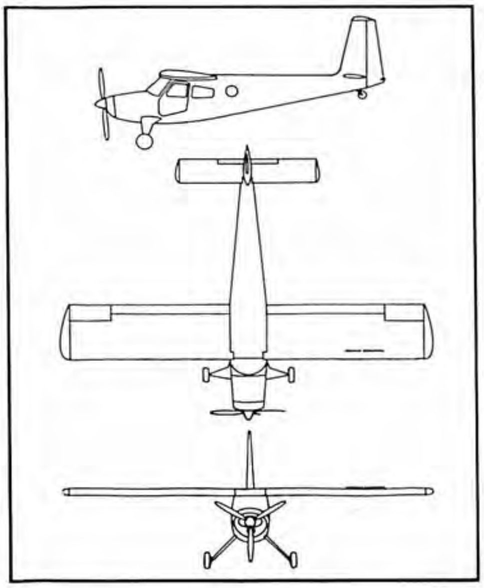
Span 2 ft. 10 in.; Length 11 ft. 5 in.; Height 8 ft.; Empty Weight 430 lb.; Rotor Diameter 17 ft.; Disc Loading 3.03 lb. per sq. ft.; Power Loading 11.1 lb. per bhp; Engine Porsche Type 702/1, 55 hp normal rated, or 62 hp at 4000 rpm takeoff; Fuel Capacity 5 gal.; Disc Area 227 sq. ft.; Stabilizer Area 2.52 sq. ft.

PERFORMANCE

Maximum Speed 68 mph at 55 hp at 4000 engine rpm at Sea Level; Cruise Speed 52 mph at 44 hp at 4000 engine rpm at Sea Level; Rate of Climb 500 vertical fpm at Sea Level; Service Ceiling 6500 ft.; Range with Maximum Payload 60 mi.; Range with Maximum Fuel Load 180 mi.

HELIO H-395 SUPER COURIER

HELIO AIRCRAFT CORP., Norwood, Massachusetts



REMARKS

This five-place model H-395 Super Courier is a fast long-range efficient load-carrying STOL-type plane. It combines a high 170 mile-per-hour cruising speed and long-range economy with stall-proof 30 mile-per-hour slow flight and ultra short field utility (i.e., it is capable of taking off and landing over a 50-foot barrier in less than 500 feet with zero wind). It is a high-wing, full cantilever, all metal monoplane with a special heavy-duty landing gear; single piece, all-flying horizontal "stabilizers;" automatic, full-span leading edge slats; slot airflow "interceptors."

SPECIFICATIONS

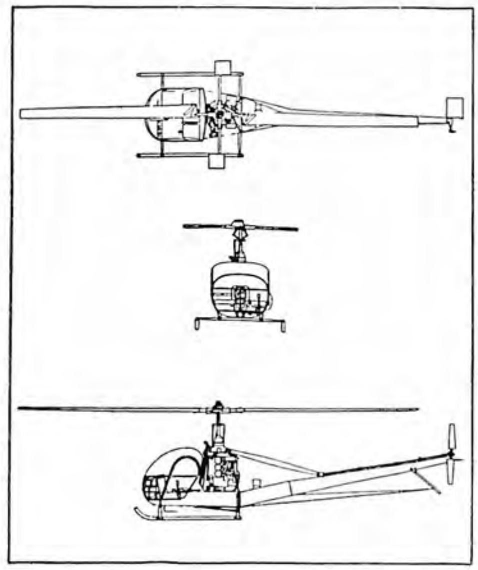
Length 31 ft.; Height 8 ft. 10 in.; Span 39 ft.; Wing Area 231 sq. ft.; Empty weight 2012 lb.; STOL (Gross Weight 3,000 lb.) (CAR, Part 3); Max. Industrial Gross Weight (CAR. Part 8), 3920 lb.; Engine 6-cycle 295 hp Lycoming GO-480 swinging a 3-bladed 96 in. diameter Hartzell propeller; Fuel Capacity 60 gal., standard; 120 gal., special.

PERFORMANCE

Maximum Speed 176 mph at Sea Level; Cruise Speed 170 mph at 8200 ft.; Speed 30 mph; Rate of Climb 1550 fpm; Service Ceiling 21,500 ft.; Maximum Range with standard 60-gal. tanks (10,000 ft. 146 mph) 842; mi; Takeoff Run 217 ft. in zero wind, 130 ft. with 10 mph wind; Takeoff Distance over 50-ft. barrier 475 ft. in zero wind, 331 ft. in 10 mph wind; Landing Roll (40° flap) 169 ft. in zero wind; Landing Distance over 50-ft. barrier (40° flap) 493 ft. in zero wind.

HILLER H-23D RAVEN

HILLER AIRCRAFT CORP., Palo Alto, California



REMARKS

The H-23D is a three-place, light observation helicopter. Major features of extended overhaul life and reduced maintenance of the H-23D Raven compared with previous models provide greatly reduced operating costs and logistics support. It has high flight and landing load safety factors. Its Lycoming VO-435 engine provides 250 horsepower, which is a 50 horsepower increase over previous models.

SPECIFICATIONS

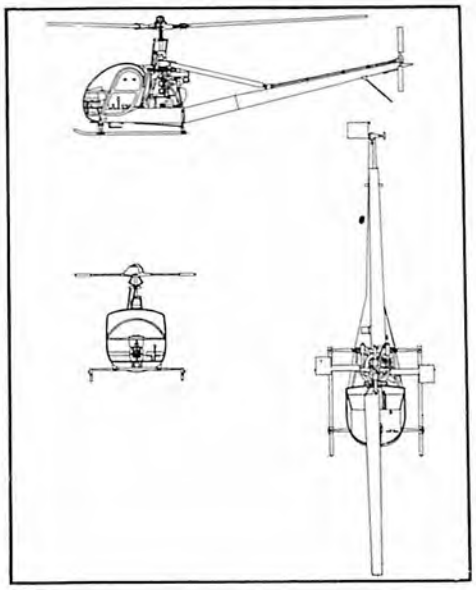
Main Rotor Diameter 35.4 ft.; Anti-torque Rotor Diameter 5 ft. 5 in.; Length 27 ft. 8 in.; Height 9 ft. 8 in.; Empty Weight 1816 lb.; Power Loading 10.8 lb. per bhp; Engine One Lycoming VO-435-23B, 250 hp at 3200 rpm takeoff; Fuel Capacity 46 gal.

PERFORMANCE

Maximum Speed 95 mph at Sea Level; Cruise Speed 82 mph at Sea Level; Rate of Climb 1050 fpm at Sea Level; Service Ceiling 13,200 ft.; Absolute Ceiling 14,000 ft.; Range with Maximum Payload 197 mi.

HILLER 12E

HILLER AIRCRAFT CORP., Palo Alto, California



REMARKS

The three-place Hiller 12E model utilizes the basic airframe of the Army H-23D, and incorporates in it 55 additional horsepower. This record power in a light utility helicopter yields such performance figures as 1500 feet per minute maximum rate of climb and a hover ceiling in ground effect four times higher than previous models. Useful load of the 12E is 1050 pounds at normal gross weight. The 12E for 1961 is delivered with a dual carburetor power pack adding 18 horsepower. Standard high compression pistons boost total power available to 340 horsepower. A number of other improvements have been incorporated in the 12E/61 to increase its operating capability.

SPECIFICATIONS

Main Rotor Diameter 35.4 ft.; Anti-torque Rotor Diameter 5 ft. 5 in.; Length 27 ft. 8 in.; Height 9 ft. 8 in.; Empty Weight 1700 lb.; Power Loading 9.02 lb. per bhp; Engine One Lycoming VO-540-A1A, 305 hp at 3200 rpm takeoff; Fuel Capacity 46 gal.

PERFORMANCE

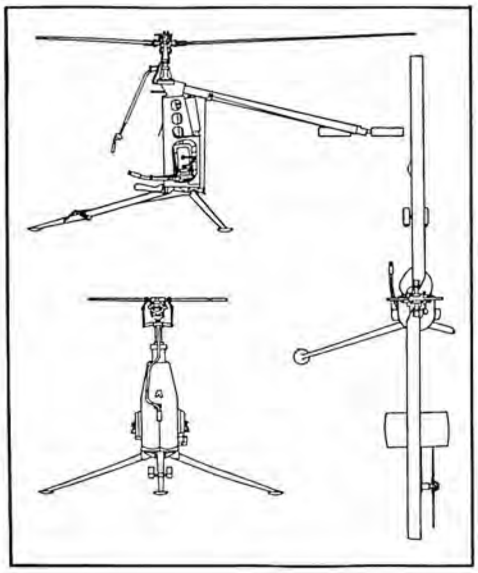
Maximum Speed 95 mph at Sea Level; Cruise Speed 87 mph at Sea Level; Rate of Climb 1500 fpm; Hover Ceiling 10,200 ft.; Service Ceiling 15,500 ft.; Absolute Ceiling 16,200 ft.; Range with Maximum Payload 185 mi; Range with Maximum Fuel Load 400 mi.

HILLER YROE-1 ROTORCYCLE

HILLER AIRCRAFT CORP., Palo Alto, California

REMARKS

Having completed many months of successful prototype demonstration flying in the United States and abroad, Hiller entered into a sub-license agreement with Saunders-Roe, Ltd., of England for the production of an evaluation quantity of ten YROE-1 Rotorcycles. Production was completed late in year and five units were delivered to the Marine Corps for field tests. The remaining five were made available for U. S. and European demonstrations. The YROE-1 is a completely foldable helicopter. One man can assemble and fly the Rotorcycle in less than ten minutes. For ease of flight, the Hiller Rotormatic Control System was incorporated and made adjustable for sensitive or sluggish control reactions depending upon operational needs.

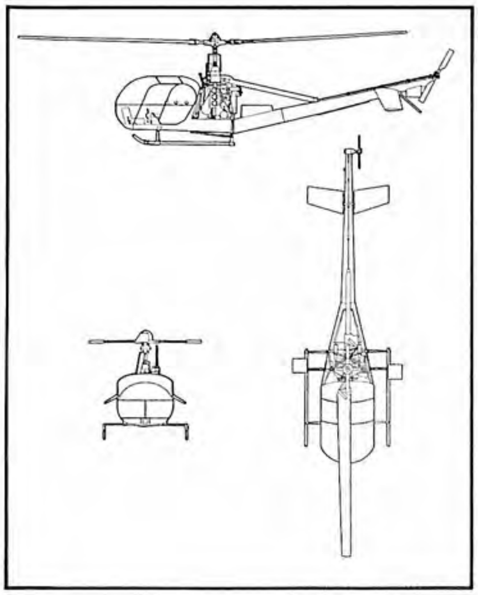


SPECIFICATIONS

Main Rotor Diameter 18 ft. 6 in.; Anti-torque Rotor Diametetr 36 in.; Length 11 ft. 8 in.; Height 7 ft.; Empty Weight 300 lb.; Power Loading 12.4 lb. per bhp; Engine One Nelson H63B, 45 hp at 4000 rpm takeoff; Fuel Capacity 2½ (standard) gal.

PERFORMANCE

Maximum Speed 70 mph at Sea Level; Cruise Speed 52 mph at Sea Level; Rate of Climb 1160 fpm at Sea Level; Service Ceiling 13,200 ft.; Absolute Ceiling 14,000 ft.; Range with Maximum Payload 37 mi.; Range with Maximum Fuel Load 166 mi.



HILLER E4 STATION WAGON

HILLER AIRCRAFT CORP., Palo Alto, California

REMARKS

The Hiller E4 is a four-place helicopter using the station wagon approach—personnel carrier or flying pickup truck. The E4 uses the same basic airframe and powerplant as the famous 12E, plus upgraded horsepower gained by dual carburetors and, as kit installation, high compression pistons. Special accessories designed for the aircraft include power-lock cargo hook and power hoist, cabin heater and defroster, soundproofing, and a wide range of accessories for passenger comfort and increased contract utilization.

SPECIFICATIONS

Main Rotor Diameter 35.4 ft.; Anti-torque Rotor Diameter 5 ft. 5 in.; Length 29.8 ft.; Height 9.8 ft.; Empty Weight 1777 lb.; Power Loading 9.02 bhp; Engine One Lycoming VO-540-A1A, 305 hp at 3200 rpm takeoff; Fuel Capacity 46 gal.

PERFORMANCE

Standard E4 performance figures: 820 fpm Vertical Rate of Climb, cruising at 90 mph, and with a useful load of 973 lb.

HOWARD 500

HOWARD AERO, INC., San Antonio, Texas

REMARKS

Model Howard 500 twin-engine executive transport offers an excellent power-to-weight ratio and a high useful load affording more range under a wide range of conditions. Advertised price is $594,000.

SPECIFICATIONS

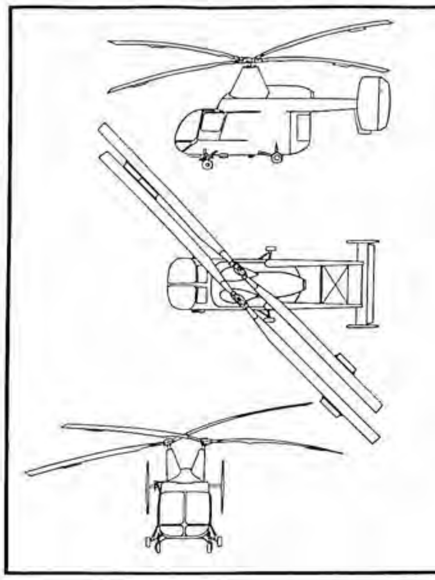
Span 70 ft. 4 in.; Length 57 ft. 10 in.; Height 13 ft. 8 in.; Empty Weight 22,000 lb.; Blade Diameter 10 ft. 11⅞ in.; Wing Loading with takeoff flap extended 52.63 lb. per sq. ft.; Cruise configuration at 34,000 lb., gross weight 57.41 lb. per sq. ft.; Power Loading 6.80 lb. per bhp; Single Engine Power Loading: 13.60 lb. per bhp; Engines Two Pratt & Whitney R-2800s, CB 16/17; CB-17 hp normal rated, or 2,500 hp (each) at 2,800 rpm takeoff; Fuel Capacity: 1,550 gal.; Propeller HS-24E60-7037A-50; Wing Area 592.22 sq. ft.; Aileron Area 17.525 sq. ft.; Flap Area 53.75 sq. ft.; Vertical Stabilizer Area 14.64 sq. ft.; Rudder Area 17.417 sq. ft.; Horizontal Stabilizer Area 93.18 sq. ft.; Elevator Area 35.32 sq. ft.

PERFORMANCE

Maximum Speed: over 400 mph at 1,500 hp at 2,600 rpm at 16,000 ft.; Cruise Speed 350 mph at 1,200 hp at 2,200 rpm at 21,000 ft.; Landing Speed 88 mph; Rate of Climb 2,400 (@ METO) fpm at Sea Level; Service Ceiling 35,000 ft.; Absolute Ceiling over 40,000 ft.; Range with Maximum Payload 2,570 mi.; Range with Maximum Fuel Load 2,800 mi.

KAMAN H-43B HUSKIE

KAMAN AIRCRAFT CORP., Bloomfield, Connecticut



REMARKS

A general utility helicopter to be used by USAF for local base crash rescue, the H-43B, Kaman Huskie is an outgrowth development of the USAF H-43A, but the Huskie has twice the interior space and twice the payload capacity. The rotor system, as in preceeding models, is a synchropter with two counter rotating, intermeshing main rotors which inherently overcome torque and require no tail rotor. Air Force orders to date call for 116 of these rugged, maneuverable aircraft. During the year a new, lower tail was designed which enhanced the Huskie's ease of handling.

SPECIFICATIONS

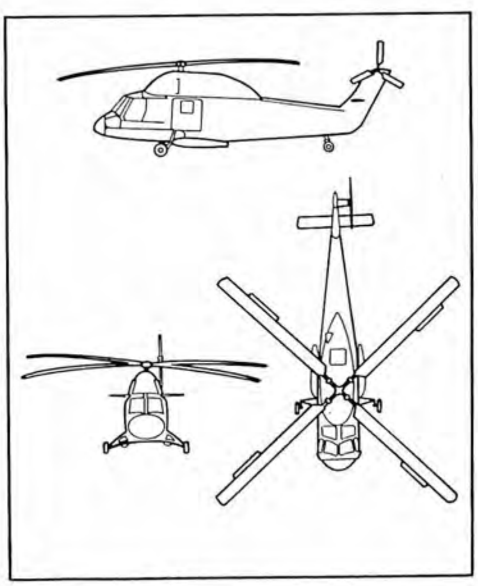
Rotor Diameter 47 ft.; Length 25 ft.; Height 12 ft. 7 in.; Engine Lycoming T53, 860 hp.

PERFORMANCE

Maximum Speed 103 knots at 1000 ft.; Cruise Speed 95 knots; Maximum Rate of Climb 2000 fpm; Service Ceiling 25,000 ft.; Range with Maximum Payload 228 nautical mi.

KAMAN HU2K SEASPRITE

KAMAN AIRCRAFT CORP., Bloomfield, Connecticut



REMARKS

The Navy's new, high-speed utility helicopter, Kaman's HU2K, Seasprite, will carry out a wide variety of missions from ships at sea and from shore bases. These will include plane guard duty with aircraft carriers where the helicopters are kept in the air during takeoffs or landings, and the helicopter is immediately ready to go to the rescue of airmen downed at sea. The HU2K will also be used for search, rescue, aerial ambulance activities, personnel transportation and the carrying of supplies from ship-to-ship and ship-to-shore. The Seasprite's advanced electronic stabilization and navigation gear, plus its compact size and ability to carry additional electronic equipment, give it submarine detection and attack capability. The new ship has retractable landing gear and Kaman's "servo-flap" control system.

SPECIFICATIONS

Main Rotor Diameter 44 ft.; Length 52 ft. 2 in. (operating); Height 12 ft. 5 in.; Empty Weight 5052 lb.; Power Loading 7.2 lb. per bhp; Engine One General Electric T-58-6, 1050 normal rated, T-58-8, 1250 hp military power in advanced models. Internal Fuel Capacity 276.0 gal.; Stabilizer Area 15.0 sq. ft.; Stabilizer Area 15.0 sq. ft.

PERFORMANCE

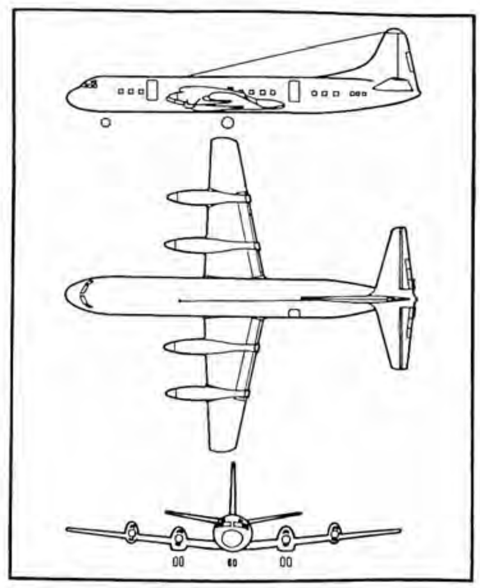
All data are classified.

LOCKHEED ELECTRA

LOCKHEED AIRCRAFT CORP., Burbank, California

REMARKS

The first Electra was airborne in 1957, and by October 1, 1960 had carried more than 6,000,000 passengers in scheduled airline service. Designed primarily for heavily traveled short-to-medium-range routes, the Electra is capable of transcontinental nonstop flight. However, it specializes in economical operation on shorter stages, rapid turnaround time at intermediate stops, altitude flexibility, fast block speeds on short and medium-range flights. It carries from 66 to 98 passengers. It is powered by four Allison 501 propjet engines developing 3750 horsepower each and Aeroproducts 606, or Hamilton Standard, four-bladed propellers. Its powerplants are half the weight of comparable piston engines and fit into nacelles only half as wide as for reciprocating units. Both cockpit and cabin feature excellent visibility, independent climate controls. Test flight program began well before flight of the first article, with both Lockheed and Allison flying the Electra's powerplants on other test vehicles. Eastern Air Lines put the Electra in service early in 1959. Other airlines ordering the Electra include American Airlines, National Air Lines, Braniff International Airways, Western Air Lines, KLM Royal Dutch Airlines, Cathay Pacific, PSA-Pacific Southwest Airlines, Garuda Indonesian Airways, Ansett/ANA, Qantas Empire Airways, Trans-Australia Airline, Tasman Empire Airways, Northwest Orient Airlines, and LOIDE.



SPECIFICATIONS

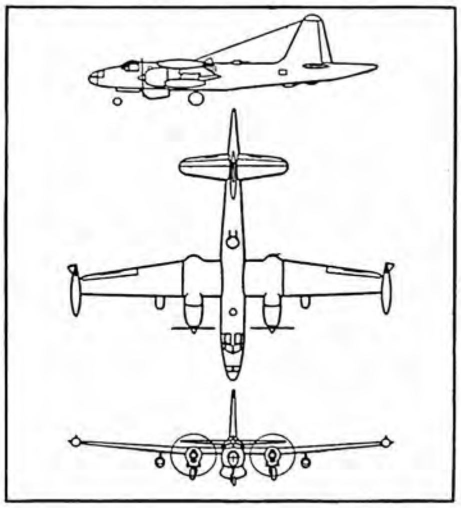
Span 99 ft.; Length 104 ft. 6.5 in.; Height 32 ft. 11 in.; Empty Weight 56,000 lb.; Maximum Gross Weight 116,000 lb.; Engines Four Allison 501 D-13 propjet, 3750 hp normal rated; Fuel Capacity 5520 gal.; Wing Area 1300 sq. ft.

PERFORMANCE

Maximum Speed 450 mph; Cruise Speed 405 mph; Rate of Climb 2400 fpm; Service Ceiling 30,000 ft.; Range with custom interior and maximum payload 2850 mi.; Range with Maximum Fuel Load (900 extra gal.) 3400 mi. with 2½-hr. reserves.

LOCKHEED P2V-7 NEPTUNE

LOCKHEED AIRCRAFT CORP., Burbank, California



REMARKS

The P2V-7 is the latest in the Neptune anti-submarine series. Identifying features are the double-bubble canopy, jet pod engines supplementing its turbo-compound powerplants, and an elongated tail housing MAD (magnetic anomaly detector) gear for locating underwater craft. A versatile plane, the Neptune can be converted for patrol, mine laying or torpedo bomber duty. The jet engines, included now on all production planes, can be used whenever desired: for extra power on takeoffs and extra speed at any time during mission. Lockheed modified earlier P2V-5 and P2V-6 airplanes with jet pods. Four ski-equipped Neptunes were flown by Navy in Operation Deepfreeze III at South Pole.

SPECIFICATIONS

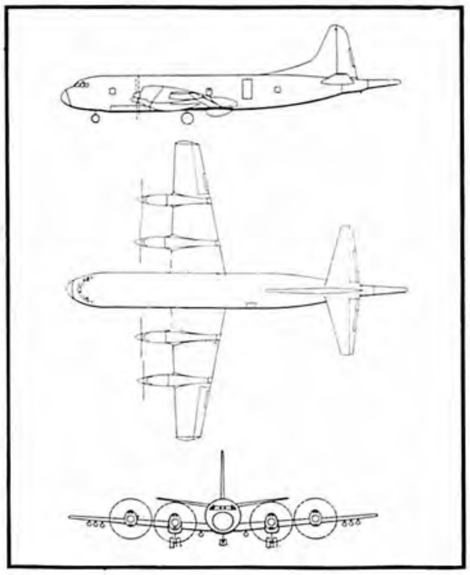
Span 101 ft. 4 in. with tip tanks; Length 91 ft. 8 in.; Height 29 ft. 4 in.; Empty Weight 46,358 lb., with jet pod engines 49,808 lb.; Gross Weight 76,338 lb., with jet pods 79,788 lb.; Engines Two Wright R-3350-32W turbo-compound, 3250 hp, and Two Westinghouse J34 engines in pods, 3400 lb. thrust; Propeller Hamilton Standard four-blade; Wing Area 1000 sq. ft.

PERFORMANCE

Maximum Speed without pods 345 mph; Service Ceiling 23,000 ft. without pods.

LOCKHEED P3V-1 ASW LANDPLANE

LOCKHEED AIRCRAFT CORP., Burbank, California



REMARKS

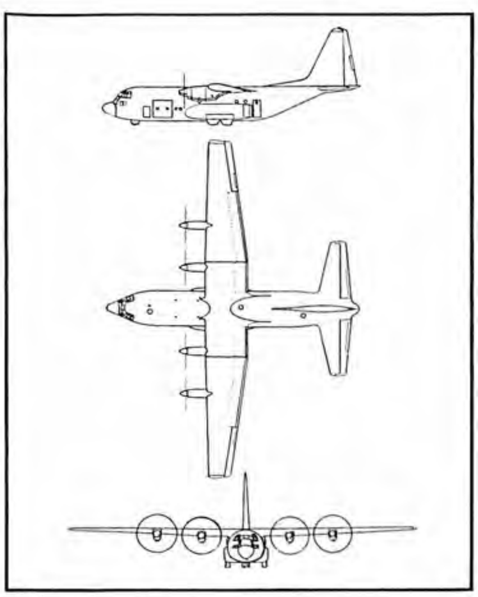
First production order for this aircraft, valued at $79 million, came from the Navy in September, 1959. The P3V-1 cruises about twice as fast as the P2V-7 Neptune and has 40 percent more range. It can search 280,000 square nautical miles of coastal area in a single flight at a cost of about one cent a square mile. It can carry a crew of ten and two and one half tons of communications, navigation and detection equipment.

SPECIFICATIONS

Span 99 ft.; Length 116 ft. 10 in.; Height 33 ft. 8.5 in.; Wing Loading 77.5 lb. per sq. ft. at 101,500 lb.; Power Loading 6.9 lb. per eshp; Engines Four Allison T-56-A-10W, 4500 hp normal rated; Fuel Capacity 9230 gal.; Propeller 4-bladed 13½ ft.; Wing Area 1300 sq. ft.

PERFORMANCE

Maximum Speed 460 mph; Cruise Speed 405 mph.



LOCKHEED C-130B HERCULES

LOCKHEED AIRCRAFT CORP., Burbank, California

REMARKS

The C-130B is another in the series of C-130 Hercules transports which have been produced at the Georgia Division of Lockheed. The first C-130As were delivered to the Tactical Air Command in 1956. This newer model features higher power engines and greater fuselage pressurization, and improved performance and payload-range capabilities. As much as 19 tons of cargo can be airlifted for delivery by parachute or landing. The Lockheed Georgia Division also produces these variants of the C-130B: the SC-130B long-range air search and rescue aircraft for the Coast Guard; the C-130BL ski-equipped transport for the Navy; and the GV-1 inflight refueler and assault transport for the Navy and Marine Corps.

SPECIFICATIONS

Span 132 ft. 7 in.; Length 97 ft. 9 in.; Height 38 ft. 4 in.; Empty Weight 67,550 lb.; Wing Loading 77.4 lb. per sq. ft.; Power Loading 8.3 lb. per eshp; Engines 4 Allison T56-A-7, 3730 eshp normal rated, or 4050 at 13,820 rpm takeoff; Fuel Capacity 6960 gal.; Propeller Hamilton Standard 4 blades, 13.5 ft. diameter; Wing Area 1745 sq. ft.; Aileron Area 110 sq. ft.; Flap Area 342 sq. ft.; Fin Area 225 sq. ft.; Rudder Area 75 sq. ft.; Stabilizer Area 381 sq. ft.; Elevator Area 155 sq. ft.

PERFORMANCE

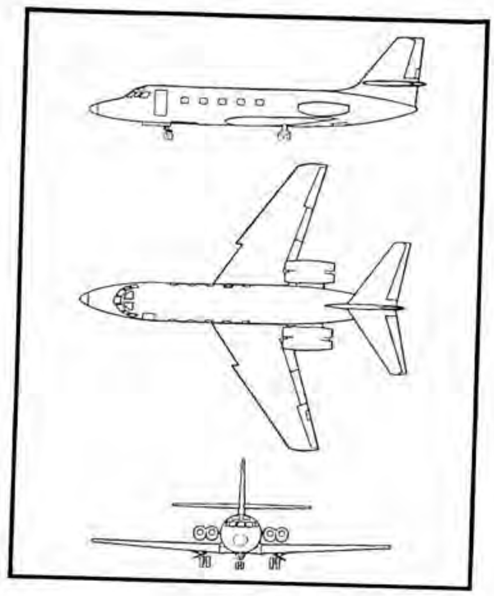
Maximum Speed 375 mph at normal power at 25,000 ft.; Cruise Speed 350 mph; Rate of Climb 2250 fpm at Sea Level; Service Ceiling at Maximum Weight over 28,000 ft.; Range with Maximum Payload 2530 mi.; Range with Maximum Fuel Load over 4000 mi.

LOCKHEED JETSTAR

LOCKHEED AIRCRAFT CORP., Burbank, California

REMARKS

At year end 1960, production-model JetStars for the U.S. Air Force were rolling down the assembly line at Lockheed Aircraft Corporation's Marietta, Ga., plant, and a half-dozen corporate version JetStars were engaged in the FAA certification program. The four-engine junior size jet transport, which flies to 550 miles per hour and to 45,000-foot altitudes, will go into corporate service in early 1961. It has been sold to corporations and government agencies in six nations. The year 1960 saw the U.S. Air Force make an off-the-shelf purchase of the JetStar for use by the Airways and Air Communications Service in checking navigational aids and air traffic control systems at American military bases over the world. The plane was given the military designation "C-140." The Canadian Department of Transport bought the JetStar for a similar purpose. The C-140 JetStar is designed to serve other military purposes, such as that of a Mission Support transport, and a Test Support aircraft. The first production JetStar made its initial flight at Dobbins Air Force Base, Ga., in July, 1960. The first prototype, which made its initial flight at Edwards Air Force Base, California, Sept. 4, 1957, and the second prototype, which flew there a short time later, were still in company flight testing in 1960. The JetStar is powered by four Pratt and Whitney JT-12 jet engines, which are mounted to the rear fuselage for quietness, comfort, and safety. Although it is a jet, the JetStar operates from short runways designed for slower, propeller-driven planes, and it is as effective on short city-to-city hops as it is on transcontinental or international flights.



SPECIFICATIONS

Span 53 ft. 8 in.; Length 60 ft. 5 in.; Height 20 ft. 6 in.; Empty Weight 19,302 lb.; Wing Loading 72.4 lb. per sq. ft.; Power Loading 3.28 lb. per lb. of thrust; Engines Four Pratt & Whitney JT 12A-6. Axial flow turbojet, 3000 lb. at 16,350 rpm takeoff; Fuel Capacity 2630 gal. with two 540 gal. external tanks; Wing Area 542.5 sq. ft.; Aileron Area 24.4 sq. ft.; Flap Area 62.6 sq. ft.; Fin Area 93.75 sq. ft.; Rudder Area 16.45 sq. ft.; Stabilizer Area 117.8 sq. ft.; Elevator Area 31.2 sq. ft.

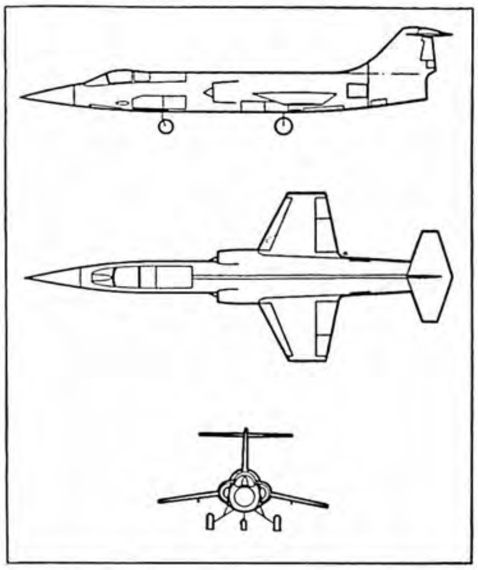
PERFORMANCE

Maximum Speed 550 mph at maximum cruise at 25,000 ft.; Cruise Speed 495 mph at cruise at 42,000 ft.; Landing Speed 120 mph; Rate of Climb 4400 (30,000 lb. weight) fpm at sea level; Service Ceiling 41,000 ft. (with 45 minute reserve); Range with Maximum Payload 2575 statute miles (with 45 minute reserve); Range with eight passengers and maximum fuel load 2650 statute miles (with 45 minute reserve).

The military C-140 is heavier than the corporate version (34,000 lb.) and offers higher performance: Maximum Speed 595 mph at 19,000 ft.; Cruise speed of 495 mph at 42,000 ft.; Range is 2200 statute miles. Specifications of the C-140 are the same as those listed for the corporate JetStar with these exceptions: Empty Weight 19,095 lb.; Engines: Four Pratt & Whitney J-60P-5 (military designation of JT 12A-6).

LOCKHEED F-104G SUPER STARFIGHTER

LOCKHEED AIRCRAFT CORP., Burbank, California



REMARKS

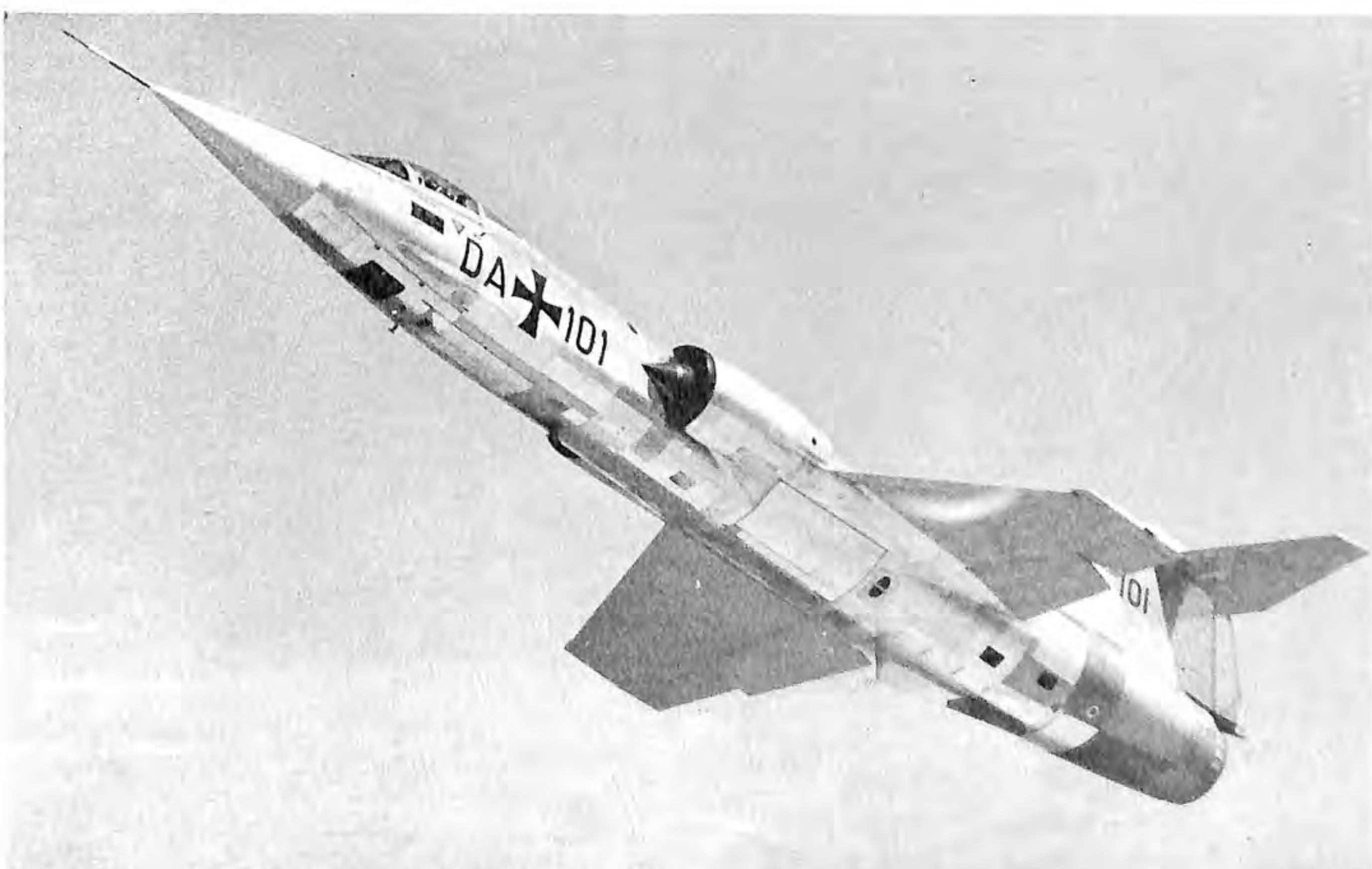
Lockheed's advanced all-weather, multi-mission F-104G Super Starfighter currently is in production at the company's Burbank and Palmdale, California, factories for Germany, Canada and Japan. Additional quantities of Super Starfighters are being manufactured in Europe for Germany, The Netherlands, Belgium and Italy. The Lockheed-licensed project will involve production facilities in each country. Super Starfighters also will be produced in Canada for the Royal Canadian Air Force and in Japan for the Japanese Air Self Defense Force. Early-model F-104Cs currently are serving with the United States Air Force's Tactical Air Command. A double-sonic F-104A Starfighter in 1958 set world records for speed, altitude and time-to-climb to seven different heights. In December of 1959, an F-104C Starfighter set a new world altitude mark of 103,395.5 ft. The high-performance fighter in 1959 received the Collier Trophy for its contribution to aviation.

SPECIFICATIONS

Span 21 ft. 11 in.; Length 54 ft. 9 in.; Height 13 ft. 6 in.; Engine General Electric J79, rated at 15,000 lb. of thrust.

PERFORMANCE

Maximum Speed Mach 2 class; Service Ceiling, upper atmosphere.

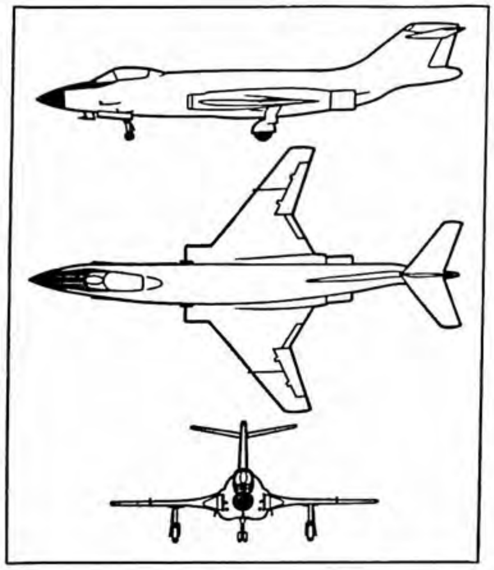


McDONNELL F-101B VOODOO

McDONNELL AIRCRAFT CORP., St. Louis 3, Missouri

REMARKS

The McDonnell F-101B, a two-place, twin-engine interceptor, is a potent weapon system in operational squadrons of the Air Defense Command. It combines speed and long-range characteristics. Equipped with MB-1 Genie rockets and Falcon missiles, the Voodoo is effective protection against enemy aircraft which might approach United States territory with hostile intent. Although performance data on the Voodoo interceptor are classified, a sister ship the F-101A, is credited with speeds of more than 1200 miles an hour. In addition to being a long-range interceptor, the F-101B has exceptional "climb" performance and operates at extremely high altitudes. It is capable of delivering advanced nuclear weapons in all kinds of weather at any target—airborne or ground—visible or invisible. The modern weapon system has every basic ingredient for the defense of the Free World—the speed to overtake and the range to intercept; the firepower to destroy all types of targets in any weather, and the margin of safety to return from the mission. The F-101B is now operating in 18 ADC squadrons. The six-year production run of more than 800 Voodoos was completed in December, 1960.

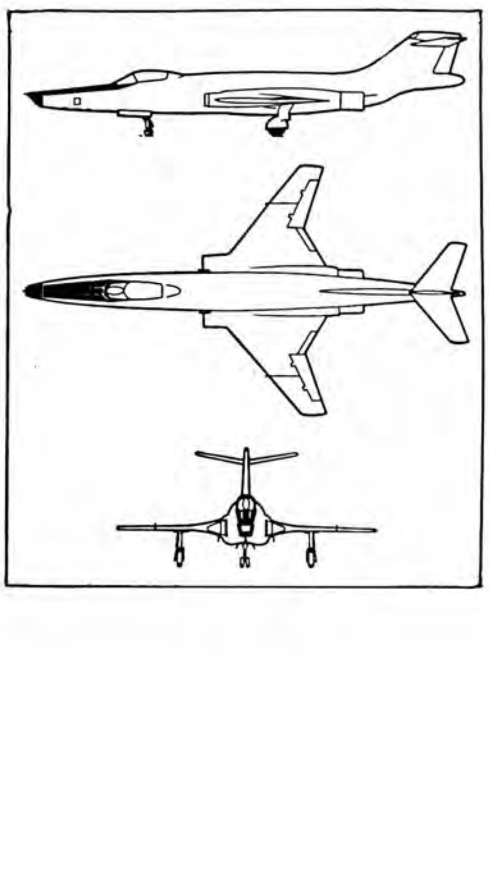


SPECIFICATIONS

Span 39 ft. 8 in.; Length 67 ft.; Height 18 ft.; Empty Weight 26,277 lb.; Engines Two J57-P-13, 10,000 lb. thrust normal rated, or 15,000 with AB thrust; Fuel Capacity 2249 gal.; Wing Area 368 sq. ft.

PERFORMANCE

Maximum Speed 1200+ mph.



McDONNELL RF-101 VOODOO

McDONNELL AIRCRAFT CORP., St. Louis 3, Missouri

REMARKS

The RF-101 Voodoo has a top speed in excess of 1000 miles per hour and makes supersonic photo missions a matter of routine. It has the capability to photograph from 45,000 feet altitude an area 217 miles long and 8 miles wide, plus an area mosaic equivalent to 20,000 square miles. First squadron deliveries of the RF-101 were made to the Tactical Air Command's 363rd Tactical Reconnaissance Wing at Shaw Air Force Base, near Columbia, South Carolina, on May 6, 1957. The RF-101, one of three versions of the Voodoo series designed and built by McDonnell Aircraft, has very long range, which is greatly extended by inflight refueling capability. This high-speed aircraft is well suited for its role in TAC's Air Strike Force operations. The RF-101 closely resembles its fighter counterpart. Slightly lighter in weight, the RF-101 has the same high-performance characteristics as the fighter version of the Voodoo. A combination viewfinder provides the pilot with a clear view of the terrain below and ahead of the airplane. Utilizing cockpit controls, the pilot can operate the entire camera system while in flight. After the basic instructions are "fed" into the system, the photo procedure becomes completely automatic. Several different types of cameras can be quickly interchanged through large access doors, making it possible to carry out any type of photo-reconnaissance mission on short notice.

SPECIFICATIONS

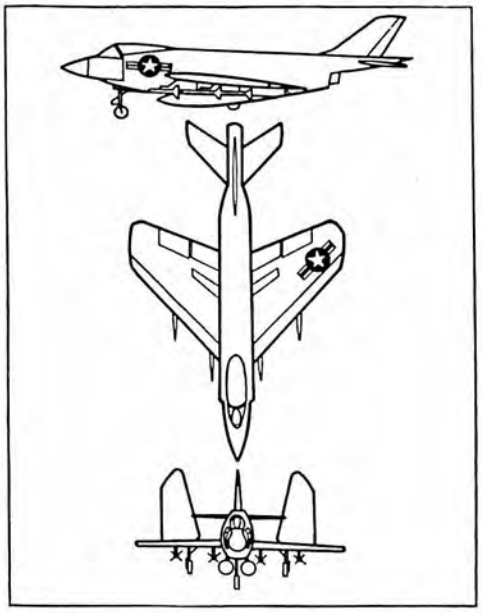
Span 39 ft. 8 in.; Length 69 ft. 3 in.; Height 18 ft.; Empty Weight 26,136 lb.; Engines Two J57-P-13, 10,000 lb. hp normal rates, or 15,000 with AB hp; Fuel Capacity 2146 gal.; Wing Area 368 sq. ft.

PERFORMANCE

Maximum Speed 1200+ mph.

McDONNELL F3H DEMON

McDONNELL AIRCRAFT CORP., St. Louis 3, Missouri



REMARKS

The McDonnell F3H Demon is a single-place, all-weather, carrier-based jet fighter that is currently in service with the U. S. Navy fleets in all parts of the world. Powered by a single Allison J71 afterburning engine, the airplane carries all-weather fire control radar and is armed with four 20mm cannon and a variety of wing-mounted air-to-air missiles, including Sparrow IIIs and Sidewinders. In addition, the Demon can carry a heavy load of bombs and/or external fuel tanks. Production of the fleet-configured Demon commenced in 1955 and ended with the delivery of the 519th Demon to the U. S. Navy in November, 1959. It has been succeeded on McDonnell assembly lines by the newer and higher-performance F4H Phantom II.

SPECIFICATIONS

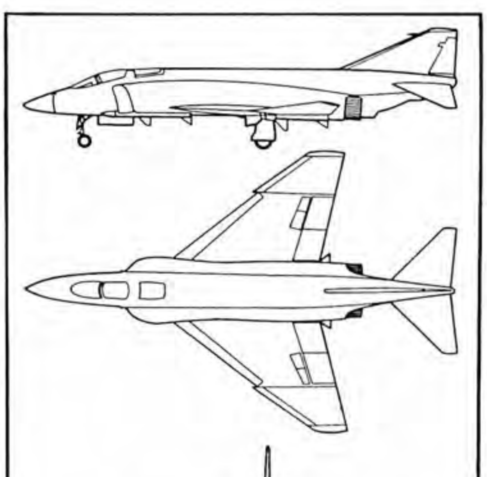
Span 35 ft. 4 in.; Length 58 ft. 11 in.; Height 14 ft. 7 in.; Empty Weight 22,133 lb.; Engine J71-A-2, 14,000 lb. thrust class; Fuel Capacity 1506 gal.; Wing Area 519 sq. ft.

PERFORMANCE

All data are classified.

McDONNELL F4H PHANTOM II

McDONNELL AIRCRAFT CORP., St. Louis 3, Missouri



REMARKS

The McDonnell F4H Phantom II is the Navy's newest and most-advanced carrier-based fighter airplane. Powered by two after-burning G. E. J79's, the F4H is manned by a crew of two, pilot and radar intercept officer, and is extensively equipped with modern electronic detection, tracking and guidance equipment —thus it is completely capable of all-weather operation, day or night. Armament consists of fuselage and wing-mounted Sparrow III and Sidewinder rocket-propelled air-to-air missiles. The airplane has extremely high performance and outstanding range for its type. An additional capability for this versatile fighter is long range special weapons attack. The airplane can carry external fuel tanks as well as a centerline special weapon and is equipped with an all-altitude bombing system.

The Phanton II first flew in May of 1958 and the airplane is now in large-scale production. Squadron deliveries commenced in December, 1960.

During the course of its test program the F4H established three new World's Records: a new altitude record of 98,557 feet was established in December, 1959, and two new speed records were established in September, 1960: 1216.78 mph for the 500-kilometer triangular closed course, and 1390.31 mph for the tight, circular 100-kilometer closed course.

SPECIFICATIONS

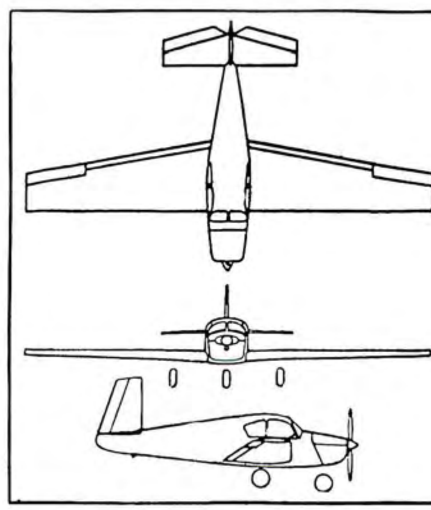
Span 38 ft. 5 in.; Length 58 ft. 3 in.; Height 16 ft. 3 in.; Engines Two General Electric J79-8, or 1600+ hp; Wing Area 530 sq. ft. Wing boundary layer control.

PERFORMANCE

Maximum Speed 1500+ mph; Cruise Speed 600+ mph; Landing Speed 130 mph; Range with Maximum Fuel Load 2000+ mi.

MOONEY MK 20A

MOONEY AIRCRAFT, INC., Kerrville, Texas



REMARKS

Mooney's 1960 MK 20A features a chrome-molybdenum welded steel island structure engineered to create maximum passenger safety. It has manually retracted gear system and a double down lock system coupled with warning lights to prevent accidental gear retraction on the ground; a full-trim tail which gives maximum stability at slow speeds and minimum drag at high speeds. Standard model sells for $15,995.

SPECIFICATIONS

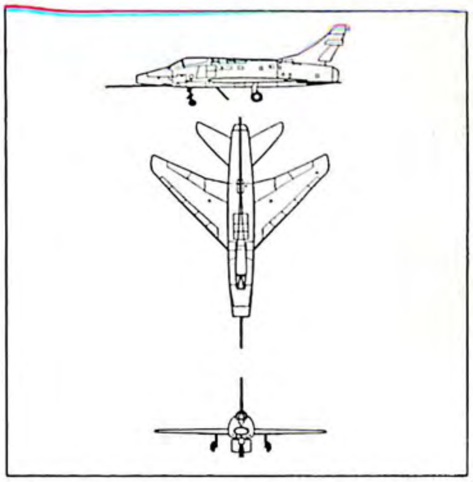
Span 35 ft.; Length 23 ft. 2 in.; Height 8 ft. 4.5 in.; Wing Loading 14.7 lb. per sq. ft.; Power Loading 13.6 lb. per bhp; Engine One Lycoming O-360, 180 hp normal rates, or 180 hp at 2700 rpm takeoff; Fuel Capacity 49 gal.; Propeller McCauley-constant speed; Wing Area 167 sq. ft.; Aileron Area 11.1 sq. ft.; Flap Area 17.2 sq. ft.; Fin Area 5 sq. ft.; Rudder Area 7.9 sq. ft.; Stabilizer Area 21.5 sq. ft.; Elevator Area 12 sq. ft.

PERFORMANCE

Maximum speed 190 mph at 180 hp at 2700 rpm at Sea Level; Cruise Speed 180 mph at 135 hp at 2400 rpm at 7500 ft.; Landing Speed 57 mph; Rate of Climb 1150 fpm at Sea Level; Service Ceiling 20,000 ft.; Absolute Ceiling 22,000 ft.; Range with Maximum Payload 1075 mi.; Range with Maximum Fuel Load 1075 mi.

NORTH AMERICAN F-100D SUPER SABRE

NORTH AMERICAN AVIATION, INC., Los Angeles 45, California



REMARKS

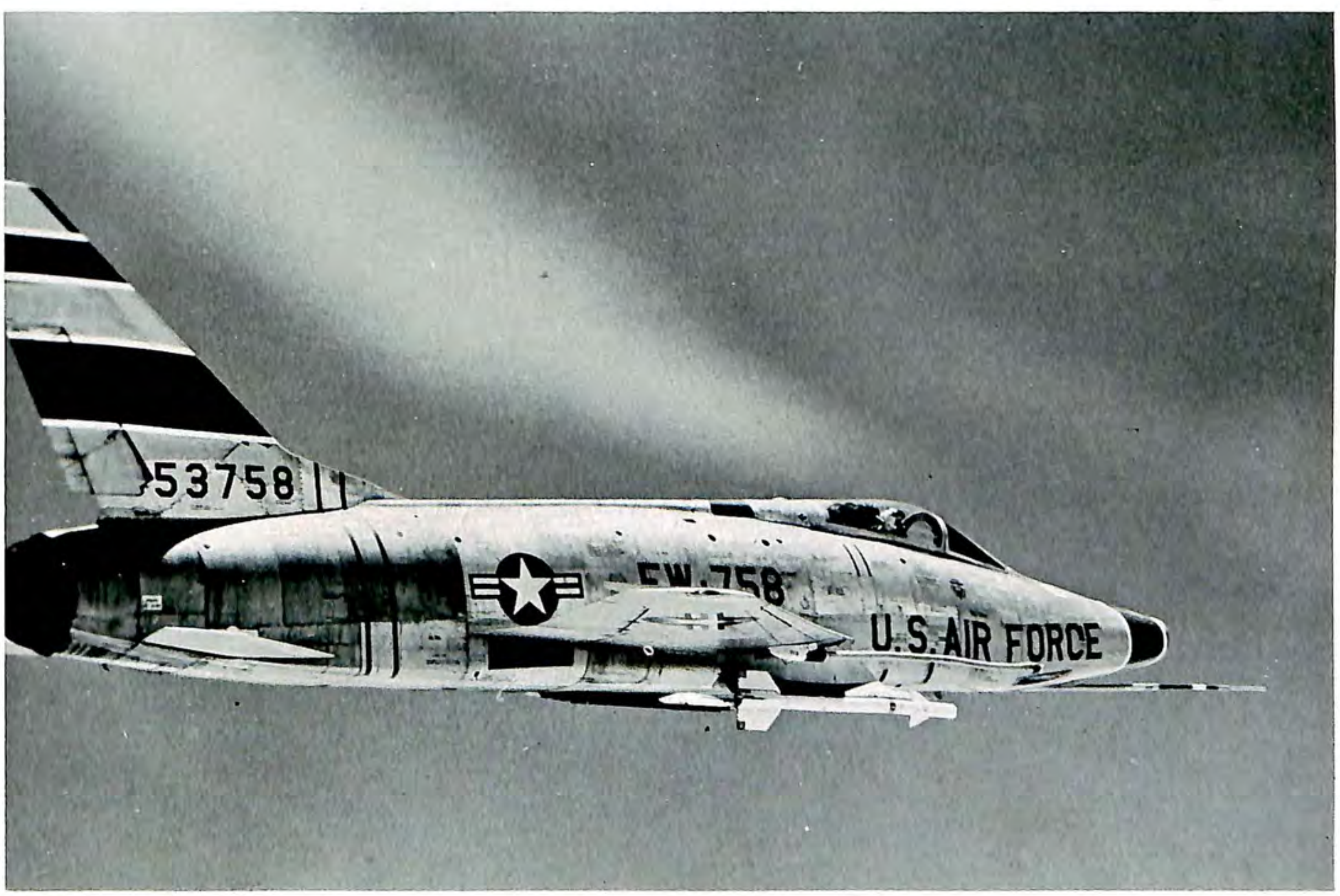
The F-100D is a fighter-bomber designed for maximum climb, maneuverability, altitude and speed. Like F-100A, which was first put into production in mid-1953, it has 45-degree swept-wing, uses tail braking parachute, has "solid" stabilizer and large ventral air brake. -C model differs from -A in that it contains inflight refueling system, has provision for carrying extra fuel drop tanks and bombs. -D model has addition of autopilot. Production of the F-100D was completed in August 1959.

SPECIFICATIONS

Span 38 ft. 7 in.; Length 46 ft. 5 in.; Height 16 ft.; Empty Weight 21,004 lb.; Wing Loading 52.5 lb. per sq. ft.; Power Loading 3.30 lb. per lb. thrust; Engines J57-21 or J57-21A, 10,000 plus lb. thrust; Fuel Capacity 1189 gal.; Wing Area 400.18 sq. ft.; Fin Area 47.02 sq. ft.; Aileron Area 37.10 sq. ft.; Flap Area 29.8 sq. ft.; Rudder Area 8.54 sq. ft.; Vertical Area 55.56 sq. ft.; Horizontal Stabilizer 98.86 sq. ft.

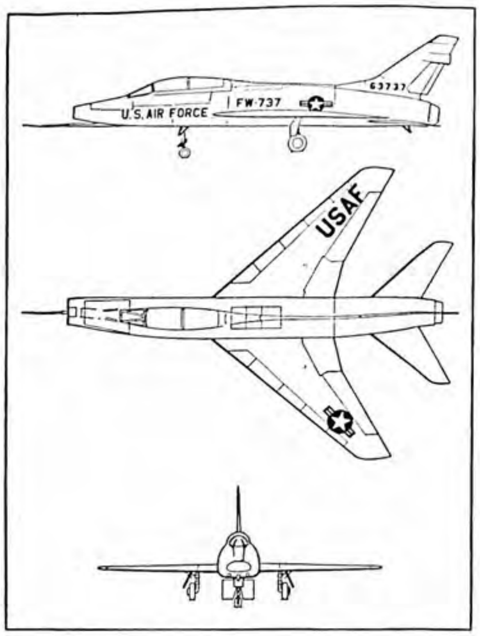
PERFORMANCE

Maximum Speed in excess 1000 mph; Cruise Speed 600 mph at 40,000 ft.; Landing Speed 155 mph; Rate of Climb 22,000 fpm at Sea Level; Service Ceiling 51,000 ft.; Range with Maximum Fuel Load 1800 mi.



NORTH AMERICAN F-100F SUPER SABRE

NORTH AMERICAN AVIATION, INC., Los Angeles 45, California



REMARKS

The latest operational model of the Super Sabre series is the supersonic two-place F-100F fighter-bomber. At speeds in excess of 1000 miles per hour and capable of delivering a bomb tonnage greater than that carried by a World War II medium bomber, the "F" has the same maximum climb, maneuverability, altitude and speed as the single-seat F-100D. All four models of the Super Sabre are featured with 45 degrees swept-back wings, a solid horizontal stabilizer which is slightly below wing level and leading edge automatic slats. Production of the F-100F was completed in September, 1959.

SPECIFICATIONS

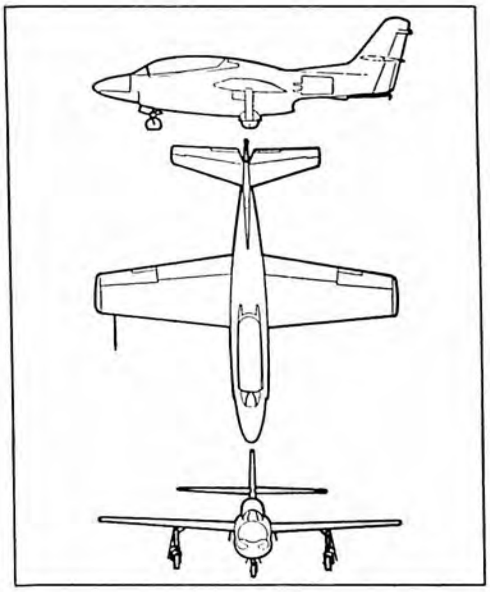
Span 38 ft. 9 in.; Length 52 ft. 6 in.; Height 16 ft. 3 in.; Empty Weight 22,336 lb.; Wing Loading 55.8 lb. per sq. ft.; Power Loading 3.30 lb. per lb. thrust; Engines J57-21 or J57-21A, 10,000 plus lb. thrust; Fuel Capacity 1189 gal.; Wing Area 385.21 sq. ft.; Fin Area 47.02 sq. ft.; Aileron Area 37.10 sq. ft.; Flap Area 29.8 sq. ft.; Rudder Area 8.54 sq. ft.; Vertical Area 57.78 sq. ft.; Horizontal Stabilizer 98.86 sq. ft.

PERFORMANCE

Maximum Speed in excess of 1000 mph; Cruise Speed 600 mph at 40,000 ft.; Landing Speed 155 mph; Rate of Climb 22,000 fpm at Sea Level; Service Ceiling 51,000 ft.; Range with Maximum Fuel Load 1800 mi.

NORTH AMERICAN T2J

NORTH AMERICAN AVIATION, INC., Los Angeles 45, California



REMARKS

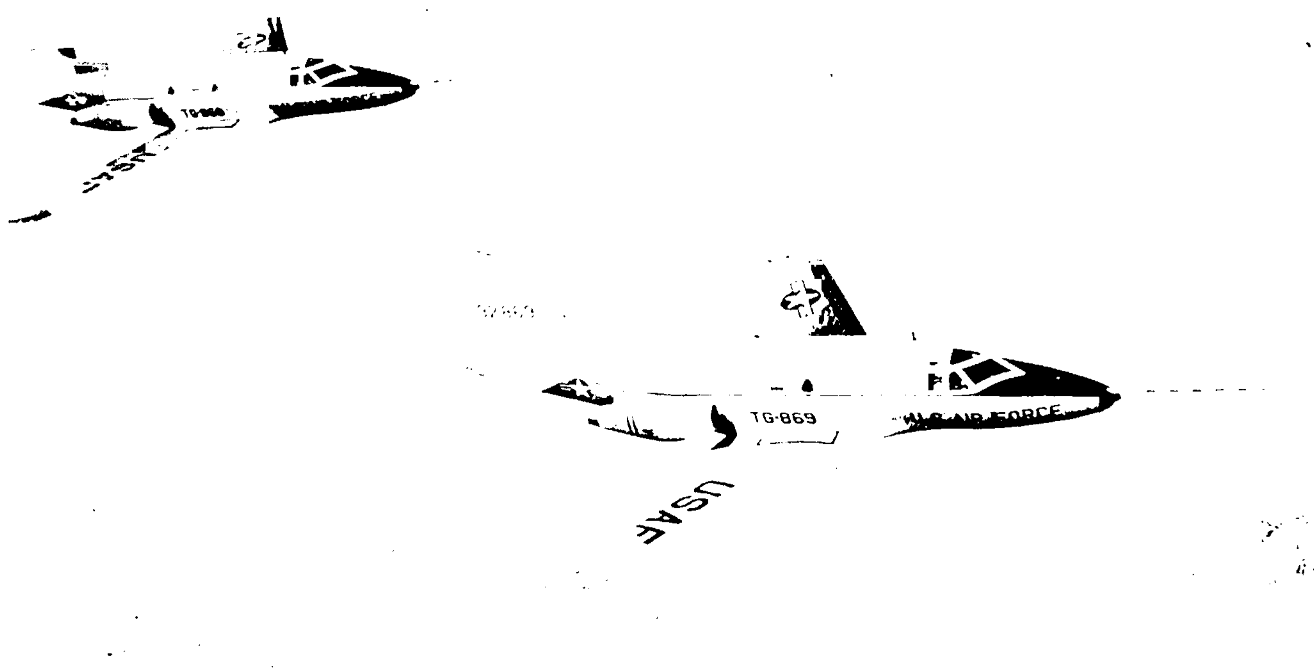
The T2J is designed to provide the fleet with a tandem seat land or carrier-based jet trainer with appropriately increased performance and versatility over the primary trainer. It is a straight wing, tricycle landing gear jet trainer. It features stepped tandem seating with a clamshell canopy for better visibility and low altitude ejection provisions. Special attention has been paid to maintenance ease and reliability.

SPECIFICATIONS

Span 36 ft.; Length 38 ft. 8 in.; Height 14 ft. 9 in.; Empty Weight 6900 lb. (approximately); Wing Loading 35 lb. per sq. ft.; Engine Westinghouse J34-WE-36, 3400 lb. thrust; Fuel Capacity 381 gal. without tip tanks, 581 gal. with tip tanks; Wing Area 255 sq. ft.; Aileron Area 190 sq. ft.; Flap Area 50 sq. ft.; Fin Area 38 sq. ft.; Total Rudder Area 10.71 sq. ft.; Stabilizer Area 68 sq. ft.; Elevator Area 17.66 sq. ft.

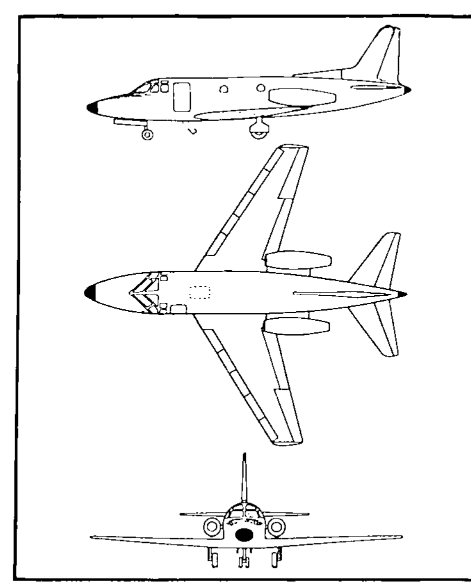
PERFORMANCE

Maximum Speed 429 knots at 25,000 ft.; Cruise Speed 362 knots at 34,700 ft.; Landing Speed 67 knots; Rate of Climb 5000 fpm at Sea Level; Service Ceiling 42,500 ft.; Absolute Ceiling 45,000 ft.; Range with Maximum Payload 840 nautical mi.; Range with Maximum Fuel Load 840 nautical mi.



NORTH AMERICAN T-39 SABRELINER

NORTH AMERICAN AVIATION, INC., Los Angeles 45, California



REMARKS

The Air Force T-39 twin-jet utility aircraft is a high performance trainer currently being built by the Los Angeles Division of North American Aviation, Inc. With a cruising speed of 500 miles per hour at altitudes above 40,000 feet the twin-jet Sabreliner is a multi-purpose aircraft with pilot, navigational, radar training and passenger-cargo carrying capabilities. A prototype Sabreliner (UTX) was built at North American's expense in 1957-58 and was first flown in September, 1958. Basic interior configuration of T-39 provides for four passengers plus pilot and co-pilot.

SPECIFICATIONS

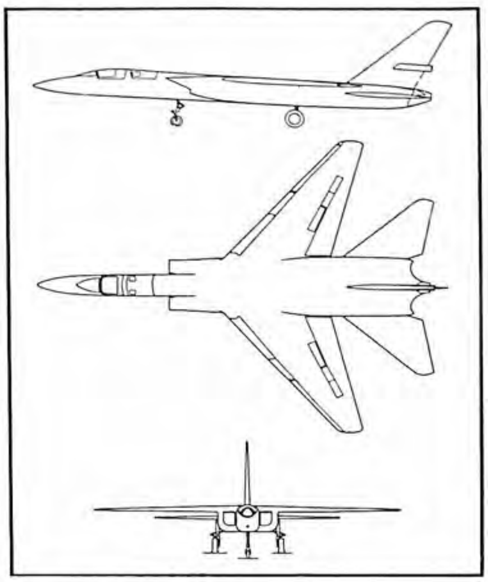
Span 44 ft. 5 in.; Length 43 ft. 9 in.; Height 16 ft.; Empty Weight 9307 lb.; Engines two Pratt and Whitney J60s, 3000 lb. thrust normal rated; Fuel Capacity 1056 gal. (extended range); Wing Area 342.1 sq. ft.; Aileron Area 16.42 sq. ft.; Flap Area 36.6 sq. ft.; Vertical Tail Area 45.6 sq. ft.; Horizontal Tail Area 77 sq. ft.

PERFORMANCE

Maximum Speed 640 mph at 16,000 ft. (optimum alt.); Cruise Speed 500 mph at 43,000 ft.; Landing Speed 100 mph; Service Ceiling 45,000 ft. Range with Maximum Fuel Load at Maximum Gross Takeoff Weight 1725 mi.

NORTH AMERICAN A3J VIGILANTE

NORTH AMERICAN AVIATION, INC., Los Angeles 45, California



REMARKS

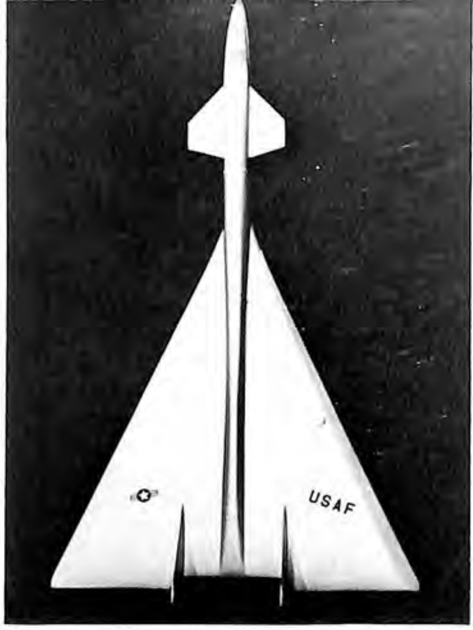
Mission of the A3J is to provide the fleet with an all-weather, carrier-based attack weapons system which can deliver both conventional and nuclear weapons at either high or low altitudes on difficult targets at supersonic speeds. The A3J-I features a high, thin swept wing and all-movable slab-type tail surfaces with spoiler/deflectors in lieu of conventional ailerons for lateral control. The wing is equipped with droopable leading edges and flaps with boundary layer control, which when used in conjunction with the spoiler/deflectors, improve low-speed flight characteristics. The cockpits are arranged in tandem. The linear bay runs lengthwise in the fuselage and the bomb is ejected rearward. First flight of the Vigilante was August 31, 1958.

SPECIFICATIONS

Approximate Span 50 ft.; Length 70 ft.; Height 20 ft.; Engines Two J79 (General Electric).

PERFORMANCE

Mach 2 range.



NORTH AMERICAN B-70 VALKYRIE

NORTH AMERICAN AVIATION, INC., Los Angeles 45, California

REMARKS

B-70 Valkyrie. This Mach 3 bomber, under development for the Strategic Air Command, is classified at this time.

SPECIFICATIONS

Engines Six J93 Turbojets (General Electric).

PERFORMANCE

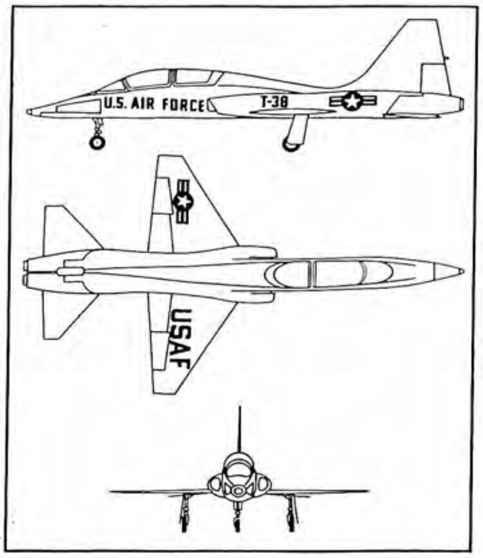
Maximum Cruise Speed 2000 mph.

NORTHROP T-38A TALON

NORTHROP CORP., Hawthorne, California

REMARKS

The T-38A Talon is a high-altitude, supersonic, low-wing, twin engined, jet-propelled, basic trainer aircraft, designed for a crew of two. The instructor and student sit tandem in a pressurized cockpit enclosed by individual jettisonable canopies. Ejection seats are provided for both crew members. Fuselage lines are characterized by distinct reverse or "coke bottle" curvature at wing junction point in conformance with "area rule" theory. Engine exhausts protrude several inches from aft fuselage providing a "twin tailpipe" effect. Engine air scoops are located just outboard of rear cockpit. Wings are placed in rear section of fuselage just aft of engine scoops. The T-38A utilizes conventional ailerons and rudder and all-movable horizontal tail. It is designed for use by USAF for flight training in the following categories: Supersonic flight, takeoff, and landing techniques, multi-jet engine operations, aerobatics, night flying, instrument instruction and cross-country navigation. The T-38A is now in production at Northrop's Norair Division, Hawthorne, California.

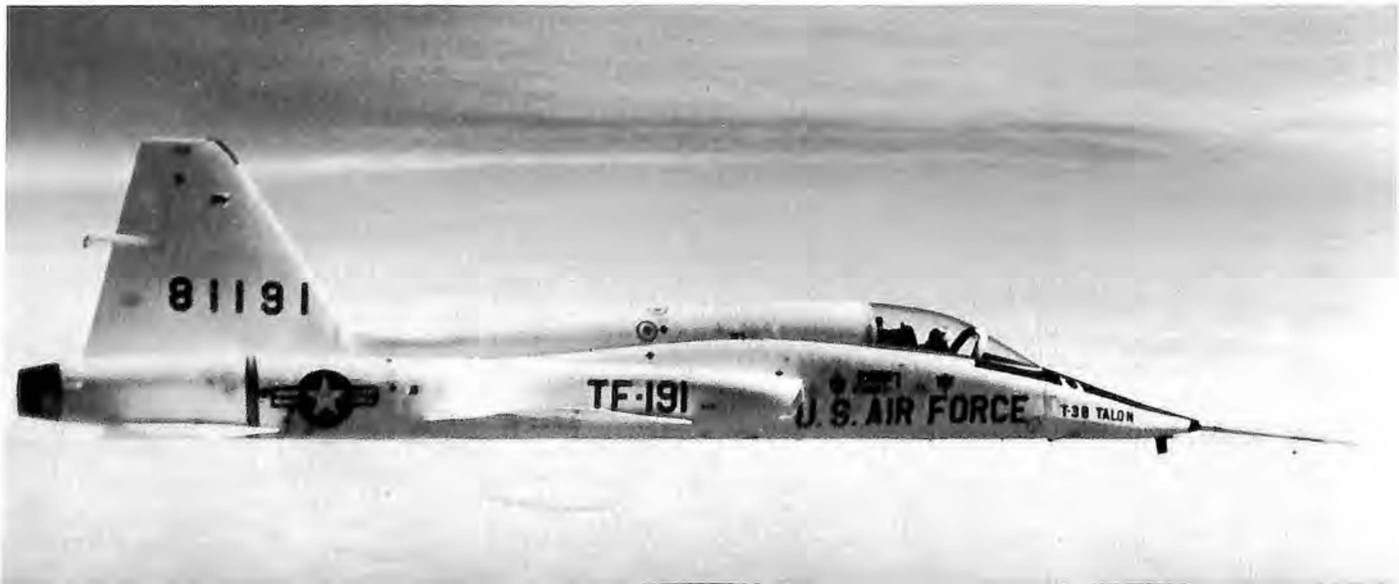


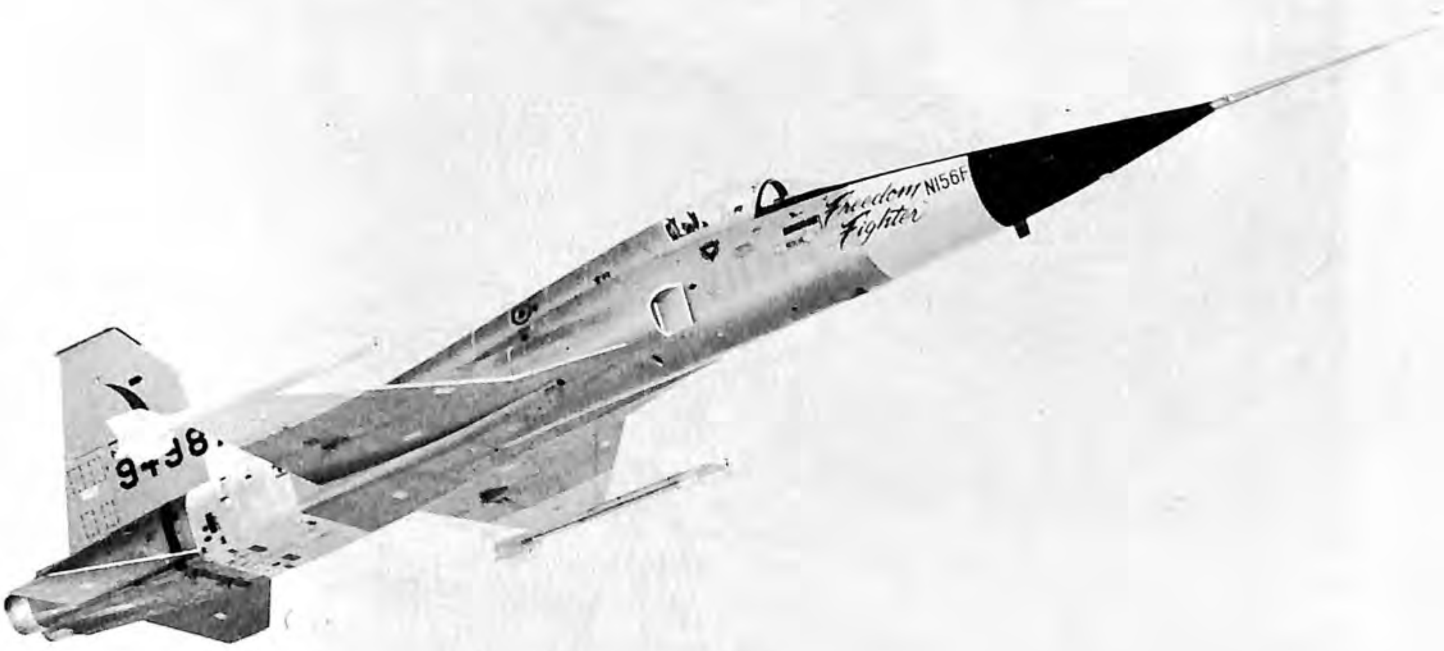
SPECIFICATIONS

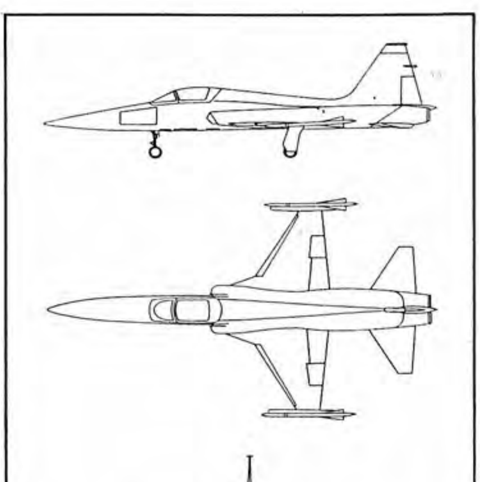
Span 25 ft. 3 in.; Length 43 ft.; Height 12 ft. 11 in.; Empty Weight 9000 lb.

PERFORMANCE

Maximum Speed Supersonic.







NORTHROP N-156F FREEDOM FIGHTER

NORTHROP CORP., Hawthorne, California

REMARKS

The N-156F is a multipurpose, twin-turbojet fighter, providing high-altitude, supersonic performance in all-weather, capable of zero-length launch and operation from short fields. The pilot is seated in a pressurized cockpit enclosed by jettisonable canopy with two-stage rocket powered ejection seat. It is the sister ship to the USAF-Northrop T-38A Talon supersonic trainer. The aircraft is versatile in armament and fire control systems. Its mission is "counterair" and includes destruction of enemy airpower both in the air and on the ground. It has a range of more than 2000 nautical miles with provisions for in-flight refueling.

SPECIFICATIONS

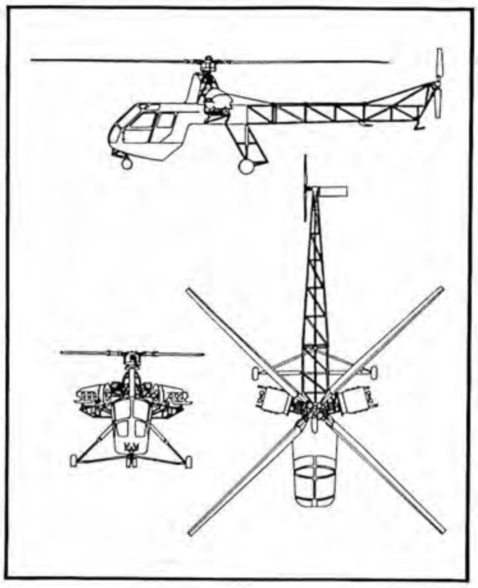
Span 26 ft. 5 in.; Length 43 ft. 11 in.; Height 13 ft.; Takeoff Weight approximately 12,000 lb.; Engines Two General Electric J85 jet-turbo.

PERFORMANCE

Maximum Speed supersonic.

OMEGA BS-12 D

OMEGA AIRCRAFT CORP., New Bedford, Massachusetts



REMARKS

The Omega Twin is a rugged utility type helicopter designed for a wide variety of commercial applications. It embodies a five-place cabin forward, and a large cargo area directly beneath the rotor center-line. Cargo can be carried in this area in a detachable pod, in a net sling, or suspended from the surrounding fuselage structure as a separate unit. The fuselage is a welded tubular steel frame with the aft portion uncovered for ease of inspection and repair, and better stability and vibration characteristics. The high tail rotor position and skid minimize the possibility of tail rotor ground contact. The four-bladed main rotor system consists of two identical two-bladed, fully articulated rotors. The helicopter has been granted Class 1 Provisional Type Certificate No. 1H14.

SPECIFICATIONS

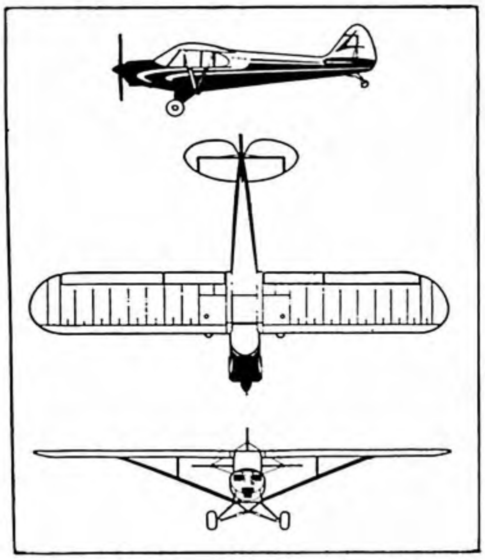
Length 48 ft. 2 in.; Height 13 ft.; Empty Weight 3300 lb.; Gross Weight 4750 lb.; Rotor Diameter 39 ft.; Engines Two Lycoming O-540-F1B5s, 260 hp at 2800 rpm takeoff.

PERFORMANCE

Maximum Speed 95 mph at Sea Level; Cruise Speed 85 mph at 75 percent power; Rate of Climb 900 fpm; Service Ceiling 10,000 ft.

PIPER PA-18 SUPER CUB

PIPER AIRCRAFT CORP., Lock Haven, Pennsylvania



REMARKS

The Piper Super Cub, PA-18 "150" is powered by a 150 hp engine. It is widely used for patrol, survey, farm and ranch use and general utility.

SPECIFICATIONS

Span 35 ft. 4 in.; Length 22 ft. 6 in.; Height 6 ft. 8 in.; Empty Weight 930 lb.; Gross Weight 1750 lb.; Overload Gross Weight 2070 lb.; Wing Loading 10 lb. per square ft.; Power Loading 11.6 lb. per hp; Engine "150" Lycoming O-320, 150 hp at 2700 rpm takeoff; Fuel Capacity 36 gal.; Propeller Sensenich; Wing Area 178.5 sq. ft.

PERFORMANCE

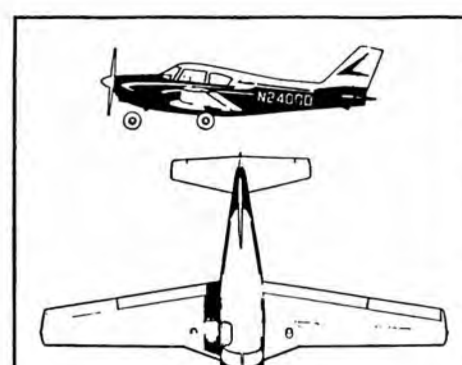
Maximum Speed 130 mph; Cruise Speed 115 mph at 75 percent power at 7000 ft.; Landing Speed 43 mph with flaps; Rate of Climb 960 fpm at Sea Level; Service Ceiling 19,000 ft.; Absolute Ceiling 21,300 ft.; Range with Maximum Payload 460 mi.

PIPER COMANCHE PA-24

PIPER AIRCRAFT CORP., Lock Haven, Pennsylvania

REMARKS

Piper offers the Comanche, high-performance, all-metal, 4 passenger plane with retractable tricycle landing gear, in two versions: Comanche with 180 hp Lycoming engine, for maximum economy; Comanche 250 with 250 hp, six-cylinder Lycoming for top performance. Advanced design features include swept rudder, stabilator and laminar flow wing section. Roomy cabin, ample luggage space and component systems designed for maintenance ease characterize the Comanches, now in volume production.



SPECIFICATIONS

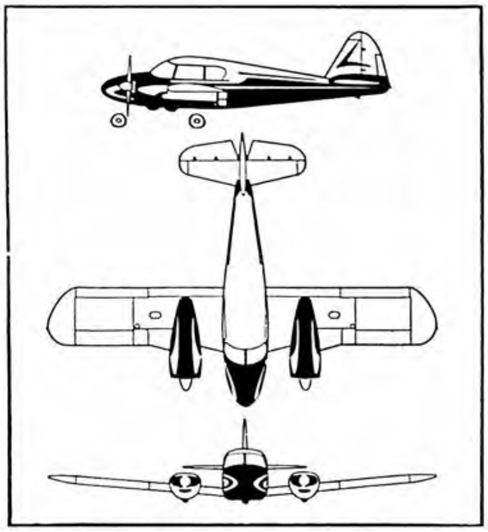
Span 36 ft.; Length 24 ft. 8 in. (24 ft. 10 in. for "250"); Height 7 ft. 4 in.; Gross Weight 2550 lb. (2900 for "250"); Empty Weight 1510 lb. (180) (1630 lb. for "250"); Wing Loading 14.3 lb. per sq. ft. (15.7 lb. for "250"); Power Loading 14.2 lb. per hp (11.2 for "250"); Engine Lycoming O-360-A for "180" (Lycoming O-540-A1A5 for "250"); 180 hp (250 for "250"), at 2700 rpm (2575 for "250") takeoff; Fuel Capacity 50 or 60 gal. (60 for "250"); Propeller Constant Speed, controllable; Wing Area 178 sq. ft.

PERFORMANCE

Maximum Speed 167 mph (190 for "250"); Cruise Speed 160 mph (181 for "250") at 75 percent power at 8000 ft.; Landing Speed 61 mph (65 for "250"); Rate of Climb 910 fpm (1350 for "250"); Service Ceiling 18,500 ft. (20,000 for "250"); Absolute Ceiling 21,000 ft. (22,000 for "250"); Range with Maximum Payload 750 mi. (740 for "250"); Range with Maximum Fuel Load 1100 mi (1650 for "250").

PIPER PA-23 TWIN APACHE

PIPER AIRCRAFT CORP., Lock Haven, Pennsylvania



REMARKS

The Piper Twin Apache G, with new rear windows opposite optional fifth seat, is all-metal design with short takeoff characteristics and slow landing speed for short field operations. It is capable of maintaining altitude at full gross weight on one engine. The rear seat can be removed in less than two minutes to provide 80 cubic feet of unobstructed stowage space. The model can be converted into an ambulance plane with room for one stretcher and attendant in the rear seat. The cabin has been built so that a hatch can be cut in the floor for camera installation. Flap and landing gear controls are shaped as an airfoil and wheel respectively for positive identification. Optional Apache configuration includes installation of a fifth passenger seat in the rear.

SPECIFICATIONS

Span 37 ft.; Length 27.1 ft.; Height 9.5 ft.; Engines Two Lycoming O-320-B 160 hp at 2700 rpm; Gross Weight 3800 lb.; Empty Weight 2320 lb.; Useful Load 1480 lb.; Wing Loading 18.6 lb. per sq. ft.; Power Loading 11.9 lb. per hp; Wing Area 204 sq. ft.; Baggage 200 lb.; Fuel Capacity 108 gal. with auxiliary tanks.

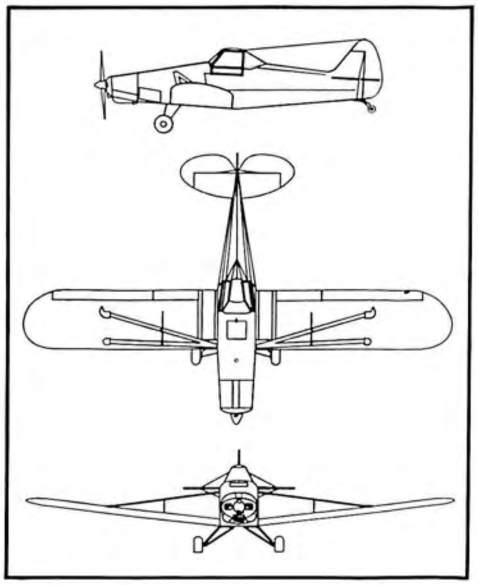
PERFORMANCE

Cruise Speed 171 mph at 7000 ft.; Range up to 1260 mi.

PIPER PA-25 PAWNEE
PIPER AIRCRAFT CORP., Lock Haven, Pennsylvania

REMARKS

Deliveries of new Piper Pawnee began in summer,. 1959. Pawnee is a long-wing airplane designed specifically for aerial application of agricultural chemicals. Single-place Pawnee, first airplane to come out of Piper's new Development Center at Vero Beach, Florida, incorporates many features for pilot safety and efficient application of spray and dust. Pawnee has useful load of 1100 pounds, hopper capacity of 150 gallons or 20 cubic feet. Pilot's cockpit is aft for maximum safety, high as possible for unobstructed vision.

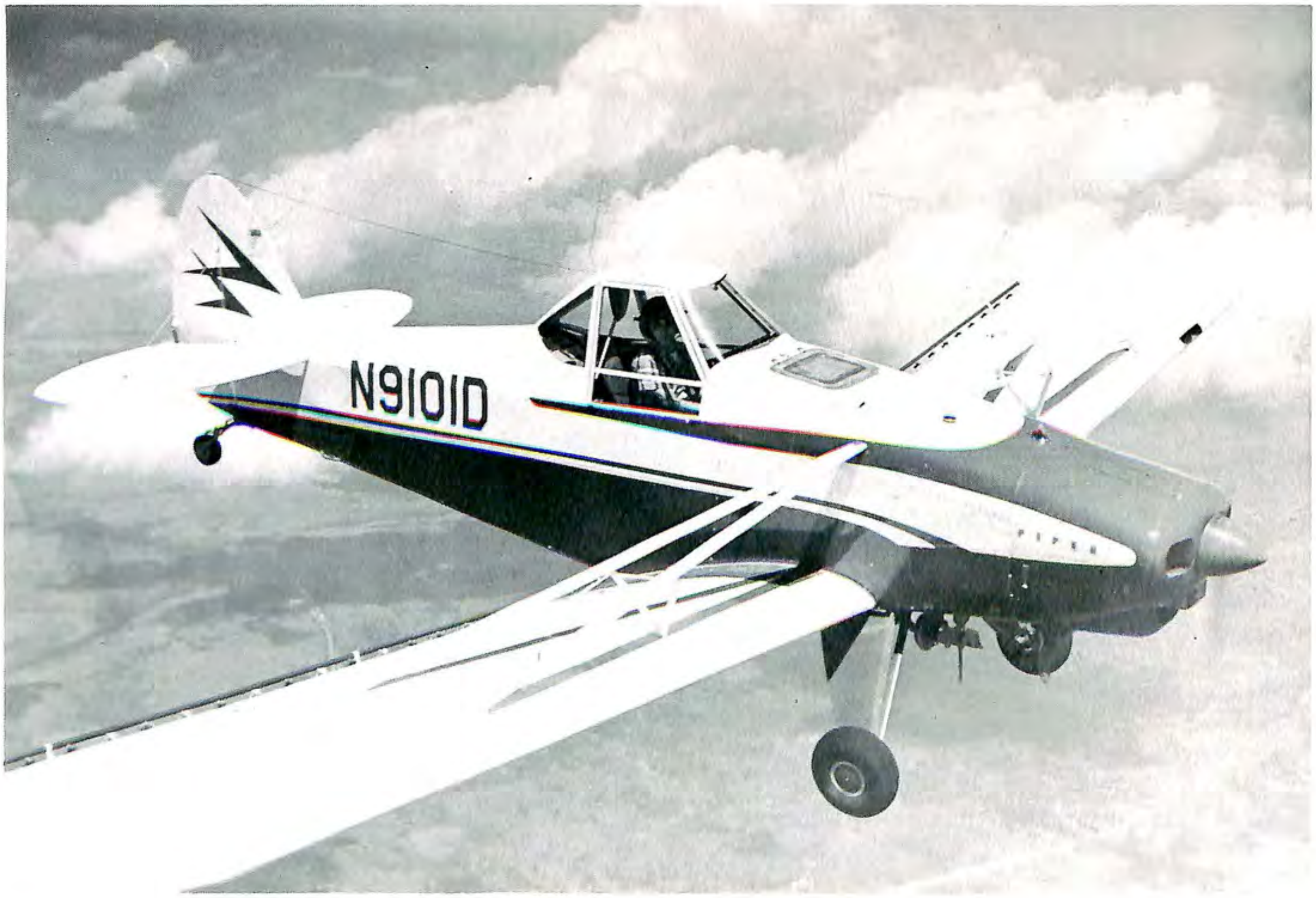


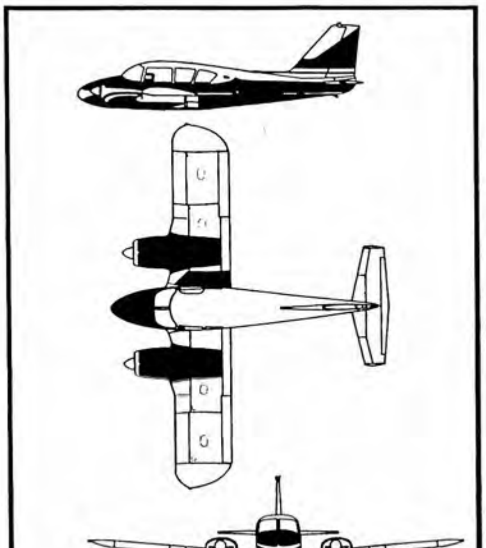
SPECIFICATIONS

Span 36 ft. 3 in.; Length 24 ft.; Height 6.8 ft.; Empty Weight 1200 lb.; Wing Loading 12.6 lb. per sq. ft.; Power Loading 15.3 lb. per hp; Engine Lycoming O-320-A2B, 150 hp at 2700 rpm takeoff; Fuel Capacity 40 gal.; Propeller McCauley-metal; Wing Area 183 sq. ft.

PERFORMANCE

Maximum Speed 113 mph; Cruise Speed 95 mph; Landing Speed 57 mph; Rate of Climb 50.5 fpm; Service Ceiling 11,300 ft.; Absolute Ceiling 13,600; Range with Maximum Payload 440 mi.





PIPER PA-23-250 AZTEC

PIPER AIRCRAFT CORP., Lock Haven, Pennsylvania

REMARKS

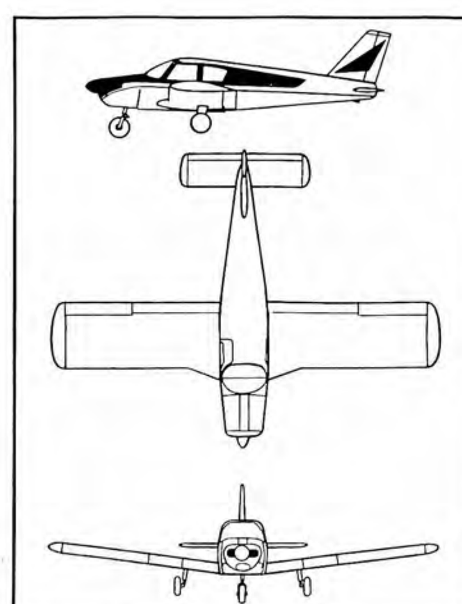
Aztec, Piper's new twin-engine executive transport, was placed on the market late in 1959. The five-passenger Aztec has a very high single-engine ceiling. Single engine service ceiling at full 4800 pounds gross weight is 7400 feet. Design features include swept rudder and single-piece stabilator. Aztec is available in three models, including AutoFlite, equipped with Piper Auto Control, transistorized automatic flight system.

SPECIFICATIONS

Span 37 ft.; Length 27 ft. 7 in.; Height 10 ft. 4 in.; Empty Weight 2775 lb.; Wing Loading 23.5 lb. per sq. ft.; Power Loading 9.6 lb. per hp; Engines Two Lycoming O-540-A1B5, 250 hp at 2575 rpm takeoff; Fuel Capacity 144 gal.; Propeller Hartzell constant speed full feathering.

PERFORMANCE

Maximum Speed 215 mph; Cruise Speed 205 mph at 75% power at 7000 ft.; Landing Speed 62 mph; Rate of Climb 1650 fpm; Service Ceiling 22,500 ft.; Absolute Ceiling 23,750 ft.; Range with Maximum Payload 1400 mi.



PIPER CHEROKEE

PIPER AIRCRAFT CORP., Lock Haven, Pennsylvania

REMARKS

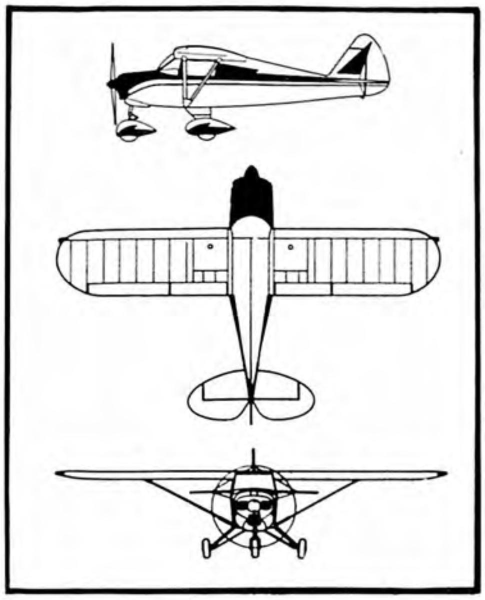
The Piper Cherokee, newest four-place business plane in the low-cost field, will go into production in January, 1961 at Piper's new manufacturing facility in Vero Beach, Florida.

SPECIFICATIONS

Span 30 ft.; Length 23.3 ft.; Height 7.3 ft.; Empty Weight 1195 lb.; Wing Loading 13.8 lb. per sq. ft.; Power Loading 13.8 lb. per hp.; Engine Lycoming O-320-B2B; Fuel Capacity 36 gal.

PERFORMANCE

Cruise Speed 132 mph at 75 percent power at 7000 ft.; Rate of Climb 680 fpm; Service Ceiling 15,000 ft.; Absolute Ceiling 17,500 ft.



PIPER COLT

PIPER AIRCRAFT CORP., Lock Haven, Pennsylvania

REMARKS

The Piper Colt is a two-passenger, 108 hp, sport and business plane with 115 mph cruising speed and side-by-side seating. It is the first "compact of the air."

SPECIFICATIONS

Span 30 ft.; Length 20 ft.; Height 6.25 ft.; Gross Weight 1650 lbs.; Wing Loading 11.2 lb. per sq. ft.; Power Loading 15.3 lb. per hp; Engine Lycoming O-235-CIB, 108 hp at 2600 rpm takeoff; Fuel Capacity 18 gal.

PERFORMANCE

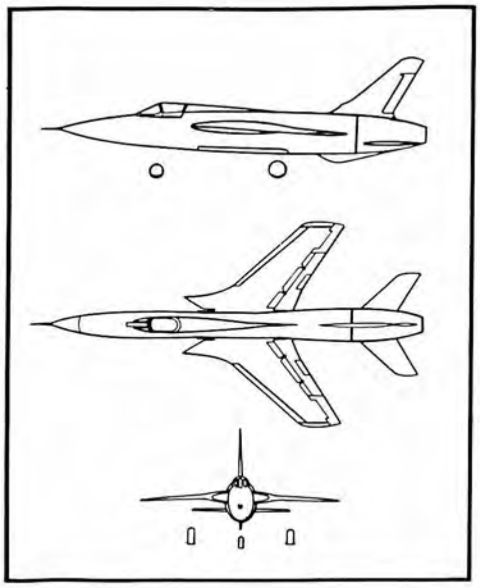
Cruise Speed 115 mph at 75 percent power at 7000 ft.; Rate of Climb 610 fpm; Service Ceiling 12,000 ft.; Absolute Ceiling 14,400 ft.

REPUBLIC F-105D THUNDERCHIEF

REPUBLIC AVIATION CORP., Farmingdale, Long Island, New York

REMARKS

The F-105D is the latest operational model of the Thunderchief series. Now in full production, it is in service with the Tactical Air Command's 4th Tactical Fighter Wing and the 4520th Combat Crew Training Wing. It is planned for deployment overseas with USAFE and PACAF. Similar to its predecessor, the F-105B, in its external configuration, the single seat 'D' has an area rule fuselage and specially designed swept-forward air-intake ducts, as well as the 360 degrees speed brake. Internally, the 'D' is radically different with its advanced electronic equipment providing all-weather, near automatic capabilities. In operation, the Mach 2 'D' 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 electronics-packed 'D' has a completely integrated bombing-navigation-search systems and can carry nuclear or thermonuclear weapons and guided or unguided missiles including the Sidewinder and Bullpup. Like the 'B', it is equipped with an automatic 20 millemeter cannon with a rate of fire of 6,000 rounds per minute.

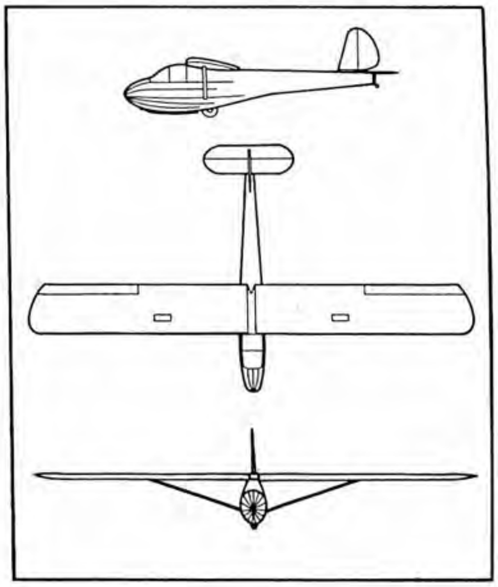


SPECIFICATIONS

Span 34 ft. 11 in.; Length 64 ft. 3 in.; Height 19 ft. 8 in.; Engine J75, 26,500 lb. thrust with water injection and afterburner.

PERFORMANCE

Speed Mach 2; Altitude Ceiling 50,000 plus.



SCHWEIZER 2-22C SAILPLANE

SCHWEIZER AIRCRAFT CORP., Elmira, New York

REMARKS

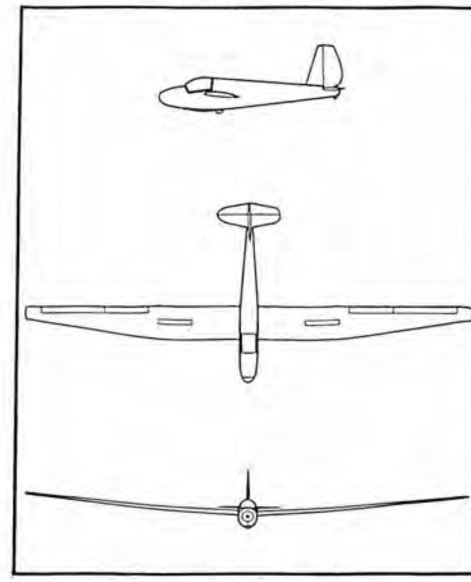
The 2-22C is the latest version of the 2-22 two-place trainer that was developed by Schweizer after World War II. The current "C" Model of this ship incorporates many improvements over the original model. The improvements include incorporation of lighter aileron control system, a fully-enclosed cabin with rear door to improve comfort and performance, re-location of the main wheel to improve control on the ground at slow speeds, positioning of cockpit seating to give more room and improve the instructor's visibility, lengthening of the nose and streamlining the canopy for better performance and appearance. Although not designed primarily for cross country, flights up to 100 miles have been made and its excellent small field landing characteristics make it ideal for the first cross-country attempts. The new model 2-22C is available in five forms. Dry Kit, Standard Kit, Unit Purchase Plan, Uncovered Sailplane and Completed Sailplane. Schweizer is also producing the 1-26 and 1-23H sailplanes.

SPECIFICATIONS

Span 43 ft.; Length 25 ft. 8.5 in.; Height 9 ft.; Empty Weight 450 lb.; Gross Weight 900 lb.; Wing Loading 4.28 lb. per sq. ft.

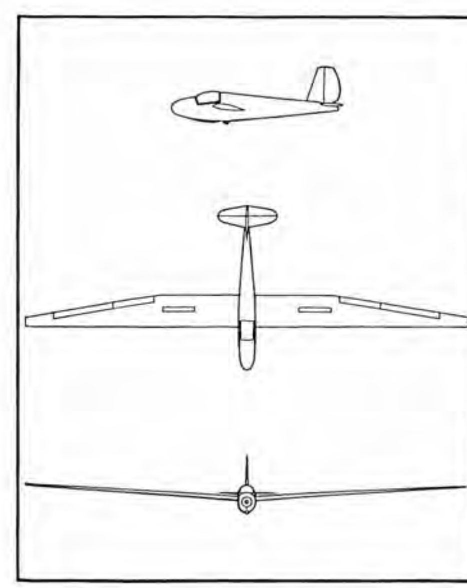
PERFORMANCE

Minimum Sinking Speed (solo) 2.8 ft./sec.; (dual) 3 ft./sec.; Cruise Speed 89 mph; Placard Speed 90 mph.



SCHWEIZER 1-23H and 1-23H-15 SAILPLANES

SCHWEIZER AIRCRAFT CORP., Elmira, New York



REMARKS

The 1-23H and 1-23H-15 are the latest FAA approved sailplanes being produced by Schweizer Aircraft. It is the development from the 1-23 series and is featured in two models; the 1-23H-15 which is the 15 meter Standard Class sailplane and the 1-23H which is the extended wing version with a span of 52 ft. 8 in. This ship incorporates the new speed limiting dive brakes which reduces the terminal velocity speed. The conversion from one model to the other is by means of detachable wing tips which can be bolted in place in a very short time. The models are available in primed, ready-to-fly form or in the completely finished model. It is a high performance sailplane and designed for contest flying.

SPECIFICATIONS

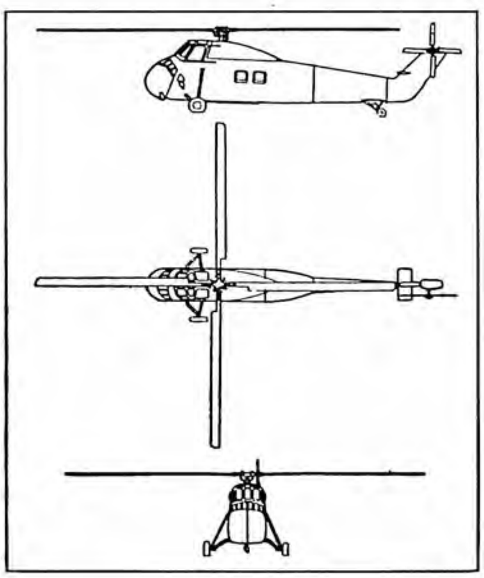
1-23H: Span 52 ft. 8 in., Length 20 ft. 10 in., Height 7 ft. 6 in., Empty Weight 480 lb., Weight Loaded 750 lb., Wing Loading 4.56 lb. per sq. ft.; 1-23H-15: Span 49 ft. 2 in., Length 20 ft. 10 in., Height 7 ft. 6 in., Empty Weight 474 lb., Weight Loaded 750 lbs., Wing Loading 4.70 lb. per sq. ft.

PERFORMANCE

1-23H: Minimum Sinking Speed 2.05 ft./sec., Cruise Speed 88.50 mph, Placard Speed 130 mph; 1-23H-15: Minimum Sinking Speed 2.15 ft./sec., Cruise Speed 87.50 mph, Placard Speed 130 mph.

SIKORSKY S-58; *HSS (Navy), H-34 (Army), HUS (Marines & Coast Guard)*

SIKORSKY AIRCRAFT DIVISION, United Aircraft Corp., Stratford, Connecticut



REMARKS

The S-58 is flown by the Navy, Marine Corps, Army, Coast Guard, eight foreign countries and commercial helicopter airlines. It is also used by the Navy for anti-submarine warfare. President Eisenhower made frequent use of the Marine and Army versions of the S-58, embarking and disembarking from the White House lawn. More than 1,300 S-58s have been manufactured. This aircraft has a seating capacity of crew (pilot and co-pilot), 12-18 passengers, eight litters or a net payload of 4000 pounds for a distance of 100 miles. Structural provisions for a 5000-pound automatic touch down release cargo sling and a 600-pound hydraulically-operated utility hoist are standard equipment. Automatic stabilization equipment is being installed on Navy, Marine, Army and Coast Guard versions of the aircraft and has been certified by the CAA for use on Commercial S-58s. Holds three world records for speed in a closed circuit without payload; 100 kilometers (62.137 mi.), 141.9 mph; 500 kilometers (310.685 mi.) 136 mph; 1000 kilometers (621.369 mi.), 132.6 mph.

SPECIFICATIONS

Length 46 ft. 9 in. (Tail Pylon Not Folded); Height 15 ft. 11 in.; Empty Weight 7,630 lb. (With Standard Equipment); Gross Weight 13,000 lb.; Useful Load 5,370 lb.; Engine Wright Cyclone 989C9HE2 1275 hp normal rated at 2500 rpm or 1525 hp at 2800 rpm takeoff; Fuel Capacity 290 gal.; Main Rotor Diameter 56 ft.

PERFORMANCE

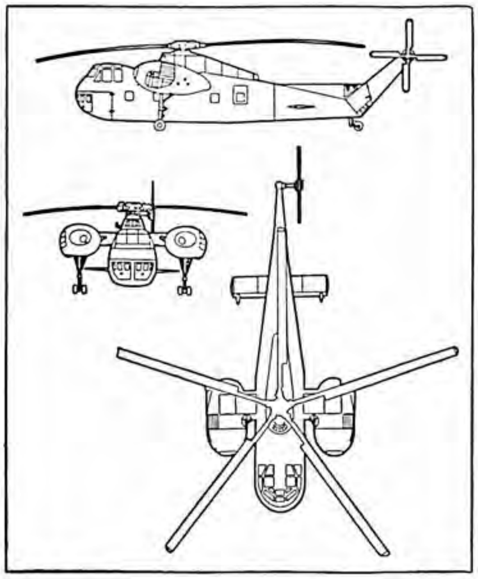
Maximum Speed 123 mph at Sea Level; Cruise Speed 98 mph; Best Rate of Climb 1100 fpm at Sea Level.

SIKORSKY S-56; *H-37 (Army); HR2S (Marines)*

SIKORSKY AIRCRAFT DIVISION, United Aircraft Corp., Stratford, Connecticut

REMARKS

The twin-engine S-56 has been delivered to both Army and Marine units and carries 36 fully-equipped troops or equivalent payload in cargo. Loading and unloading may be achieved through clamshell doors in the nose, a cabin floor hatch or cargo door located on the right side of the fuselage. A traversing electric hoist with 2000-pound capacity permits easy cargo shifting in the cabin. Auto-pilot and semi-automatic blade folding equipment are featured as is retractable landing gear. Five-bladed main and four-bladed tail rotors are all metal. More than 150 S-56s have been made. Holds two world records: Maximum speed without payload (over 3 Kil. course), 162.7 mph; altitude with 5000 Kg. load (11,023.110 lb.), 12,100 ft.



SPECIFICATIONS

Rotor Diameter 72 ft.; Length 64 ft. 3 in.; Gross Weight 31,000 lb.; Engines Two Pratt & Whitney R2800, derated to 2100 hp.

PERFORMANCE

Maximum Speed 130 mph; Cruise Speed 115 mph; Best Rate of Climb at Sea Level 910 fpm.

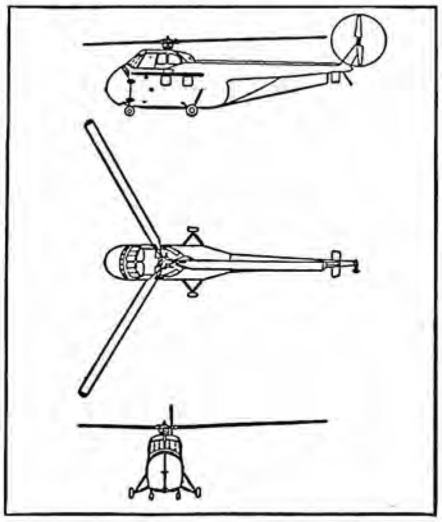
SIKORSKY S-55;

H-19 (Air Force, Army) HRS (Marines) HO4S (Navy, Coast Guard)

SIKORSKY AIRCRAFT DIVISION, United Aircraft Corp., Stratford, Connecticut

REMARKS

The S-55 has a seating capacity of crew (pilot and co-pilot), passengers (commercial-7) (military-10), with aternate cargo capacity of 330 cubic feet. More than 1280 S-55s have been manufactured.

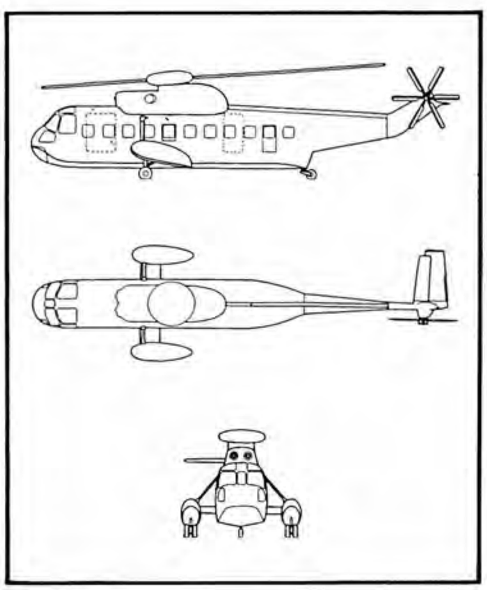


SPECIFICATIONS

Main Rotor Diameter 53 ft.; Tail Rotor Diameter 8 ft. 9 in.; Length 42 ft. 3 in.; Height 13 ft. 4 in.; Empty Weight 4950 lb.; Gross Weight 7200 lb.; Engine Pratt & Whitney S3H2 rated at 600 bhp; Fuel Capacity 185 gal. Alternate 7500 lb. G. W. configuration uses Wright R1300 engine derated to 700 hp.

PERFORMANCE

Maximum Speed 101 mph; Cruise Speed 85 mph; Maximum Rate of Climb at Sea Level 700 fpm; Range 400 st. mi.; Service Ceiling 10,500 ft.



SIKORSKY S-61; *HSS-2 (Navy)*

SIKORSKY AIRCRAFT DIVISION, United Aircraft Corp., Stratford, Connecticut

REMARKS

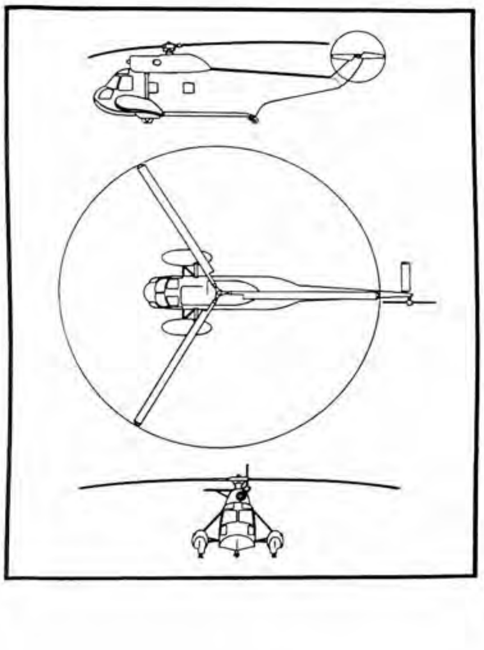
The HSS-2, the world's largest amphibious helicopter, has a flying boat hull and twin gas turbine engines. It is being produced for the Navy as an anti-submarine warfare weapons system and will be the Navy's first all-weather helicopter. The HSS-2 has undergone the most thorough and extensive development program in the history of the industry, and fleet deliveries are scheduled to commence in the first half of 1961. The HSS-2 was flown publicly for the first time March 24, 1959. Along with the production of the HSS-2 is the commercial S-61L, a 25-28 passenger helicopter which has been ordered by Los Angeles Airways and Chicago Helicopter Airways. First flight of the S-61L took place December 6, 1960, with deliveries scheduled for 1961.

SPECIFICATIONS

Rotor Diameter 62 ft.; Overall Length 72 ft. 8.5 in.; Fuselage Length 58 ft. 11 in.; Empty Weight 9,270 lb.; Gross Weight 18,700 lb.; Useful Load 9,730 lb.; Engines Two General Electric T58-8s, 1250 shp maximum power, 1050 shp normal rated power; Fuel Capacity 390 gal.

PERFORMANCE

Average Cruising Speed 136 mph at Sea Level; Maximum Speed 147 mph at Sea Level; Best Rate of Climb 1600 fpm at Sea Level; Range with Normal Fuel Load 250 st. mi.



SIKORSKY S-62

SIKORSKY AIRCRAFT DIVISION, United Aircraft Corp., Stratford, Connecticut

REMARKS

The single-turbine S-62 is the first American turbine-powered helicopter to be certified by the Federal Aviation Agency for commercial operations. It also is the first helicopter of any type to be certified under the FAA's new helicopter transport regulations, which are far more stringent than previous requirements. The FAA certificate permits the S-62 to carry a pilot, a co-pilot and 11 passengers. The S-62 is an amphibious helicopter with a flying boat hull, and it can operate from land, water, ice, snow, swamp, mud, or almost any other surface. The first flight took place May 22, 1958, and production is now under way. This helicopter is expected to have wide commercial and military applications. The S-62 flew from the start with proven mechanical components having extended overhaul periods. This was accomplished under the Sikorsky building block concept of blending a new airframe and a modern gas turbine power plant with the mechanical components of the time-tested Sikorsky S-55. The S-55 has mechanical components proved in world-wide operations during more than 1,200,000 flight-hours and the almost 1300 helicopters of this type manufactured during the past eleven years.

SPECIFICATIONS

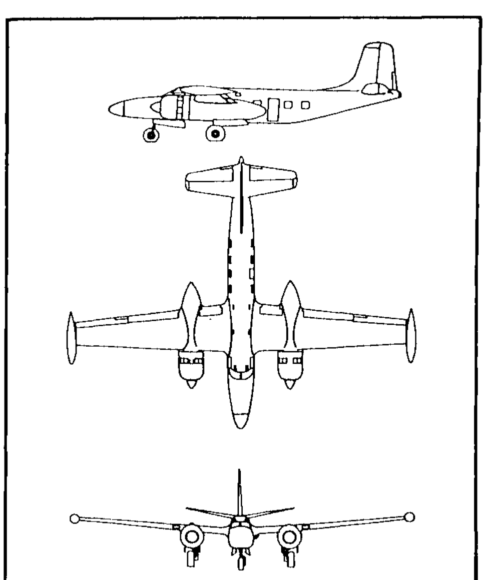
Length 44 ft. 7 in.; Height 14 ft 2 in.; Empty Weight 4,789 lb.; Gross Weight 7500 lb.; Useful Load 2,711 lb.; Engine General Electric CT58-100-1, 1050 shp maximum power, 900 shp normal rated power (derated to 670 shp); Fuel Capacity 182 gal.; Main Rotor Diameter 53 ft.

PERFORMANCE

Crusing Speed 98 mph at Sea Level; Maximum Speed 109 mph at Sea Level; Maximum Rate of Climb 1380 fpm at Sea Level; Range with normal Fuel Load 270 mi.

TEMPO II

L. B. SMITH AIRCRAFT CORP., Miami 48, Florida



REMARKS

The first production prototype of L. B. Smith Aircraft's pressurized executive transport, designated Tempo II, completed F.A.A. flight test demonstrations and was certificated on September 21, 1960. Further testing, in accordance with CAR-4b standards, was accomplished during the latter part of 1960 with the result that Tempo II is the only Executive version of the Douglas B-26 in production today to be available for delivery with an F.A.A. approved, 4b type Aircraft Flight Manual.

Because of its inherent good design, safety record, excellent handling characteristics, the famous Douglas B-26 was selected as the basic airframe upon which the Tempo II development program was begun . . . Retaining only the wings, control surfaces and nacelles of the original plane . . . a completely new, fail-safe, pressurized fuselage is manufactured using CAR-4b procedures as a manufacturing guide, that is nine feet, five and one-half inches longer than that of the standard B-26 fuselage, with a constant interior height of six feet, two inches from the cockpit to the rearmost passenger seat . . . thus providing more space for both pilot and passengers than any executive version of the B-26 now in production.

In addition to the longer, higher cabin . . . the original cabin-cutting, carry thru wing spars have been eliminated and replaced by two sets of fuselage spar-ring frames of one and one-quarter inches thick, rolled aluminum alloy plate. This exclusive design permits stand-erect, walk-thru passage from the pilot compartment to the passenger area. The installation causes the wings and engines to be moved outboard, for an increased wing span of twenty inches, contributing to lower cabin noise levels and results in overall, net performance gains due to the increased wing area for added lift and decreased wing loading.

The cabin area, forward of the aft ring spar and aft of the pilot compartment, is utilized for a full height lavatory, a complete galley and the radio rack. The standard ten passenger cabin is thereby cleared for installation of executive seating and furniture. Tempo II's entire interior, decorated to suit individual needs and tastes is included as standard equipment.

The pressurization system, encompassed by strictly "off-the-shelf" components with the exception of plumbing and ducting, provides a differential of 4.17 psi or a cabin pressure less than 8,000 ft. at a 20,000 foot operating altitude.

Early in December, 1960, the second Tempo II was ready for delivery to General Mills, Inc. of Minneapolis.

SPECIFICATIONS

Span 73 ft. 5½ in.; Length 60 ft. 3.5 in.; Height 20 ft. 0 in.; Empty Weight 24,500 lb.; Wing Loading 61.6 lb. per sq. ft.; Power Loading 7.3 lb. per bhp; Engines Two Water Injected Pratt & Whitney R-2800 Cs; 1800 hp normal rated, or 2400 hp at 2800 rpm takeoff; Fuel Capacity 1400 gal.; Propeller Hamilton Standard 43E60/6895-20 (reversible); Wing Area 570 sq. ft.; Aileron Area 13.62 sq. ft.; Flap Area 65.9 sq. ft.; Fin Area 48.2 sq. ft.; Rudder Area 23.4 sq. ft.; Stabilizer Area 83.4 sq. ft.; Elevator Area 32.7 sq. ft.

PERFORMANCE

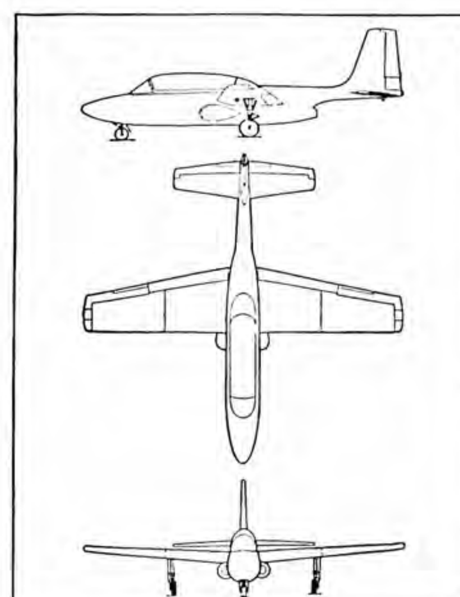
Maximum Speed 405 (TAS); Cruise Speed 350 (TAS) mph at 67 percent hp at 2,400 rpm at 20,000 ft.; Landing Speed 111 mph; Rate of Climb 1,650 fpm at Sea Level; Service Ceiling 29,600 ft.; Range with Maximum Fuel Load 2,400 mi.

TEMPCO TT-1 PINTO TRAINER

TEMPCO AIRCRAFT CORP., Milwaukee, Wisconsin

REMARKS

The TT-1 Pinto primary jet trainer completed its pioneering role for the Navy at Saufley Field, Pensacola, Florida. Training of pilots in the Navy's first all-jet syllabus began in January, 1959, with initial solo flights in March, 1959. Other classes followed the pioneers, and in August, night solo flights were performed in TT-1s. Evaluation of the all-jet program was completed in August, 1960, and further production is deferred pending the Navy's decision to reinstitute the all-jet training program. The TT-1 has performance and features planned for easy transition into jets to be flown later in the program. The Pinto is suitable for all conventional aerobatics and has such equipment as ejection seats, liquid oxygen system, integrated torso harness, UHF radio and speed brakes. It was designed specifically for efficient introduction of jet "feel" to primary trainees, but to accomplish more than has been previously taught in that stage of training. The TT-1 combines a subsonic dive speed of 450 knots with a stall speed low enough for first solo flights. Ruggedly built and economical to operate, the TT-1 is stressed for more powerful engines if desired, and the company currently is developing a TT-2 version which will raise the maximum limits of the flight envelope while retaining the minimums desirable in a primary trainer.

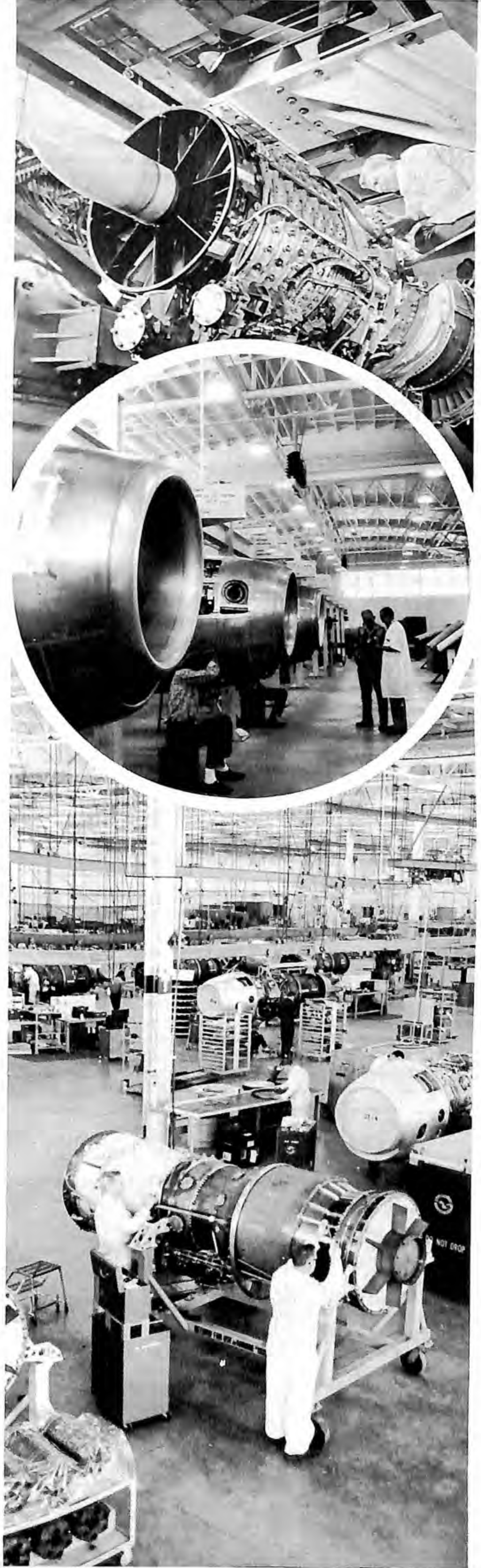


SPECIFICATIONS

Span 29 ft. 10 in.; Length 30 ft.; Height 10 ft. 10 in.; Empty Weight 3139 lb.; Gross Weight 4400 lb.; Overload Gross Weight 4440 lb.; Wing Loading 29.4 lb. per sq. ft.; Power Loading 4.78 lb. per bhp; Engine Continental J69-T-2, 920 lb. thrust; Fuel Capacity 124 gal.; Wing Area 150 sq. ft.; Aileron Area 10.4 sq. ft.; Flap Area 15.65 sq. ft.; Fin Area 23.5 sq. ft.; Rudder Area 5.32 sq. ft.; Stabilizer Area 39 sq. ft.; Elevator Area 11.6 sq. ft.

PERFORMANCE

Maximum Speed 286 knots at 100 percent rpm at 15,000 ft.; Average Cruise Speed 234 knots at 100 percent rpm at 22,350 ft.; Landing Speed 70 to 75 knots; Rate of Climb 1900 fpm at Sea Level; Service Ceiling 30,000 ft.; Absolute Ceiling 32,800 ft.; Range with Maximum Fuel Load 239 nautical mi.



ENGINES IN PRODUCTION

AEROJET-GENERAL CORPORATION

AZUSA, CALIFORNIA

• **MODEL: 15KS-1000 AIRCRAFT ROCKET ENGINE**

Data

Type: Solid-propellant rocket.

Specs

Diameter: 10.30 in. Length: 33.45 in. Empty Weight: 72 lb. Loaded Weight: 144 lb.

Performance

Rating: 1000 lb. thrust, or 400 horsepower, for 15 secs.

Equipment

The engine consists of a steel cylinder closed on the fore end. The igniter is on the fore end, and the exhaust nozzle and pressure release diaphragm are on the aft end. Thrust is transmitted to the aircraft attachment fittings through two mounting lugs welded on the cylinder.

Remarks

The 15KS-1000 aircraft rocket engine was originally developed as a smokeless JATO (jet-assisted takeoff unit) for the Navy, Bureau of Aeronautics. It is one of the two rocket engines certificated by the FAA.

• **MODEL: 5KS-4500 AIRCRAFT ROCKET ENGINE**

Data

Type: Solid-propellant rocket.

Specs

Diameter: 9.38 in. Length: 54.57 in. Empty Weight: 123 lb. Loaded Weight: 236 lb.

Performance

Rating: 4500 lb. thrust for 5 secs.

Equipment

The engine consists of a steel cylinder closed on the fore end. The igniter is on the fore end, and the canted exhaust nozzle and the pressure release diaphragm are on the aft end. Thrust is transmitted to the aircraft attachment fittings by two mounting lugs welded on the cylinder.

Remarks

5KS-4500 units are used for the assisted takeoff of carrier-based aircraft, or whenever high thrust is required for short duration. These engines are also employed to propel high-velocity deceleration sleds.

- **MODEL: AJ10-24 BOOSTER ROCKET ENGINE**

Data

Type: Liquid bi-propellant rocket, gas or chemically pressurized.

Specs

Diameter: 15 in. Length: 130 in.

Equipment

Assembly consists of a cylindrical section which contains the oxidizer, fuel and pressurizing tanks. The pressure regulator and rocket motor are attached to the tank section.

Remarks

This powerplant is used to propel the Aerobee high-altitude sounding rocket in investigations of the upper atmosphere.

- **MODEL: 15NS-250 AIRCRAFT ROCKET ENGINE**

Data

Type: Solid-propellant rocket.

Specs

Diameter: 6 in. Length: 26.6 in. overall. Empty Weight: 21 lb. Loaded Weight: 42 lb.

Performance

Rating: 250 lb. thrust for duration of 15 secs. Nominal at 60°F.

Equipment

The engine consists of a steel cylinder closed on the forward end. The igniter is on the fore end, while the exhaust nozzle and two pressure release diaphragms are on the aft end. Thrust is transmitted to the attachment fittings by two mounting lugs welded on the cylinder.

Remarks

The 15NS-250 "Junior JATO" aircraft rocket engine was developed specifically for use as standby rocket power on light aircraft. This engine received FAA Engine Type Certificate 250 on April 25, 1958. It is one of the only two rocket engines to be so certificated by the FAA.

- **MODEL: 2.2KS-11,000 ROCKET ENGINE**

Data

Type: Solid-propellant rocket.

Specs

Diameter: 11.38 in. Length: 52.0 in. overall. Empty Weight: 113 lb. Loaded Weight: 256 lb.

Performance

Rating: 11,000 lb. thrust for a duration of 2.2 secs.

Equipment

The engine consists of a steel cylinder closed on the fore end. The igniter and the pressure release diaphragm are on the fore end, while the exhaust nozzle is on the aft end. Thrust is transmitted to the attachment fittings by two mounting bands installed around the cylinder.

Remarks

2.2KS-11,000 units are employed to propel high-velocity test sleds and may be employed as zero launch missile boosters.

- **MODEL: 2.2KS-33,000 ROCKET ENGINE**

Data

Type: Solid-propellant rocket.

Specs

Diameter: 13.42 in. Length: 109.50 in. overall. Empty Weight: 426 lb. Loaded Weight: 838 lb.

Performance

Rating: 33,000 lb. thrust for a duration of 2.2 secs.

Equipment

The engine consists of a steel cylinder closed on the fore end. The igniter and the pressure release diaphragm are on the fore end and the adjustable nozzle is on the aft end. The nozzle may be canted 1° above the chamber center line to 22° below and 4° to either side of the principal plane of adjustment. Thrust is transmitted to the attachment fittings by two mounting bands installed around the cylinder.

Remarks

2.2KS-33,000 units may be employed as zero launch missile boosters or to propel high-velocity test sleds.

- **MODEL: 40NS-4500 ROCKET ENGINE**

Data

Type: Solid-propellant rocket.

Specs

Diameter: 16.03 in. Length: 152.5 in. overall. Empty Weight: 1382 lb. Loaded Weight: 2380 lb.

Performance

Rating: 4500 lb. thrust for a duration of 40 secs.

Equipment

The engine consists of a steel cylinder closed on the fore end. The igniter and the pressure release diaphragm are on the fore end while the exhaust nozzle is on the aft end. Thrust is transmitted to the aircraft attachment fittings by mounting bands installed around the cylinder.

Remarks

40 NS-4500 units may be employed for assist takeoff of large aircraft.

- **MODEL: AJ10-33 BOOSTER ROCKET ENGINE**

Remarks

This triple thrust chamber, liquid-propellant, rocket sled powerplant is the most powerful such unit ever developed. It was designed and built for use at the Hurricane Supersonic Research' Site at Hurricane Mesa, Utah, to test airplane cockpit ejection systems for supersonic aircraft. This engine develops the equivalent of one-half million horsepower during the run, driving the sled at a maximum velocity of 1600 ft. sec. with an acceleration of 8-10 g's. The use of multiple thrust chambers makes possible the high velocities noted above as well as better control of the thrust level and consequent wide applications in the rocket-sled field.

- **MODEL: AJ10-37 BOOSTER ROCKET ENGINE**

Remarks

This engine is used as the powerplant for the second stage of the Vanguard, satellite-launching vehicle. Performance data are classified on this bi-propellant liquid rocket engine. The second stage engine drives the satellite and its third stage from the 40-mile first stage burnout altitude to the second stage burnout altitude of 130 miles. The vehicle then coasts to its orbital altitude where a small amount of residual propellant is burned to tip the vehicle over to a horizontal position. The third stage engine then fires to complete the satellite launching mission.

AIRCOOLED MOTORS, INC.

SYRACUSE, NEW YORK

- **MODEL: FRANKLIN 6A4-165-B3**

Data

Type: 6 cylinder, air-cooled, horizontally opposed. FAA Type Certificate: 238.

Specs

Length: 27$^{13}/_{32}$ in. Fuel Grade: 80 octane. Bore: 4.5 in. Stroke: 3.5 in. Displacement: 335 cu. in. Compression Ratio: 7:1. Dry Weight: 324 lb. with hub and accessories. Weight per hp: 1.97 lb.

Performance:

Takeoff Power: 165 hp at 2800 rpm. Cruise: 124 hp at 2200 rpm. Fuel Consumption: .5 lb. per hp hr. Oil Consumption: .002 lb. per hp hr.

Equipment

Carburetor: Marvel-Schebler MA4-5. Ignition: Dual Scintilla S6N21. Starter: Delco-Remy. Generator: Delco-Remy. Fuel Pump: AC.

• MODEL: FRANKLIN 6V4-200-C32, C33

Data

Type: 6 cylinder, air-cooled, horizontally opposed. FAA Type Certificate: 244.

Specs

Length: 29$\frac{1}{32}$ in. Fuel Grade: 91 octane. Bore: 4.5 in. Stroke: 3.5 in. Displacement: 335 cu. in. Compression Ratio: 8.5:1. Dry Weight: 333 lb. with accessories. Weight per hp: 1.66 lb.

Performance

Takeoff Power: 200 hp. Fuel Consumption: .52 lb. per hp hr. Oil Consumption: .002 lb. per hp hr.

Equipment

Carburetor: Marvel-Schebler MA4-5. Ignition: Dual Scintilla S6RN21. Starter: Delco-Remy. Generator: Delco-Remy. Fuel Pump: Weldon.

Remarks

This model was designed for helicopter installations.

• MODEL: FRANKLIN 6V-335-A, B

Data

Type: 6 cylinder, air-cooled, horizontally opposed; 210 hp. FAA Type Certificate: 244.

Specs

Length: 34¾ in. Fuel Grade: 91 octane. Bore: 4.5 in. Stroke: 3.5 in. Displacement: 335 cu. in. Compression Ratio: 8.5:1. Dry Weight: 308 lb. Weight per hp: 1.46 lb.

Performance

Takoff Power: 210 hp. Fuel Consumption: .52 lb. per hp hr. Oil Consumption: .002 lb. per hp hr.

Equipment

Carburetor: Marvel-Schebler MA4-5. Ignition: Dual Scintilla S6RN21. Starter: Delco-Remy. Generator: Delco-Remy. Fuel Pump: Weldon. Designed for helicopter installation.

• MODEL: FRANKLIN 6A4-150-B3

Data

Type: 6 cylinder, air-cooled, horizontally opposed. FAA Type Certificate: 238.

Specs

Length: 37⅜ in. Fuel Grade: 80 octane. Bore: 4.5 in. Stroke: 3.5 in. Displacement: 335 cu. in. Compression Ratio: 7:1. Dry Weight: 321 lb. with hub and accessories. Weight per hp: 2.14 lb.

Performance

Takeoff Power: 150 hp at 2600 rpm. Cruise: 113 hp at 2350 rpm. Fuel Consumption: .5 lb. per hp hr. Oil Consumption: .002 lb. per hp hr.

Equipment

Carburetor: Marvel-Schebler MA-3SPA. Ignition: Dual Eisemann LA-6 or Scintilla S6RN21. Starter: Delco-Remy. Generator: Delco-Remy. Fuel Pump: AC.

• MODEL: 6VS-335

Data

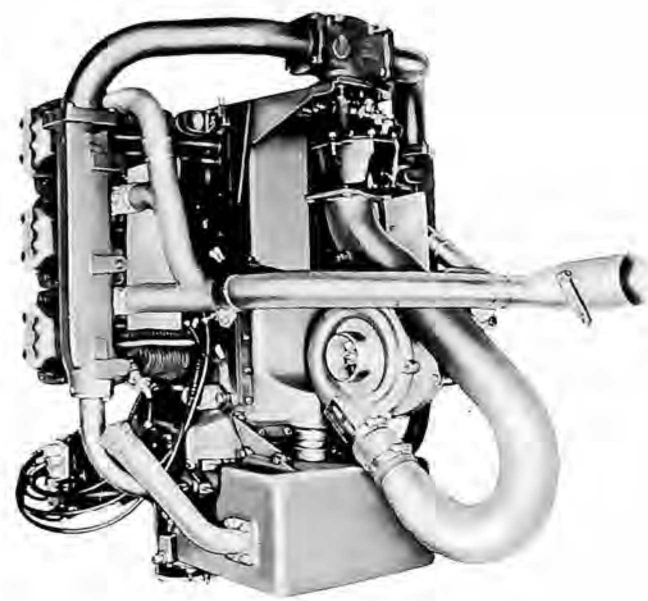
Type: 6 cylinder, air-cooled, horizontally opposed, turbosupercharged. FAA Type Certificate: 1E2.

Specs

Height: 38$\frac{9}{64}$ in. Depth: 39¾ in. Width: 31$\frac{9}{16}$ in. Displacement: 335 cu. in. Bore: 4½ in. Stroke: 3½ in. Compression Ratio: 7:1. Fuel Grade: 100/130. Dry Weight: 284 lb. Total Weight: 360 lb., including starter, carburetor, ignition, fuel pump, turbo and complete exhaust system.

Performance

Fuel Consumption: Normal rating .55 lb. per hp hr., at 70% power, .50 lb. per hp hr., Oil Consumption: Normal rating .020 lb. per hp hr., at 70% power. .015 lb. per hp hr. Other performance data: 225 hp sea level rating, maintains full rating up to 15,000 ft.



FRANKLIN Model 6VS-335

Equipment

Carburetor: Marvel MA-6. Magnetos: Two Scintilla S6RN23s. Starter: Delco-Remy 24 volt. Generator: (Optional) Pierson 28 volt. Turbosupercharger; Fuel pump, Complete exhaust system. Designed for helicopter installation.

• MODEL: FRANKLIN 6A-335-A

Data

Type: 6 cylinder, air-cooled, horizontally opposed; 210 hp.

Specs

Length: 36⅝ in. Width: 31$\frac{19}{32}$ in. Displacement: 335 cu. in. Bore: 4½ in. Stroke 3½ in. Compression Ratio: 8.5:1. Fuel Grade: 91 octane. Dry Weight: 308 lb.

Equipment

Carburetor: Marvel-Schebler MA4-5. Magnetos: Scintilla S6RN21. Starter: Delco-Remy 24 volt. Generator: Pierson 24 volt, 20 amp.

AiRESEARCH MANUFACTURING DIVISION

THE GARRETT CORPORATION

PHOENIX, ARIZONA

• MODEL: GTC 85 Series

Type: Gas Turbine Compressor, open cycle without regenerator.

Specs

Length: 39.0 in. Width: 26.95 in. Weight: 230 pounds, complete with accessories. Compressor: centrifugal. Turbine: single stage, radial inward flow inlet, axial flow discharge.

Performance

(Typical of one unit, units of both higher and lower perf. available): Total air mass flow, 132 lbs./min. Pressure ratio: 3.69:1 rating (cont. air hp): 200 ahp fuel consumption 1.18 lbs./ahp/hr. oil consumption: 0.25 lbs./ahp/hr.

Remarks

Reliable, compact, independent source of pneumatic power for starting turbojet and turboprop engines and for furnishing compressed air for turbine driven vapor or air cycle refrigeration machines, cabin heating, ground checkout, ice and snow removal and other low pressure pneumatic functions. Unit can be aircraft mounted or installed in either a trailer or self-propelled vehicle.

ALLISON DIVISION

GENERAL MOTORS CORPORATION

INDIANAPOLIS, INDIANA

• **MODEL: T56-A-7**

Data

Type: Axial-flow propjet.

Specs

Length: 145 in. Width: 28 in. Fuel Grade: JP-4. Dry Weight: 1850 lb. Compressor Stages: 14. Turbine Stages: 4.

Performance

Fuel Consumption: 0.541. Oil Consumption: 2.8.

Equipment

Starter: Govt. furn. equip.

Remarks

Designed for installation in Lockheed C-130B Hercules; ESHP 4050 at 13,820 rpm, sea level conditions.

• **MODEL: T56-A-8**

Data

Type: Axial-flow propjet.

Specs

Length: 145 in. Width: 28 in. Fuel Grade: JP-5. Dry Weight: 1850 lb. Compressor Stages: 14. Turbine Stages: 4.

Performance

Maximum Thrust: 740. Normal Rated Thrust: 718. Fuel Consumption: 0.544. Oil Consumption: 2.8.

Equipment

Starter: Govt. furn. equip.

Remarks

ESHP 4050 at 13,820 rpm, sea level conditions.

• **MODEL: T56-A-9**

Data

Type: Axial-flow propjet.

Specs

Length: 145 in. Width: 28 in. Fuel Grade: JP-4. Dry Weight: 1679 lb. Compressor Stages: 14. Turbine Stages: 4.

Performance

Maximum Thrust: 726. Normal Rated Thrust: 702. Fuel Consumption: 0.55. Oil Consumption: 3.6.

Equipment

Starter: Govt. furn. equip.

Remarks

Current production installation is Lockheed C-130A Hercules; ESHP 3750 at 13,820 rpm, sea level conditions.

• **MODEL: T56-A-10W**

Data

Type: Axial-flow propjet.

Specs

Length: 145 in. Width: 28 in. Fuel Grade: JP-4/JP-5. Dry Weight: 1850 lb. Compressor Stages: 14. Turbine Stages: 4.

Performance

Maximum Thrust: 750. Normal Rated Thrust: 718. Fuel Consumption: 0.541. Oil Consumption: 2.8.

Equipment

Starter: Govt. furn. equip.

Remarks

Designed for P3V-1 Lockheed Electra; ESHP 4500 with water-alcohol injection.

• **MODEL: B2**

Data

Type: Free turbine propjet.

Specs

Length: 38.5. Width: 15.8. Fuel Grade: JP-4 (Alternate 115/145). Dry Weight: 147 lb. Compressor Stages: 7 axial; 1 centrifugal. Turbine Stages: Single-stage gas producer; Two-stage power turbine.

Performance

Fuel Consumption: 0.70.

Remarks

Rated at 250 SHP.

• **MODEL: C2**

Data

Type: Free turbine turbo-shaft.

Specs

Length: 34.6. Width: 15.8. Fuel Grade: JP-4 (Alternate 115/145). Dry Weight: 110 lb. Compressor Stages: 7 axial; 1 centrifugal. Turbine Stages: Single-stage gas producer; Two-stage power turbine.

Performance

Fuel Consumption: 0.70.

Remarks

Rated at 250 SHP.

• **MODEL: 501-D13 PROPJET ENGINE**

Data

Type: Axial-flow propjet.

Specs

Length: 145 in. Width: 27 in. Weight: 1750 lb. Compressor Stages: 14. Turbine Stages: 4.

Equipment

Starter: Airframe-furnished.

Remarks

Current production installation in Lockheed Electra commercial transport; ESHP 3750 at 13,820 rpm, sea level conditions.

• **MODEL: T56-A-1A**

Data

Type: Axial-flow propjet.

Specs

Length: 145 in. Width: 27 in. Total Weight: 1645 lb. Compressor Stages: 14. Turbine Stages: 4.

Equipment

Starter: Govt. furn. equip.

Remarks

Current production installation is in Lockheed C-130A Hercules; ESHP 3750 at 13,820 rpm, sea level conditions.

BOEING AIRPLANE COMPANY

INDUSTRIAL PRODUCTS DIVISION

• **MODEL: 502-10S**

Data

Type: Simple Cycle Two-Shaft Free Power Turboprop.

Specs

Length: 41.5 in.; Width: 24 in.; Fuel Grade: all fuels except leaded gasoline; Dry Weight: 325 lb. (290 Magnesium). Compressor Stages: 1 Single-Stage Centrifugal; Turbine Stages: Single-Stage Gas Producer; Single-Stage Power Turbine.

Performance

360 hp at 3400 rpm; Fuel Consumption: 0.90.

Equipment

Starter: 24 volt 30 ampere Starter-Generator.

Remarks
Powerplant for Radioplane RP-77D Target Drone.

• **MODEL: 502-10V**

Data
Type: Simple Cycle Two-Shaft Free Power Turboshaft.

Specs
Length: 41.5 in.; Width: 24 in.; Fuel Grade: All fuels except leaded gasoline; Dry Weight: 280 lb.; Compressor Stages: One Single-Stage Centrifugal; Turbine Stages: Single-Stage Gas Producer; Single-Stage Power Turbine.

Performance
270 hp at 6000 rpm; Fuel Consumption: 1.02.

Equipment
Starter: 24 volt 30 ampere Starter-Generator.

Remarks
Powerplant for Gyrodyne DSN-3 Drone Helicopter.

• **MODEL: 502-10W**

Data
Type: Simple Cycle Two-Shaft Free Power Turboprop.

Specs
Length: 41.5 in.; Width: 24 in.; Fuel Grade: All fuels except leaded gasoline; Dry Weight: 325 lb. (290-Magnesium); Compressor Stages: One Single-Stage Centrifugal; Turbine Stages: Single-Stage Gas Producer; Single-Stage Power Turbine.

Performance
325 hp at 2600-2900 rpm; Fuel Consumption: 0.89.

Equipment
Starter: 24 volt 30 ampere Starter-Generator.

• **MODEL: 502-10WA**

Data
Type: Simple Cycle Two-Shaft Free Power Turboshaft.

Specs
Length: 41.5 in.; Width: 24 in.; Fuel Grade: All fuels except leaded gasoline; Dry Weight: 300 lb. (265 Magnesium); Compressor Stages: One Single-Stage Centrifugal; Turbine Stages: Single-Stage Gas Producer; Single-Stage Power Turbine.

Performance
285 hp at 3000-3400 rpm; Fuel Consumption: 0.93.

Equipment
Starter: 24 volt 30 ampere Starter-Generator.

• **MODEL: 502-11BA**

Data
Type: Gas Turbine-Driven Compressor.

BOEING Model 502 Series Gas Turbine

Specs
Length: 50 in.; Width: 28.5 in.; Fuel Grade: All fuels except leaded gasoline; Dry Weight: 410 lb. (includes air compressor); Compressor Stages; One Single-Stage Centrifugal; Turbine Stages: Single-Stage Gas Producer; Single-Stage Power Turbine.

Performance
205 air hp; Fuel Consumption: 1.19.

Equipment
Starter: 24 volt 30 ampere Starter-Generator.

Remarks
Used in Boeing Turbo-Starter ground support unit by 10 domestic and foreign airlines.

• **MODEL: T60-BO-2 (520-2)**

Data
Type: Simple Cycle Two-Shaft Free Power Turboshaft.

Specs
Length: 57.32 in.; Width: 25.5 in.; Fuel Grade: All fuels except leaded gasoline; Dry Weight: 325 lb.; Compressor Stages: One Single-Stage Centrifugal; Turbine Stages: Single-Stage Gas Producer; Single-Stage Power Turbine.

Performance
430 hp at 6200 rpm; Fuel Consumption: 0.72.

Equipment
Starter: Government furnished equipment. (24 volt 30 ampere Starter-Generator.)

• **MODEL: 520-4**

Data
Type: Simple Cycle Two-Shaft Free Power Turboprop.

Specs
Length: 68.67 in.; Width: 25.5 in.; Fuel Grade: All fuels except leaded gasoline; Dry Weight: 340 lb.; Compressor Stages: One Single-Stage Centrifugal; Turbine Stages: Single-Stage Gas Producer; Single-Stage Power Turbine.

Performance
475 hp at 2390 rpm; Fuel Consumption: 0.71.

Equipment
Starter: 24 volt 30 ampere Starter-Generator.

CONTINENTAL AVIATION & ENGINEERING CORPORATION

DETROIT, MICHIGAN

• **MODEL: 352-5A (J69-T-25)**

Data
Type: Turbojet.

Specs
Diameter: 22.3 in. Length: 50 in. Fuel Grade: JP-4. Dry Weight: 364 lb. Compressor Stages: 1. Turbine Stages: 1.

Performance
Maximum Thrust: 1025. Normal Rated Thrust: 880. Fuel Consumption: 1.12 (S.F.C.). Oil Consumption: 0.5 lb./hr.

Equipment
Starter: Electric.

Remarks
Current production installation: Cessna T-37B USAF Jet Trainer.

• **MODEL: 356-7A (J69-T-29)**

Data
Type: Turbojet.

Specs
Diameter: 22.3 in. Length: 46 in. Dry Weight: 335 lb. Compressor Stages: 2. Turbine Stages: 1.

Performance

Maximum Thrust: 1700. Normal Rated Thrust: 1375. Fuel Consumption: 1.085 (S.F.C.). Oil Consumption: 1.0 lb./hr.

Equipment

Starter: Electric.

Remarks

Current production installation: Ryan Q-2C "Firebee."

• MODEL: 141

Data

Type: Gas Turbine Air Compressor.

Specs

Length: 44.6 in. Width: 15.94 in. Total Weight: 197 lb. Compressor Stages: 1. Turbine Stages: 2.

Performance

Rated Air hp: St'd day 191, 130°F 182. Air Delivery: St'd day 2.2 lb./sec. Delivery Pressure: St'd day, PSIA 52.5. RPM: 35,000.

Equipment

Starter: Electric.

Remarks

Current production installation: Used in TC-106 (USAF type MA-1A) trailer mounted turbine air compressor. Also suitable as powerplant for pressure-jet helicopters.

• MODEL: 217-5A (T72-T-2)

Data

Type: Turboshaft.

Specs

Diameter: 19.4 in. Length: 42.5 in. Compressor Ratio: 6:1; Fuel Grade; JP-4; Dry Weight: 210 lb.; Compressor Stages: 2; Turbine Stages: 3.

Performance

Maximum hp: 500 lb. Normal Rated hp: 405 lb., Fuel Consumption: 0.67 SFC; Oil Consumption: .4 pts/hr; 6000 rpm output shaft, free turbine design.

• MODEL: 217-6A

Data

Type: Turboprop.

Specs

Diameter: 19.4 in. Length: 42.5 in. Compressor Ratio: 6:1; Fuel Grade: JP-4; Dry Weight: 230 lb.; Compressor Stages: 2; Turbine Stages: 3.

Performance

Maximum hp: 500 lb. Normal Rated hp: 405 lb. Fuel Consumption: 0.67 SFC; Oil Consumption: 0.4 pts/hr; 2100 rpm prop drive free turbine design.

• MODEL: CJ69-1400

Data

Type: Turbojet.

Specs

Diameter: 22.3 in. Length: 44.8 in. Conpressor Ratio: 5:1; Fuel Grade: JP-4; Dry Weight: 370 lb.; Compressor Stages: 2.

Performance

Maximum thrust: 1400 lb. Normal Rated Thrust: 1200 lb.; Fuel Consumption: 1.04 SFC; Oil Consumption: .5 pts/hr.

CONTINENTAL MOTORS CORPORATION

MUSKEGON, MICHIGAN

• MODEL: O-470-J

Data

Type: 6 cylinder, air-cooled, horizontally opposed, FAA Type Certificate: 273.

Specs

Length: 36.03 in. Width: 33.32 in. Displacement: 470 cu. in. Bore: 5.00 in. Stroke: 4.00 in. Compression Ratio: 7.0:1 Fuel Grade: 80/87 octane. Dry Weight: 378 lb.

Performance

Rating: 225 hp at 2550 rpm at sea level.

Equipment

Carburetor: Marvel. Magneto: Scintilla. Starter: Delco-Remy. Generator: Delco-Remy, 12 volt, 35 amp.

• MODEL: O-470-M

Data

Type: 6 cylinder, air-cooled, horizontally opposed, FAA Type Certificate: 273.

Specs

Length: 43.31 in. Width: 33.58 in. Displacement: 470 cu. in. Bore: 5.00 in. Stroke: 4.00 in. Compression Ratio: 8.0:1 Fuel Grade: 91/96 octane. Dry Weight: 410 lb.

Performance

Rating: 240 hp at 2600 rpm at sea level.

Equipment

Carburetor: Bendix. Magneto: Scintilla. Starter: Delco-Remy. Generator: Delco-Remy, 24 volt, 15 amp.

• MODEL: O-300-A & B

Data

Type: 6 cylinder, air-cooled, horizontally opposed, FAA Type Certificate: 253.

Specs

Length: 36.38 in. Width: 31.50 in. Displacement: 300 cu. in. Bore: 4.0625 in. Stroke: 3.875 in. Compression Ratio: 7.0:1. Fuel Grade: 80/87 octane. Dry Weight: 268 lb.

Performance

Rating: 145 hp at 2700 rpm at sea level.

Equipment

Carburetor: Marvel. Magneto: Scintilla. Starter: Delco-Remy. Generator: Delco-Remy, 12 volt, 20 amp.

• MODEL: O-470-K & L

Data

Type: 6 cylinder, air-cooled, horizontally opposed, FAA Type Certificate: 273.

Specs

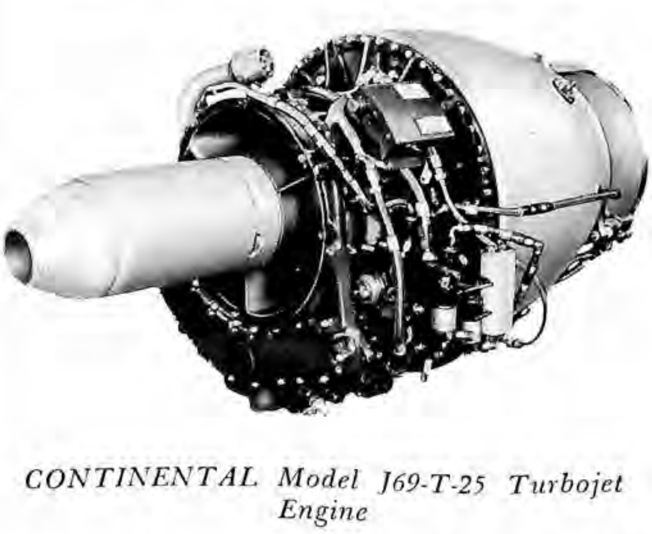
Length: 36.03 in. Width: 33.58 in. Displacement: 470 cu. in. Bore: 5.00 in. Stroke: 4.00 in. Compression Ratio: 7.0:1. Fuel Grade: 80/87 octane. Dry Weight: 404 lb.

Performance

Rating: 230 hp at 2600 rpm at sea level.

Equipment

Carburetor: Marvel. Magneto: Scintilla. Starter: Delco-Remy. Generator: Delco-Remy, 12 volt, 35 amp.



CONTINENTAL Model J69-T-25 Turbojet Engine

• **MODEL: A65-8F**

Data

Type: 4 cylinder, air-cooled, horizontally opposed, FAA Type Certificate: 205.

Specs

Length: 27.00 in. Width: 31.50 in. Fuel Grade: 80/87 octane. Bore: 3.875 in. Stroke: 3.625 in. Displacement: 171 cu. in. Compression Ratio: 6.3:1. Dry Weight: 171 lb.

Performance

Rating: 65 hp at 2300 rpm at sea level.

Equipment

Carburetor: Marvel. Ignition: Scintilla.

• **MODEL: C85-12F**

Data

Type: 4 cylinder, air-cooled, horizontally opposed, FAA Type Certificate: 233.

Specs

Length: 28.50 in. Width: 31.50 in. Fuel Grade: 80/87 octane. Bore: 4.062 in. Stroke: 3.625 in. Displacement: 188 cu. in. Compression Ratio: 6.3:1. Dry Weight: 181 lb.

Performance

Rating: 85 hp at 2575 rpm at sea level.

Equipment

Carburetor: Stromberg. Ignition: Scintilla. Starter: Delco-Remy. Generator: Delco-Remy, 12 volt, 20 amp.

• **MODEL: C90-12F**

Data

Type: 4 cylinder, air-cooled, horizontally opposed, FAA Type Certificate: 252.

Specs

Length: 28.50 in. Width: 31.50 in. Fuel Grade: 80/87 octane. Bore: 4.062 in. Stroke: 3.875 in. Displacement: 200 cu. in. Compression Ratio: 7:1. Dry Weight: 188 lb.

Performance

Rating: 90 hp at 2475 rpm at sea level.

Equipment

Carburetor: Marvel. Ignition: Scintilla. Starter: Delco-Remy. Generator: Delco-Remy, 12 volt, 20 amp.

• **MODEL: E-185-9**

Data

Type: 6 cylinder, air-cooled, horizontally opposed, FAA Type Certificate: 246.

Specs

Length: 48.40 in. Width: 33.39 in. Fuel Grade: 80/87 octane. Bore: 5 in. Stroke: 4 in. Displacement: 470 cu. in. Compression Ratio: 7:1. Dry Weight: 352 lb.

Performance

Rating: 205 hp at 2600 rpm at sea level.

Equipment

Carburetor: Bendix. Ignition: Scintilla. Starter: Provisions for direct cranking starter. Generator: Delco-Remy, 12 volt, 35 amp. This engine also available with full AN accessory section.

• **MODEL: E-225-4**

Data

Type: 6 cylinder, air-cooled, horizontally opposed, FAA Type Certificate: 267.

Specs

Length: 48.4 in. Width: 33.39 in. Fuel Grade: 80/87 octane. Bore: 5 in. Stroke: 4 in. Displacement: 470 cu. in. Compression Ratio: 7:1. Dry Weight: 355 lb.

Performance

Rating: 225 hp at 2650 rpm at sea level.

Equipment

Carburetor: Bendix. Ignition: Scintilla. Starter: Eclipse. Generator: Delco-Remy, 12 volt, 35 amp. This engine also available with full AN accessory section.

• **MODEL: O-470-2**

Data

Type: 6 cylinder, air-cooled, horizontally opposed, FAA Type Certificate: 281.

Specs

Length: 37.73 in. Width: 33.62 in. Displacement: 470 cu. in. Bore: 5.00 in. Stroke: 4.00 in. Compression Ratio: 7.0:1 Fuel Grade: 100/130 octane. Dry Weight: 484 lb.

Performance

Rating: 265 bhp at 2600 rpm at sea level.

Equipment

Carburetor: Bendix. Magneto: Scintilla. Starter: Eclipse. Generator: Eclipse, 30 volt, 50 amp.

Remarks

The engine has a belt driven supercharger.

• **MODEL: O-470-15**

Data

Type: 6 cylinder, air-cooled, horizontally opposed, FAA Type Certificate: 269.

Specs

Length: 45.20 in. Width: 33.41 in. Displacement: 470 in. Bore: 5.00 in. Stroke: 4.00 in. Compression Ratio: 7.0:1. Fuel Grade: 80/87 octane. Dry Weight: 405 lb.

Performance

Rating: 213 bhp at 2600 rpm at sea level.

Equipment

Carburetor: Stromberg. Magneto: Scintilla. Starter: Bendix. Generator: Bendix, 24 volt, 50 amp.

• **MODEL: IO-470-C**

Data

Type: 6 cylinder, air-cooled, horizontally opposed, FAA Type Certificate: 273.

Specs

Length: 37.56 in. Width: 33.58 in. Displacement: 470 cu. in. Bore: 5.00 in. Stroke: 4.00 in. Compression Ratio: 8.0:1. Fuel Grade: 91/96 octane. Dry Weight: 432 lb.

Performance

Rating: 250 bhp at 2600 rpm at sea level.

Equipment

Carburetor: CMC Injector. Magneto: Scintilla. Starter: Delco-Remy. Generator: Delco-Remy, 12 volt, 50 amp.

• **MODEL: 10-470-D**

Data

Type: 6 cylinder, air-cooled, horizontally opposed, FAA Type Certificate: 3E2.

Specs

Length: 43.53 in. Width: 33.58 in. Displacement: 470 cu. in. Bore: 5.00 in. Stroke: 4.00 in. Compression Ratio: 8.6:1. Fuel Grade: 100/130 octane. Dry Weight: 426 lb. Total Weight: 466 lb. with accessories.

Performance

Rating: 260 bhp at 2625 rpm at sea level.

Equipment

Fuel Injector: Continental Motors. Magnetos: Scintilla. Starter: Delco-Remy. Generator: Delco-Remy, 25 amp, 24 volt.

• **MODEL: 10-470-J**

Data

Type: 6 cylinder, air-cooled, horizontally opposed, FAA Type Certificate: 3E1.

Specs

Length: 37.93 in. Width: 33.58 in. Displacement: 470 cu. in. Bore: 5.00 in. Stroke: 4.00 in. Compression Ratio: 7.0:1. Fuel Grade: 80/87 octane. Dry Weight: 402 lb.

Performance

Rating: 225 bhp at 2600 rpm at sea level.

Equipment

Fuel Injector: Continental Motors. Magneto: Scintilla. Starter: Delco-Remy. Generator: Delco-Remy, 35 amp, 12 volt.

• **MODEL: FSO-526-A (HELICOPTER)**

Data

Type: 6 cylinder, fan-cooled, horizontally opposed, FAA Type Certificate: 292.

Specs

Length: 47.69 in. Width: 33.64 in. Displacement: 526 cu. in. Bore: 5.125 in. Stroke: 4.25 in. Compression Ratio: 7.0:1. Fuel Grade: 91/96 octane. Dry Weight: 568 lb.

Performance

Rating: 270 bhp at 3200 rpm at sea level to 7,900 ft. critical altitude.

Equipment

Carburetor: Bendix. Magneto: Scintilla.

Remarks

This engine has a gear driven supercharger.

- **MODEL: GO-300-A**

Data

Type: 6 cylinder, air-cooled, horizontally opposed, FAA Type Certificate: 298.

Specs

Length: 39.12 in. Width: 31.50 in. Displacement: 300 cu. in. Bore: 4.0625 in. Stroke: 4.25 in. Compression Ratio: 7.3:1. Propeller Shaft Ratio: 7.5:1. Fuel Grade: 80/87 octane. Dry Weight: 312 lb.

Performance

Rating: 175 bhp at 3200 rpm at sea level.

Equipment

Carburetor: Marvel. Magneto: Scintilla. Starter: Delco-Remy. Generator: Delco-Remy, 12 volt, 25 amp.

Remarks

The engine has a geared propeller shaft.

- **MODEL: O-200-A**

Data

Type: 4 cylinder, air-cooled, horizontally opposed wet sump, FAA Type Certificate: 252.

Specs

Length: 28.53 in. Width: 31.56 in. Displacement: 200 cu. in. Bore: 4.062 in. Stroke: 3.875 in. Compression Ratio: 7.0:1. Fuel Grade: 80/87 octane. Dry Weight: 190 lb. Total Weight: 220.00 lb., with accessories.

Performance

Rating: 100 bhp at 2750 rpm at sea level.

Equipment

Carburetor: Marvel. Magneto: Scintilla. Starter: Delco-Remy. Generator: Delco-Remy, 12 volt, 20 amp.

- **MODEL: G10-470-A**

Data

Type: Six cylinder, air-cooled, horizontally opposed, FAA Type Certificate (Pending).

Specs

Length: 44.89 in. Width: 33.56 in. Displacement: 471 in. Bore: 5.00 in. Stroke: 4.00 in. Compression Ratio: 8.6:1. Propeller Shaft Ratio: 688.1. Fuel Grade: 100/130 octane. Dry Weight: 507 lb., complete with accessories.

Performance

Rating: 310 bhp at 3400 rpm at sea level.

Equipment

Fuel Injector: Continental Motors. Magnetos: Scintilla. Starter: Delco-Remy. Generator: Delco-Remy 24 volt, 73 amp.

Remarks

Engine has a geared propeller shaft and generator drive.

- **MODEL: TS10-470-B**

Data

Type: Six cylinder, air-cooled, horizontally opposed, FAA Type Certificate: 3E3.

Specs

Length: 42.82 in. Width: 33.56 in. Displacement: 471 in. Bore: 5.00 in. Stroke: 4.00 in. Compression Ratio: 7.5:1. Fuel Grade: 100/130 octane. Dry Weight: 503 lb., complete with accessories.

Performance

Rating: 260 bhp at 2600 rpm at sea level to 16,000 ft. critical altitude.

Equipment

Fuel Injector: Continental Motors. Turbo-Supercharger: AiResearch. Magneto: Scintilla. Starter: Delco-Remy. Generator: Delco-Remy, 12 volt, 50 amp.

Remarks

Length includes Turbo-Supercharger system.

GENERAL ELECTRIC COMPANY

FLIGHT PROPULSION DIVISION

CINCINNATI 15, OHIO

- **MODEL: J93**

Data

Type: Turbojet.

Equipment

Compressor: Variable Stator; Afterburner and Nozzle Section: Converging-Diverging Exhaust Nozzle; Controls: Controlled Environment Pod employed for accessories, mounted beneath compressor section; accessory pod is completely removable as a single unit for ease of maintenance; Single Shaft; Light Weight Construction, incorporating honey-comb structures.

Remarks

Installed in North American Aviation B-70 Valkyrie Long-Range Bomber. Applicable to future Mach 3 commercial transports.

- **MODEL: CJ-805-23**

Data

Type: Turbofan.

Specs

Diameter: 31.6 in. for basic engine, 53.0 with Aft-Fan Unit; Length: 138.6 in. with Thrust Reverser; Fuel Grade: Commercial JP; Total Weight: 4270 lb. with Thrust Reverser; Compressor Stages: 17; Turbine Stages: three plus one Fan Stage.

Performance

Maximum Thrust: 16,100 lb.; Normal Rated Thrust: 13,600 lb.; Fuel Consumption: .528; Oil Consumption: 2 lb. per hr.

Remarks

Installed in Convair 990 Coronado.

- **MODEL: 240 Turboshaft Engine**

Data

Type: Marine or Industrial Gas Turbine.

Specs

Diameter: 65 in.; Length: 290 in.; Height: 95 in.; Compression Ratio: 12:1; Fuel Grade: JP or Diesel #2; Total Weight: Approximately 6,000 lb.; Compressor Stages: 17; Turbine Stages: three plus one-stage power turbine.

Performance

Maximum Thrust: 20,500 shp; Normal Rated Thrust: 14,000 shp; Fuel Consumption: .478 at Maximum lb./hr./shp; Oil Consumption: 3 lb. per hr. at Maximum.

Remarks

Installed in MARAD Hydrofoil.

- **MODEL: CJ-805-3B**

Data

Type: Turbojet.

Specs

Diameter: 31.6 in.; Length: 188.94 in. (with Reverser/Suppressor); Fuel Grade: Commercial JP; Total Weight: 3200 lb.; Compressor Stages: 17; Turbine Stages: three.

Performance

Maximum Thrust: 11,650; Normal Rated Thrust: 9190 lb.; Fuel Consumption: .728; Oil Consumption: 1 lb. per hr.

Remarks

Installed in Convair 880M.

• **MODEL: CJ-805-23C**

Data

Type: Turbofan.

Specs

Diameter: 31.6 in. Basic Engine, 53.0 with Aft-Fan Unit; Length: 166.3 in.; Fuel Grade: Commercial JP; Total Weight: 4,465 lb.; Compressor Stages: 17; Turbine Stages: three plus one Fan Stage.

Performance

Maximum Thrust: 16,100 lb.; Normal Rated Thrust: 13,600 lb.; Fuel Consumption: .528; Oil Consumption: 2 lb. per hr.

Remarks

Installed in Sud Caravelle VII.

• **MODEL: J79**

Data

Type: Military Turbojet.

Specs

Diameter: 38.3 in.; Length: 204 in.; Compression Ratio: 12:1; Fuel Grade: JP 4 and 5; Total Weight: 3,200 lb. approximate, less afterburner; Compressor Stages: 17; Turbine Stages: Three.

Performance

Maximum Thrust: 16,150 lb.; Normal Rated Thrust: 9,700 SLS; Fuel Consumption: 2.0 at Maximum Thrust; Oil Consumption: 1 lb. per hr.; Single Rotor Variable Stator Design.

Remarks

Current production installation includes: Lockheed F-104 Starfighter, Convair B-58 Hustler, North American A3J Vigilante, McDonnell F4H Phantom II.

SMALL AIRCRAFT ENGINE DEPARTMENT
LYNN, MASSACHUSETTS

• **MODEL: T58-6**

Data

Type: Turboshaft.

Specs

Diameter: 16 in.; Length: 55 in.; Fuel Grade: JP-4/JP-5 (contaminated fuel). Dry Weight: 271 lb. Compressor Stages: 10. Turbine Stages: 2. Free Power Turbine: 1.

Performance

Maximum shp: 1050. Normal Rated shp: 900. Fuel Consumption: .64 military.

Applications

Sikorsky HSS-2; Kaman HU2K; Vertol YHC-1A; Kaman K-16 (VTOL); Fairchild M224 (VTOL).

Remarks

Current production installation: military: Sikorsky HSS-2; Vertol YHC-1A; Kaman HU2K; Sikorsky HSS-1 (experimental); Vertol H-21D (experimental); Kaman K-16 (experimental VTOL); Fairchild M-224-1 (experimental VTOL). Civilian version, designated CT-58-100, certified by FAA for use in commercial helicopters. Announced commercial applications: Sikorsky S-61; Sikorsky S-62; Vertol 107 Model II. T58-8, 1250 shp growth engine, successfully completed 50-hr. PFRT August 1959. 150-hr. qualification test scheduled for July 1960.

• **MODEL: T58-8**

Data

Type: Turboshaft.

Specs

Diameter: 16 in. Length: 55 in. Fuel Grade: JP-4/JP-5 (contaminated fuel). Dry Weight: 285 lb. Compressor Stages: 10. Turbine Stages: 2 plus 1 free power turbine.

Performance

Maximum HP: 1250 Military. Normal Rated HP: 1050 lb. Fuel Consumption: 0.61 Military.

Applications

Sikorsky HSS-2; Kaman HU2K; Vertol YHC-la; Kaman K-16 (VTOL); Fairchild M224 (VTOL).

• **MODEL: CT58-100**

Data

Type: Turboshaft.

Specs

Diameter: 16 in. Length: 55 in. Fuel Grade: JP-4/JP-5 (Contaminated Fuel). Dry Weight: 280 lb. Compressor Stages: 10. Turbine Stages: 2 plus 1 free power turbine.

Performance

Maximum HP: 1050 Takeoff Power. Normal Rated HP: 900 lb. Fuel Consumption: 0.64.

Applications

Sikorsky S-61—ordered by L. A. Airways and Chicago Airways; Sikorsky—S-62 in operation by Petroleum Helicopters and L. A. Airways; Vertol 107, Model II—ordered by New York Airways:

• **MODEL: CT58-110**

Data

Type: Turboshaft.

Specs

Diameter: 16 in. Length: 55 in. Fuel Grade: JP-4/JP-5 (Contaminated Fuel). Dry Weight: 290 lb. Compressor Stages: 10. Turbine Stages: 2 plus 1 free power turbine.

Performance

Maximum HP: 1250 Takeoff Power. Normal Rated HP: 1050 lb. Fuel Consumption: 0.61 lb./hp/hr.

Applications

Sikorsky S-61—ordered by Los Angeles Airways and Chicago Airways; Sikorsky S-62—in operation by Petroleum Helicopters and Los Angeles Airways; Vertol 107, Model II—ordered by New York Airways.

• **MODEL: CF700**

Data

Type: Turbofan.

Specs

Diameter: 33 in. Length: 69 in. Fuel Grade: JP-4. Total Weight: 585 lb., 665 lb. with reverser. Compressor Stages: 8. Turbine Stages: 2.

Performance

Maximum Thrust: 4000 lb. takeoff. Normal Rated Thrust: 1020 lb., normal, Continuous 36,000 ft., Mach 0.8. Fuel Consumption: 0.69 takeoff. Fuel consumption: 0.97 lb./lb./hr. normal, Continuous 36,000 ft., Mach 0.8.

Remarks

Engine development program, proceeding on company funds, calls for producing flight-worthy engines by mid-1961 and FAA certified engines in early 1962.

• **MODEL: CF700-2B**

Data

Type: Aft-Turbofan.

Specs

Diameter: 34 in. Length: 64 in. Fuel Grade: JP-4/JP-5. Dry Weight: 615 lb. Compressor Stages: 8. Turbine Stages: 2.

Performance

Maximum Thrust: 4200 lb. Fuel Consumption: 0.69 lb./hr./lb.

Applications

The CF700 has been selected by McDonnell to power its M220 corporate jet aircraft. With the promise of new standards in range and economy, the aft-turbofan engine will be the logical choice for many of the executive and military craft now in design stages.

• **MODEL: CJ610**

Data

Type: Turbojet.

Specs

Diameter: 17.6 in. Length: 39.7 in. Fuel Grade: JP-4/JP-5. Dry Weight: 355 lb. Compressor Stages: 8. Turbine Stages: 2.

Performance

Maximum Thrust: 2700 lb. Fuel Consumption: 0.97 lb./hr./lb.

Applications

The CJ610/CF700 constitute the ideal powerplant combination for the budding executive aircraft market. This package provides the customer with a broad spectrum of power. If the CJ610 is selected as initial powerplant, the CF700 represents the natural follow-on for future growth versions of the aircraft.

- **MODEL: T64-2**

Data

Type: Turboshaft

Specs

Height: 30 in. Length: 91 in. Fuel Grade: JP-4/JP-5. Dry Weight: 854 lb. Compressor Stages: 14. Turbine Stages: 2.

Performance

Maximum SHP: 2650 (military). Normal Rated HP: 2235. Fuel Consumption: 0.506.

Applications

The T64's ability to operate continuously at altitudes from 100 degrees above to 45 degrees below horizontal, its low fuel consumption and attractive power-to-weight ratio suit the engine for application in high performance helicopters, VTOL and STOL aircraft, and fixed wing utility aircraft, military and commercial.

- **MODEL: T64-4**

Data

Type: Turboshaft.

Specs

Height: 36 in. Length: 113 in. Fuel Grade: JP-4/JP-5. Dry Weight: 1079 lb. Compressor Stages: 14. Turbine Stages: 2 plus 2 free power turbines.

Performance

Maximum HP: 2700 lb. military shaft. Normal Rated HP: 2330 lb. Fuel Consumption: 0.495 military.

- **MODEL: T64-8**

Data

Type: Turboshaft.

Specs

Height: 46 in. Length: 113 in. Fuel Grade: JP-4/JP-5. Dry Weight: 1,084 lb. Compressor Stages: 14. Turbine Stages: 2 plus 2 free power turbines.

Performance

Maximum HP: 2700 military shaft. Normal Rated HP: 2330 lb. Fuel Consumption: 0.495 military.

- **MODEL: T64-6**

Data

Type: Turboshaft.

Specs

Height: 30 in. Length: 83 in. Fuel Grade: JP-4/JP-5. Dry Weight: 713 lb. Compressor Stages: 14. Turbine Stages: 2 plus 2 free power turbines.

Performance

Maximum HP: 2650 military shaft; Normal Rated HP: 2235 lb. Fuel Consumption: 0.506 lb/hp/hr (contaminated fuel).

- **MODEL: 720-722**

Data

Type: Turboshaft.

Specs

Diameter: 16 in. Length: 55 in. Fuel Grade: 720-JP-4/JP-5 diesel (contaminated fuel) 722-Natural gas. Dry Weight: 320 lb. Compressor Stages: 10. Turbine Stages: 2 plus 1 free power turbine.

Performance

Maximum HP: 1000 lb. Fuel Consumption: 12,400 btu/hp/hr.

Applications

Pacific Telephone and Telegraph Co.-Power for 750 KW stand-by generator unit; Halliburton-Pump drive for oil well fracturing unit; Trunkline-Compressor drive for natural gas pipeline pumping station; Grumman-Maneuvering or "docking" engine for Maritime Administration (MARAD) 80 ton hydrofoil boat; Dynamic Development-Main propulsion for Bureau of Ships 24-foot experimental hydrofoil boat; Jered-Main propulsion for Marine Corps experimental amphibious landing vehicle.

- **MODEL: J85-5**

Data

Type: Turbojet—piloted configuration.

Specs

Diameter: 20.3 in. Length: 104 in. Fuel Grade: JP-4. Total Weight: 525 lb. Compressor Stages: 8. Turbine Stages: 2.

Performance

Maximum Reheat Thrust, SLS, Standard Day: 3850 lb. Military Thrust, SLS, Standard Day: 2500 lb. Power to Weight Ratio: 7-3:1. Specific Weight: .136.

Equipment

Afterburner. Starter: Air Impingement.

Remarks

Scheduled production installation: Northrop N-156F; Northrop T-38; Radioplane Q4-B. J85-5 has successfully run its official 50 hr. PFRT.

- **MODEL: J85-7**

Data

Type: Turbojet-missile configuration.

Specs

Diameter: 17.7 in. Length: 42 in. Fuel Grade: JP-4. Total Weight: 325 lb. Compressor Stages: 8. Turbine Stages: 2.

Performance

Military Thrust: 2450 lb., SLS, Standard Day. Power to Weight Ratio: 7.5:1 Specific Weight: .132.

Equipment

Starter: Air Impingement.

Remarks

Scheduled production installation: McDonnell GAM-72. J85-7 has successfully run its official QT.

LYCOMING DIVISION
AVCO CORPORATION
STRATFORD, CONNECTICUT

- **MODEL: T53-L-1A (LTC1B-1)**

Data

Type: Shaft turbine engine. FAA Type Certificate: 1-E6.

Specs

Diameter: 23.0 in. Length: 47.61 in. Width: 23.0 in. Pressure Ratio: 6:1. Fuel Grade: Mil-F-5624 Grade JP-4. Dry Weight: 480 lb. Compressor Stages: 50 axial plus 1 cent. Turbine Stages: 1 compressor, 1 free power.

Performance

Maximum SHP: 860 military. Normal Rated SHP: 770. Fuel Consumption: 0.735 ESFC at military power.

Remarks

Development was sponsored by Army and Air Force on this single stage free-type power turbine, combination axial-centrifugal compressor driven by a single stage turbine, and external annular vaporizing combustor engine. Current production installation: Bell H40/HU-1; Kaman H43B. Also installed in prototype vehicles: Ryan Model 92; Doak Model 16; Vertol Model 76; Bu Ships "Halobates" Boat, Army "Flying Duck." Vertol Model 107; Vanguard Omniplane, Curtiss-Wright X-100.

- **MODEL: T53-L-3**

Data

Type: Turboprop.

Specs

Diameter: 23.0 in. Length: 58.40 in. Width: 23.0 in. Pressure Ratio: 6:1. Fuel Grade: JP-4. Dry Weight:

530 lb. Compressor Stages: 5 axial plus 1 cent. Turbine Stages: 1 compressor plus 1 free power.

Performance

Maximum SHP: 960. Normal Rated SHP: 825. Fuel Consumption: .655 ESFC at takeoff. Oil Consumption: .14 gal. per hr.

Remarks

Developed under sponsorship of Army and Air Force on this single stage free-type power turbine, axial-centrifugal compressor dirven by single stage turbine, and external annular vaporizing combustor engine. Now in production for use in Grumman AO-1 Mohawk high-performance observation plane for Army.

• **MODEL: T53-L-5**

Data

Type: Shaft turbine engine.

Specs

Diameter: 23.0 in. Length: 47.6 in. Width: 23.0 in. Pressure Ratio: 6:1. Fuel Grade: JP4. Dry Weight: 485 lb. Compressor Stages: 5 axial plus 1 centrifugal. Turbine Stages: 1 compressor plus 1 free power.

Performance

Maximum SHP: 960 takeoff. Normal Rated SHP: 825. Fuel Consumption: 0.664 ESFC at takeoff.

Remarks

Development funded by Army. This engine is a shaft turbine version of the T53-L-3 turboprop embodying Lycoming's "Universal Engine" concept. Only difference between these two engines is in reduction gear and fuel control. For use in growth versions of vehicles presently using T53-L-1. Scheduled for Bell HU-1B.

• **MODEL: T55-L-3**

Data

Type: Shaft turbine engine.

Specs

Diameter: 24.25 in. Length: 44.03 in. Width: 24.75 in. Pressure Ratio: 6:1. Fuel Grade JP-4. Dry Weight: 600 lb. Compressor Stages: 7 axial plus 1 cent. Turbine Stages: 1 compressor plus 2 free power.

Performance

Maximum SHP: 1900 military. Normal Rated SHP: 1700 Fuel Consumption: .641 ESFC at military power. Oil Consumption: .25 gal. per hr.

Remarks

Engine has two stage free-type power turbine combination axial-centrifugal compressor driven by a single stage turbine, and external vaporizing annular combustor.

• **MODEL: T55-L-1**

Data

Type: Turboprop.

Specs

Diameter: 24.25 in. Length: 58.85 in. Width: 24.25 in. Pressure Ratio: 6:1. Fuel Grade: JP-4. Dry Weight: 695 lb. Compressor Stages: 7 axial plus 1 cent. Turbine Stages: 1 compressor plus 2 free power.

Performance

Maximum SHP: 1600. Normal Rated SHP: 1325. Fuel Consumption: .648 ESFC at takeoff. Oil Consumption: .25 gal. per hr.

Remarks

Engine has 2-stage free-type power turbine combination axial-centrifugal compressor driven by a single stage turbine, and external vaporizing annular combustor.

• **MODEL: T55-L-5**

Data

Type: Shaft turbine engine.

Specs

Diameter: 24.25 in. Length: 45.21 in. Width: 24.76 in. Pressure Ratio: 6:1. Fuel Grade: JP4. Dry Weight: 570 lb. Compressor Stages: 7 axial plus 1 centrifugal. Turbine Stages: 1 compressor plus 2 free power.

Performance

Maximum SHP: 2200 military. Normal Rated SHP: 1850. Fuel Consumption: 0.629 ESFC at military power. Oil Consumption: .25 gal. per hr.

Remarks

High speed version of T55-L-3. Output shaft speed equal to power turbine speed. Scheduled for production for use in Vertol YHC-1B "Chinook" cargo helicopter for Army. Embodies Lycoming's "Universal Engine" concept.

• **MODEL: T53-L-7**

Data

Type: Turboprop.

Specs

Length: 58.40 in.; Width: 23.00 in.; Fuel Grade: JP-4; Dry Weight: 522 lb.; Compressor Stages: 5 Axial plus 1 cent.; Turbine Stages; 1 compressor plus 1 free power.

Performance

Maximum SHP: 1100 at 1700 rpm. Normal rated SHP: 1100 at 1700 rpm; Fuel Consumption: ESFC at military .649.

Remarks

The T53-L-7 is the higher rated version of the T53-L3 to be used in advance models of the Grumman AO-1 Mohawk.

• **MODEL: T53-L-9**

Data

Type: Turboshaft.

Specs

Length: 47.61 in.; Width: 23.00 in.; Fuel Grade: JP-4; Dry Weight: 485 lb.; Compressor Stages: 5 Axial plus 1 Cent.; Turbine Stages: 1 Compressor plus 1 free power.

Performance

Maximum SHP: 1100 at 6610 rpm. Normal Rated SHP: 900 at 6610 rpm. Fuel Consumption: SFC at .690 military power.

Remarks

The T53-L-9 is a universal helicopter engine for use in the advance model of the Bell HU-1D Iroquois, utiliity and cargo transport hedicopters and VTOL/STOL aircraft.

LYCOMING DIVISION
AVCO CORPORATION
WILLIAMSPORT, PENNSYLVANIA

• **MODEL: O-235-C1B**

Data

Type: 4 cylinder, air-cooled, horizontally opposed, 115 hp. FAA Type Certificate: 223.

Specs

Length: 29.81 in. Fuel Grade: 80 octane. Bore: 4.375 in. Stroke: 3.875 in. Displacement: 233.3 cu. in. Compression Ratio: 6.75:1. Dry Weight: 236 lb. with hub and accessories. Weight per hp: 2.05 lb.

Performance

Takeoff Power: 115 hp 2800 rpm. Cruise: 80 hp at 2350 rpm. Fuel Consumption: .52 lb. per hp hr. Oil Consumption: .012 lb. per hp hr.

Equipment

Carburetor: Marvel-Schebler MA-3A. Ignition: Dual Scintilla S4LN-21. Starter: Delco-Remy. Generator: Delco-Remy.

• **MODEL: O-290-D2C**

Data

Type: 4 cylinder, air-cooled, horizontally opposed, direct drive, 140 hp. FAA Type Certificate: 229.

Specs

Length: 29.81 in. Width: 32.24 in. Height: 22.68 in. Bore: 4.875. Stroke: 3.875. Compression Ratio: 7.00:1. Displacement: 289.0 cu. in. Weight: 265 lb. Fuel Grade: 80/87.

Performance

Takeoff Power: 140 hp at 2800. Rated Power: 135 hp at 2600 rpm. Fuel Consumption: 6.5 gal. per hr. at 2250 rpm, economy cruise.

Equipment

Carburetor: Marvel-Schebler MA-3FPA. Magnetos: Scintilla S4LN-20 and S4LN-21. Generator: Delco-Remy, 12 volt. Starter: Delco-Remy.

- **MODEL: O-320-A2C**

Data

Type: 4 cylinder, air-cooled, horizontally opposed, direct drive, 150 hp. FAA Type Certificate: 274.

Specs

Length: 29.81 in. Height: 22.99 in. Width: 32.24 in. Bore: 5.125. Stroke: 3.875. Displacement: 319 cu in. Compression Ratio: 7.00:1. Weight: 273 lb. Fuel Grade: 80/87.

Performance

Takeoff and Rated Power: 150 hp at 2700 rpm. Fuel Consumption: 8.2 gal. per hr. at 2350 rpm, economy cruise.

Equipment

Carburetor: Marvel-Schebler MA-4SPA. Magnetos: Scintilla S4LN-20 and S4LN-21. Generator: Delco-Remy, 12 and 24 volt. Starter: Delco-Remy.

- **MODEL: O-320-B2C**

Data

Type: 4 cylinder, air-cooled, horizontally opposed, direct drive, 160 hp. FAA Type Certificate: 274.

Specs

Length: 29.81 in. Width: 32.24 in. Height: 22.99 in. Bore: 5.125. Stroke: 3.875. Displacement: 319 cu. in. Compression Ratio: 8.50:1. Weight: 277 lb. Fuel Grade: 91/96.

Performance

Takeoff and Rated Power: 160 hp at 2700 rpm. Fuel Consumption: 8.2 gal. per hr. at 2350 rpm, economy cruise.

Equipment

Carburetor: Marvel-Schebler MA-4SPA. Magnetos: Scintilla S4LN-20 and S4LN-21. Generator: Delco-Remy, 12 or 24 volt. Starter: Delco-Remy, 12 or 24 volt.

- **MODEL: O-320-B3C**

Data

Type: 4 cylinder, air-cooled, horizontally opposed, direct drive, 160 hp, FAA Type Certificate 274.

Specs

Length: 29.81 in.; Width: 32.24 in.; Displacement: 320 cu. in.; Bore: 5.125 in.; Stroke: 3.875 in.; Compression Ratio: 8.50:1; Fuel Grade: 91/96; Dry Weight: 277 lb.

Performance

Takeoff and Normal Rated Thrust: 160 hp at 2700 rpm at Sea Level. Cruising: 120 hp at 2450 at 7000 ft. Fuel Consumption: 10.0 gal. per hr. at 75 percent rated power, 8.8 gal. per hr. at 65 percent rated power. Oil Consumption: .012 lb. bhp per hr. at rated power.

Equipment

Carburetor: Marvel-Schebler MA4-SPA. Magnetos: Scintilla S4LN-200 and S4LN-204. Starter: Delco-Remy. Generator: Delco-Remy.

- **MODEL: O-340-A1B**

Data

Type: 4 cylinder, air-cooled, horizontally opposed, direct drive, 170 hp. FAA Type Certificate: 277.

Specs

Length: 29.81 in. Width: 32.55 in. Height: 24.55 in. Bore: 5.125. Stroke: 4.125. Compression Ratio: 8.50:1. Displacement: 340.4 cu. in. Weight: (with starter and generator) 29.79 lb. Fuel Grade: 91/96.

Performance

Takeoff and Rated Power: 170 hp at 2700 rpm. Fuel Consumption: 8.5 gal. per hr. at 2350 rpm and 65 percent rated power.

Equipment

Carburetor: Marvel-Schebler MA4-5. Magnetoes: Scintilla S4LN-20 and S4LN-21. Generator: Delco-Remy, 12 volt. Starter: Delco-Remy.

- **MODEL: O-360-A1D**

Data

Type: 4 cylinder, air-cooled, horizontally opposed, 180 hp. FAA Type Certificate: 286.

Specs

Length: 29.81 in. Width: 33.37 in. Height: 24.59 in. Displacement: 361 cu. in. Bore: 5.125 in. Stroke: 4.375. Compression Ratio: 8.50:1. Fuel Grade: 91/96. Dry Weight: 284 lb.

Equipment

Carburetor: Marvel-Schebler MA4-5 Magnetos: Scintilla S4LN-20, S4LN-21. Starter: Delco-Remy. Generator: Delco-Remy.

- **MODEL: O-360-A1C**

Data

Type: 4 cylinder, air-cooled, horizontally opposed, 180 hp, FAA Type Certificate 286.

Specs

Length: 30.67 in.; Width: 33.37 in.; Displacement: 360 cu. in.; Bore: 5.125 in.; Stroke: 4.375 in.; Compression Ratio: 8.50:1; Fuel Grade: 91/96; Dry Weight: 288 lb.

Performance

Takeoff and Normal Rated Power: 180 hp at 2700 rpm at Sea Level. Cruising: 135 hp at 2450 rpm at Sea Level. Fuel Consumption: 10.5 gal. per hr. at 75 percent rated power, 9.0 gal. per hr. at 65 percent rated power. Oil Consumption: .012 lb. bhp per hr. at rated power.

Equipment

Carburetor: Bendix PSH-5BD. Magnetos: Scintilla S4LN-200 and S4LN-204. Starter: Delco-Remy. Generator: Delco-Remy.

- **MODEL: O-360-C2D**

Data

Type: 4 cylinder, air-cooled, horizontally opposed, direct drive helicopter, 180 hp. FAA Type Certificate: 286.

Specs

Height: 19.68 in. Length: 30.67 in. Width. 33.37 in. Displacement: 360 cu. in. Bore: 5.125 in. Stroke: 4.375 in. Compression Ratio: 8.50:1. Fuel Grade: 91/96. Dry Weight: 288 lb.

Performance

Takeoff and Rated Power: 180 hp at 2700 rpm.

- **MODEL: O-540-F1B5**

Data

Type: 6 cylinder, horizontally opposed 260 hp. FAA Type Certificate 295.

Specs

Height: 24.56 in. Length: 38.42 in. Width: 33.37 in. Displacement: 540 in. (3) Bore: 5.125 in. Stroke: 4.375 in. Compression Ratio: 8.50:1. Fuel Grade: 91/96. Dry Weight: 398 lb.

Performance

Maximum Power: 260 hp at 2800 rpm to 800 ft. alt. Normal Rated Power: 235 hp at 2800 rpm to 4000 ft. alt. Fuel Consumption: 13.5 gal. per hr. at 65% rated.

Equipment

Carburetor: Marvel-Schebler MA4-5. Magneto: Scintilla S6LN-200, S6LN-204. Starter: Delco-Remy. Generator: Delco-Remy.

Remarks

Current production installation: Certificated for helicopter operation.

- **MODEL: VO-360-A1B**

Data

Type: 4 cylinder, horizontally opposed, vertical, air-cooled helicopter, 180 hp. FAA Type Certificate: 1-E1.

Specs

Height: 23.05 in. Length: 30.00 in. Width: 33.37 in. Displacement: 360 cu. in. Bore: 5.125 in. Stroke: 4.375 in. Compression Ratio: 8.50:1. Fuel Grade: 91/96. Dry Weight 298 lb.

Performance

Takeoff and Rated Power: 180 hp at 2900. Fuel Consumption: 13.5 gal. per hr. at 80 percent rated power.

Equipment

Carburetor: Marvel-Schebler MA4-5. Magneto: Two Scintilla S4LN-21s.

Remarks

Current production installation: Brantly B-2 helicopter (Army HO-3).

- **MODEL: VO-435-A1E**

Data

Type: 6 cylinder, air-cooled, horizontally opposed, for vertical helicopter installation 260 hp. FAA Type Certificate: 279.

Specs

Height: 25.19 in. Width: 33.58 in. Depth: 24.13 in. Fuel Grade: 80/87. Bore: 4.875. Stroke: 3.875. Displacement: 434 cu. in. Compression Ratio: 7.30:1. Weight: 391 lb.

Performance

Takeoff: 260 hp at 3400 rpm. Rated Power: 250 hp at 3200 rpm. Fuel Consumption: 20.0 gal. per hr. at 80 percent rated power.

Equipment

Carburetor: Marvel-Schebler MA4-5 AA. Magnetos: Scintilla S6LN-200 and S6RN-204. Hand cranking provisions optional. New design crankcase and oil pump.

- **MODEL: VO-540-B1B,-B1C**

Data

Type: 6 cylinder, horizontally opposed, vertical, air-cooled helicopter 305 hp. FAA Type Certificate: 304.

Specs

Height: 24.57 in. Length: 34.73 in. Width: 34.70 in. Displacement: 540 cu. in. Bore: 5.125 in. Stroke: 4.375 in. Compression Ratio: 7.30:1. Fuel Grade: 80/87. Dry Weight: 429 lb.

Performance

Takeoff Power: 305 hp at 3200 rpm. Rated Power: 305 hp at 3200 rpm. Fuel Consumption: 17.0 gal. per hr. at 60 percent rated power.

Equipment

Carburetor: Marvel-Schebler MA-6AA. Magneto: Scintilla S6RN-200, S6LN-204.

- **MODEL: GO-435-C2B2-6**

Data

Type: 6 cylinder, horizontally opposed, geared, air-cooled, 240 hp. FAA Type Certificate: 228.

Specs

Height: 28.02 in. Length: 38.64 in. Width: 33.12 in. Displacement: 430.0 in. Bore: 4.875 in. Stroke: 3.875 in. Compression Ratio: 7.30:1. Fuel Grade: 80/87. Dry Weight: 430 lb.

Equipment

Carburetor: Marvel-Schebler MA4-5. Magnetos: Scintilla S6LN-20, and S6LN-21.

- **MODEL: GO-480-B1E6,-B1D**

Data

Type: 6 cylinder, horizontally opposed, air-cooled, gear drive, 270 hp. FAA Type Certificate: 275.

Specs

Length: 38.64 in. Width: 33.12 in. Height: 28.02 in. Bore: 5.125 in. Stroke: 3.875 in. Displacement: 479.7. Compression Ratio: 7.30:1. Weight: 432 lb. Fuel Grade: 80/87.

Performance

Takeoff Power: 270 hp at 3400 rpm (2180 prop rpm). Rated Power: 260 at 3000 rpm. Fuel Consumption: 14.1 gal. per hr. at 2600 rpm, economy cruise.

Equipment

Carburetor: Bendix-Stromberg PS-5BD. Magnetos: Scintilla S6LN-20, S6LN-21.

- **MODEL: GO-480-G1G6**

Data

Type: 6 cylinder, horizontally opposed, geared, air-cooled, 295 hp. FAA Type Certificate: 275.

Specs

Height: 28.02 in. Length: 39.84 in. Width: 33.12 in. Displacement: 480 cu. in. Bore: 5.125 in. Stroke: 3.875 in. Compression Ratio: 8.70:1. Fuel Grade: 100/130. Dry Weight: 439 lb.

Performance

Takeoff Power: 295 hp at 3400 rpm. Rated Power: 280 hp at 3000 rpm.

- **MODEL: GO-480-G1F6**

Data

Type: 6 cylinder, reduction gear drive, horizontally opposed, air cooled, 295 hp. FAA Type Certificate: 275.

Specs

Length: 39.84 in. Width: 33.12 in. Height: 28.02 in. Bore: 5.125 in. Stroke: 3.875 in. Compression Ratio: 8.70:1. Displacement: 479.7 cu. in. Weight: 437 lb. Fuel Grade: 100/130.

Performance

Takeoff Power: 295 hp at 3400 rpm. Rated Power: 280 hp at 3000 rpm. Fuel Consumption: 13.0 gal. per hr. at rated speed and 60 percent rated power.

Equipment

Carburetor: Bendix-Stromberg PS-5BD. Magnetos: Scintilla S6LN-20 and S6RN-21.

- **MODEL: GO-480-G2F6**

Data

Type: 6 cylinder, gear drive, horizontally opposed, air-cooled, 295 hp. FAA Type Certificate: 275.

Specs

Height: 28.02 in. Length: 41.79 in. Width: 33.12 in. Bore: 5.125 in. Stroke: 3.875 in. Compression Ratio: 8.70:1. Displacement: 479.7 cu. in. Weight: 443 lb. Fuel Grade: 100/130.

Performance

Takeoff Power: 295 hp at 3400 rpm. Rated Power: 285 hp at 3100 rpm. Fuel Consumption: 13.5 gal. per hr. at rated speed and 60 percent rated power.

Equipment

Carburetor: Bendix-Stromberg PS-5BD. Magnetos: Scintilla S6LN-20, S6LN-21.

- **MODEL: GSO-480-B1A6**

Data

Type: 6 cylinder, horizontally opposed, geared, supercharged, 340 hp. FAA Type Certificate: 284.

Specs

Length: 49.31 in. Height: 33.08 in. Width: 33.12 in. Bore: 5.125 in. Stroke 3.875 in. Displacement: 497.7. Compression Ratio: 7.30:1. Weight: 498 lb. Fuel Grade: 100/130.

Performance

Takeoff Power: 340 hp at 3400 rpm (2180 prop. rpm). Rated Power: 320 hp at 3200 rpm. Fuel Consumption: 16.0 gal. per hr. at 60 percent rated power at 2600 rpm.

Equipment

Carburetor: Bendix PS-7BD. Magnetos: Scintilla S6LN-20 and S6RN-21.

• MODEL: GSO-480-B1B6 (O-480-1)

Data

Type: 6 cylinder, horizontally opposed, geared, supercharged, 340 hp. FAA Type Certificate: 284.

Specs

Length: 46.22 in. Height: 33.26 in. Width: 33.12 in. Bore: 5.125. Stroke: 3.875. Displacement: 479.7 cu. in. Compression Ratio: 7.30:1. Weight: 500 lb. Fuel Grade: 100/130.

Performance

Takeoff Power: 340 hp at 3400 rpm (2180 prop. rpm). Rated Power: 320 hp at 3200 rpm. Fuel Consumption: 16.0 gal. per hr. at 60 percent rated hp and 2600 rpm.

Equipment

Carburetor: Bendix PSH-7BD. Magnetos: Scintilla S6LN-20, S6RN-21.

• MODEL: GSO-480-B1C6

Data

Type: 6 cylinder, horizontally opposed, geared, supercharged, 340 hp. FAA Type Certificate 284.

Specs

Height: 22.56 in. Length: 52.18 in. Width: 33.12 in. Displacement: 480 in. Bore: 5.125 in. Stroke: 3.875 in. Compression Ratio: 7.30:1. Fuel Grade: 100/130. Dry Weight: 497 lb.

Performance

Takeoff Power: 340 at 3400 rpm. Normal Rated Power 320 at 3200 rpm. Fuel Consumption: 16 gal. per hr. 60% rated power 2600 rpm. Takeoff and rated power to 8000 ft. altitude.

Equipment

Carburetor: Bendix PSH-7BD. Magneto: Scintilla S6LN-20, S6RN-21.

Remarks

Current production installation: Trecker P136-L-2 Super Gull.

• MODEL: GSO-480-B2D6

Data

Type: 6 cylinder, horizontally opposed, geared, supercharged, 340 hp. FAA Type Certificate 284.

Specs

Height: 22.56 in. Length: 47.06 in. Width: 33.12 in. Displacement: 480 in. (3). Bore: 5.125 in. Stroke: 3.875 in. Compression Ratio: 7.30:1. Fuel Grade: 100/130. Dry Weight: 498.

Performance

Takeoff Power: 340 at 3400 rpm. Normal Rated Power: 320 at 3200 rpm. Fuel Consumption: 16 gal. per hr. 2600 rpm.

Equipment

Carburetor: Bendix PSD-7BD. Magneto: Scintilla S6LN-20, S6RN-21.

Remarks

Current production installation: McKinnon Enterprises 4-engine model G-21A Goose Conversion.

• MODEL: O-540-A1D5

Data

Type: 6 cylinder, air-cooled, horizontally opposed, direct drive, 250 hp. FAA Type Certificate: 295.

Specs

Length: 38.42 in. Height: 24.56 in. Width: 33.37 in. Bore: 5.125. Stroke: 4.375. Diplacement: 541.5 cu. in. Compression Ratio: 8.50:1. Weight: 397. Fuel Grade: 91/96.

Performance

Takeoff Power: 250 hp at 2575 rpm. Rated Power: 250 hp at 2575 rpm. Fuel Consumption: 12 gal. per hr. at economy cruise.

Equipment

Carburetor: Marvel-Schebler MA4-5. Magnetos: Two Scintilla, S6LN-21. Generator: Delco-Remy 12 or 24 volt. Starter: Delco-Remy.

• MODEL: SO-580-A1B (O-580-3)

Data

Type: 8 cylinder, air-cooled, opposed, supercharged, for horizontal or vertical helicopter installation, 400 hp. FAA Type Certificate: 285.

Specs

Length: 46.67 in. Width: 33.12 in. Height: 24.58 in. Bore: 4.875 in. Stroke: 3.875 in. Compression Ratio: 7.3:1. Displacement: 578 cu. in. Weight: 578 lb. Fuel Grade: 100/130.

Performance

Takeoff Power: 400 hp at 3300 rpm. Rated Power: 350 hp at 3000 rpm. Fuel Consumption: 16.5 gal. per hr. at rated speed and 80 percent rated power.

Equipment

Carburetor: Bendix PS-9BDE. Magnetos: Scintilla (2) S4LN-20 and (2) S4RN-21.

• MODEL: IGSO-480-A1B6

Data

Type: 6 cylinder, horizontally opposed, geared and supercharged, fuel injection, air-cooled, 340 hp. FAA Type Certificate: 284.

Specs

Height: 23.29 in. Length: 47.56 in. Width: 33.12 in. Displacement: 480 cu. in. Bore: 5.125 in. Stroke: 3.875 in. Compression Ratio: 7.30:1. Fuel Grade: 100/130. Dry Weight: 496 lb.

Performance

Takeoff Power: 340 hp at 3400 rpm. Rated Power: 320 hp at 3200 rpm. Fuel Consumption: 15.8 gal. per hr. at 60 percent rated power.

Equipment

Fuel Injector: Simmonds Type 570. Magneto: Scintilla S6LN-20, -21, -64, -61.

Remarks

Current production installations: Beechcraft Twin-Bonanza, Beechcraft Queen Air, Aero Design Alti-Cruiser.

• MODEL: IMO-360-B1B

Data

Type: 4 cylinder, horizontally opposed, air-cooled, fuel injection, drone, 225 hp at 3400 rpm.

Specs

Height: 17.49 in. Length: 33.25 in. Width: 34.25 in. Displacement: 360 in. (3). Bore: 5.125 in. Stroke: 4.375 in. Compression Ratio: 8.70:1. Fuel Grade: 100/130. Dry Weight: 274 lb.

Performance

Takeoff and Rated Power: 225 hp. at 3400 rpm. Full throttle fuel consumption: 22 gal. per hr.

Equipment

Fuel Injector: Simmonds Type 580. Magnetos: Scintilla S4LN-21.

Remarks

Current production installation: Aerojet-General Surveillance Drone.

• MODEL: IO-360-B1A

Data

Type: 4 cylinder, air-cooled, horizontally opposed, direct drive, fuel injection, 180 hp.

Specs

Length: 32.81 in. Width: 33.37 in. Displacement: 360 cu. in. Bore: 5.125 in. Stroke: 4.375 in. Compression Ratio: 8.50:1. Fuel Grade: 91/96. Dry Weight: 292 lb.

Performance

Takeoff and Normal Rated Power: 180 hp at 2700 rpm at Sea Level. Cruising: 135 hp at 2450 rpm. Fuel Consumption: 11.0 gal. per hr. at 75 percent rated power, 8.5 gal. per hr. at 65 percent rated power. Oil Consumption: .012 lb. bhp per hr. at rated power.

Equipment

Fuel Injector: Simmonds Type 530. Magnetos: Scintilla S6LN-200 and S6LN-204. Starter: Delco-Remy. Generator: Delco-Remy.

• MODEL: O-435-4

Data

Type: 6 cylinder, horizontally opposed, air-cooled, 255 hp. FAA Type Certificate 228.

Specs

Length: 38.53 in. Width: 33.12 in. Displacement: 435 cu. in. Bore: 4.875 in. Stroke 3.875 in. Compression Ratio: 7.30:1. Fuel Grade: 80/87. Dry Weight: 405 lb.

Performance

Takeoff: 255 hp at 3400 rpm at Sea Level. Normal Rated Power: 245 hp at 3200 rpm at Sea Level. Cruising: 200 hp at 3200 rpm at 7000 ft. Fuel Consumption: 18.6 gal. per hr. at 80 percent rated power. Oil Consumption: .012 lb. bhp per hr. at rated power.

Equipment

Carburetor: Marvel-Schebler MA-4-5. Magnetos: Scintilla S6LN-50 and S6LN-51.

• MODEL: IO-540-A1A

Data

Type: 6 cylinder, air-cooled, horizontally opposed, direct drive, fuel injection, 290 hp.

Specs

Length: 39.77 in. Width: 34.25 in. Displacement: 540 cu. in. Bore: 5.125 in. Stroke: 4.375 in. Compression Ratio: 8.70:1. Fuel Grade: 100/130. Dry Weight: 441 lb.

Performance

Takeoff and Normal Rated Power: 290 hp at 2575 rpm at Sea Level. Cruising: 220 hp at 2330 rpm at 6000 ft. Fuel Consumption: 16.5 gal. per hr. at 75 percent rated power, 13.5 gal. per hr. at 65 percent rated power. Oil Consumption: .012 lb. bhp per hr. at rated power.

Equipment

Fuel Injector: Simmonds Type 530. Magnetos: Scintilla S6LN-200 and S6LN-204. Starter: Delco-Remy. Generator: Delco-Remy.

• MODEL: VO-540-C1A

Data

Type: 6 cylinder, horizontally opposed, vertical, air-cooled helicopter, 305 hp. FAA type certificate 304.

Specs

Length: 34.73 in.; Width: 34.70 in.; Displacement: 540 cu. in.; Bore: 4.875 in.; Stroke 3.875 in.; Compression Ratio: 8.70:1; Fuel Grade: 100/130; Dry Weight: 439 lbs.

Performance

Takeoff and Normal Rated Power: 305 hp at 3200 rpm at Sea Level. Cruising: 240 hp at 3200 rpm at 9500 ft. Fuel Consumption: 24.0 gal. per hr. at 80 percent rated power, 21.0 gal. per hr. at 70 percent rated power. Oil Consumption: .014 lb. bhp per hr. at rated power.

Equipment

Carburetor: Twin Marvel-Schebler MA-6AA. Magnetos: Scintilla S6RN-200 and S6RN-204.

• MODEL: IGO-540-A1A

Data

Type: 6 cylinder, air-cooled, horizontally opposed, geared drive, fuel injection, 350 hp.

Specs

Length: 43.88 in.; Width: 34.25 in.; Displacement: 540 cu. in.; Bore: 5.125 in.; Stroke: 4.375 in.; Compression Ratio: 8.70:1; Fuel Grade: 100/130; Dry Weight: 508 lb.

Performance

Takeoff: 350 hp at 3400 rpm at Sea Level. Normal Rated Power: 325 hp at 3000 rpm at Sea Level. Cruising: 240 hp at 2700 rpm at 6000 ft. Fuel Consumption: 21.0 gal. per hr. at 75 percent of rated power, 15.0 gal. per hr. at 65 percent of rated power. Oil Consumption: .014 lb. bhp per hr. at rated power.

Equipment

Fuel Injection: Simmonds Type 580 or Bendix RS10-ED1. Magnetos: Scintilla S6RN-600 and S6RN-604.

• MODEL: IGSO-540-A1A

Data

Type: 6 cylinder, air-cooled, horizantally opposed, geared drive, fuel injection, supercharged.

Specs

Length: 48.50 in.; Width: 34.25 in.; Displacement: 540 cu. in.; Bore: 5.125 in.; Stroke: 4.375 in.; Compression Ratio: 7.30:1; Fuel Grade 100/130: Dry Weight: 538 lb.

Performance

Takeoff: 380 hp at 3400 rpm at 12,000 ft. Normal Rate Power: 360 hp at 3200 rpm at 11,500 ft. Cruising: 270 hp at 2,750 rpm at 13,000 ft. Fuel Consumption: 26.0 gal. per hr. at 75 percent of rated power, 21.0 gal. per hr. at 65 percent of rated power. Oil Consumption: .015 lb. bhp per hr. at rated power.

Equipment

Fuel Injector: Simmonds Type 580. Magnetos: Scintilla S6RN-600 and S6RN-604. Starter: Delco-Remy. Generator: Delco-Remy.

• MODEL: IGO-540-B1A

Data

Type: 6 cylinders, horizontally opposed, air-cooled, geared drive, fuel injection, tuned induction, 4 cycle.

Specs

Length: 43.88 in.; Width: 34.25 in.; Displacement: 541.3 in.; Bore: 5.125 in.; Stroke: 4.375 in.; Compression Ratio: 8.70:1; Fuel Grade: 100/130; Dry Weight: 504 lb.

Performance

Takeoff: 380 hp at 3400 rpm at 12,000 ft. Normal Rated Power: 325 hp at 3000 rpm at Sea Level. Cruising: 240 hp at 2700 rpm at 6000 ft. Fuel Consumption: (CR) .42 lb. per hp per hr.

Equipment

Carburetor: Simmonds Type 530 port fuel injection. Magnetos: Bendix-Scintilla S6RN-200 and S6RN-204. Starter: Bendix-Utica 756-10C.

• MODEL: IGSO-540-B1A

Data

Type: 6 cylinders, horizontally opposed, air-cooled, geared drive, fuel injection, supercharged, 4 cycle, FAA Type Certificate 1E7.

Specs

Length: 48.50 in.; Width: 34.52 in.; Displacement: 541.3 in.; Bore: 5.125 in.; Stroke: 4.375 in.; Compression Ratio: 7.30:1; Fuel Grade: 100/130; Dry Weight: 532 lb.

Performance

Takeoff: 380 hp at 3400 rpm at 12,000 ft. Normal Rated Power: 360 hp at 3200 rpm at 11,500 ft. Cruising: 270 hp at 2750 rpm at 13,000 ft. Fuel Consumption: (CR) .48 lb. per hp per hr. Oil Consumption: (CR) .014 lb. per hp per hr.

Equipment

Carburetor: Simmonds SU 580 injection pump. Magnetos: Bendix-Scintilla S6RN-600 and S6RN-604. Starter: Bendix-Utica 756-10C.

• MODEL IO-540-B1A5

Data

Type: 6 cylinder, air-cooled, horizontally opposed, direct drive, fuel injection, 290 hp, FAA Type Certificate 1E4.

Specs

Length: 38.62 in.; Width: 34.25 in.; Displacement: 541.1 cu. in.; Bore: 5.125 in.; Stroke: 4.375 in.; Compression Ratio: 8.70:1; Fuel Grade: 100/130; Dry Weight: 437 lb.

Performance

Takeoff: 290 hp at 2575 rpm at Sea Level. Normal Rated Power: 290 hp at 2574 rpm at Sea Level. Cruising: 220 hp at 2350 rpm at 6000 ft. Oil Consumption: .012 lb. bhp per hr. at between 75 percent and rated power.

Equipment

Carburetor: Fuel Injection System Bendix Servo RS-10B1. Magnetos: Scintilla S6LN-200 and S6LN-204. Starter: Delco-Remy 12 volt. Generator: Delco-Remy 12 volt, 20 amp.

• MODEL: VO-540-B1D

Data

Type: 6 cylinder, horizontally opposed, vertical, air-cooled helicopter, 305 hp. FAA Type Certificate 304, dual carburetoration.

Specs

Length: 34.73 in. Width: 34.70 in. Displacement: 541.5 in. Bore: 4.875 in. Stroke: 3.875 in. Compression Ratio: 7.30:1. Fuel Grade: 80/87. Dry Weight: 437 lb.

Performance

Takeoff and Normal Rated Power: 305 hp at 3200 rpm at Sea Level. Cruising: 240 hp at 3200 rpm at 8000 ft. Fuel Consumption: 31.7 gal. per hr. at normal rated power.

Equipment

Carburetor: 2 Marvel-Schebler. Magnetos: Scintilla S6RN-200 and S6LN-204. Starter: 20004, Type XIV-A.

PRATT & WHITNEY AIRCRAFT DIVISION
UNITED AIRCRAFT CORPORATION
East Hartford, Connecticut

• MODEL: TWIN WASP D SERIES (R-2000)

Data

Type: 14 cylinder, air-cooled, radial. FAA Type Certificate: 230.

Specs

Diameter: 49.1 in. Length: 59.66 in. Fuel Grade: 100/130. Bore: 5.75 in. Stroke: 5.5 in. Displacement: 2004 cu. in. Compression Ratio: 6.5:1. Dry Weight: Single speed, 1585 lb.; two speed, 1605 lb.

Performance

Takeoff: 1450 at 2700 rpm and 1000 ft. Normal Rated Power: 1200 hp at 2550 rpm and 5000 ft.

Equipment

Carburetor: Stromberg PD-12F13. Ignition: two Scintilla SF14LN-8.

Remarks

Powers Douglas C-54 military transport and the commercial version, the DC-4.

• MODEL: DOUBLE WASP CB SERIES (R-2800)

Data

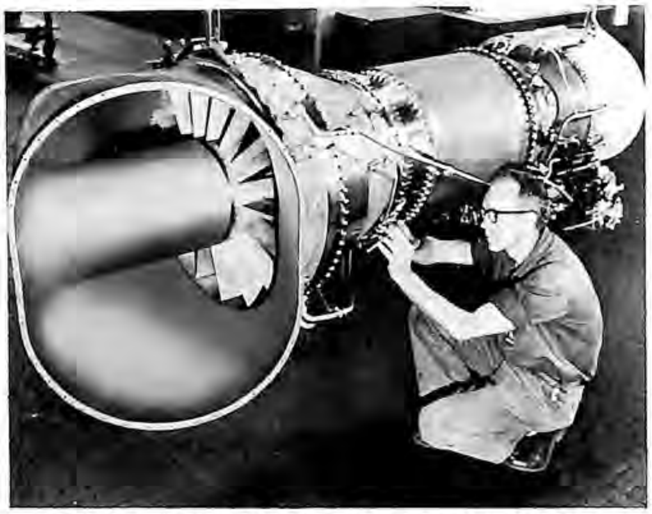
Type: 18 cylinder, air-cooled, radial. FAA Type Certificate: 264.

Specs

Diameter: 52.8 in. Length: 81.40 in. Fuel Grade: 100/130 or 108/135. Bore: 5.75 in. Stroke: 6 in. Displacement: 2804 cu. in. Compression Ratio: 6.75:1. Dry Weight: Two speed, 2390 lb.; Single speed, 2357 lb.

Performance (CB 3)

Takeoff Power: 2400 hp at 2800 rpm at 4000 ft. with water injection; 2050 hp at 2700 rpm at 6000 ft. dry. Normal Rated Power: 1800 hp at 2600 rpm at 8500 ft. CB16, same in low, but has maximum continuous rating in high of 1700 hp.



PRATT & WHITNEY Model JFTD12 Gas Turbine

Equipment

Carburetor: Stromberg PR-58E5. Ignition: Scintilla DLN-10 low tension.

Remarks

Military versions of the Double Wasp power the following production aircraft: Bell XHSL-1 helicopter, Fairchild C-123 transport, Convair T-29 trainer, Douglas C-118A cargo, Grumman AF-28 and -2W hunter-killer teams, North American AJ-1 carrier bomber. Commercial versions power the Convair 240, 340 and 440 transports, Douglas DC-6, -6A, and -6B transports and Martin 2-0-2A and 4-0-4 transports.

• MODEL: PT2G-6 (T34-P-9W)

Data

Type: Axial-flow turboprop.

Specs

Diameter: 34.06 in. Length: 155.12 in. Fuel Grade: JP-4. Dry Weight: 2870 lb. Compressor Stages: 13. Turbine Stages: 3.

Performance

Maximum Power: 7500 ESHP wet, 6500 ESHP dry. Normal Rated Power: 5650 ESHP. Fuel Consumption: 0.55 TSFC at takeoff wet, 0.67 TSFC cruise at 80 percent normal rated power. Oil Consumption: 5.0-lb. per hr. maximum. Military rated power 6300 ESHP.

Remarks

Current production installation: Douglas C-133B.

• MODEL: PT2G-7

Data

Type: Axial-flow turboprop.

Specs

Diameter: 34.06 in. Fuel Grade: JP4. Dry Weight: 2870 lb. Compressor Stages: 13. Turbine Stages: 3.

Performance

Maximum Power: 7500 ESHP-wet, 6500 ESHP-dry. Normal Rated Power: 5650 ESHP. Maximum Continuous Power: 5650 ESHP. Maximum Cruise Power: 4840 ESHP.

Remarks

Current production installation: commercial.

• MODEL: JT3C-2 (J57-P-43W)

Data

Type: Twin-spool, axial-flow turbojet.

Specs

Diameter: 38.6 in. Length: 167.33 in. Fuel Grade: JP-4. Dry Weight: 3840 lb. Compressor Stages: 16. Turbine Stages: 3.

Performance

Maximum Thrust: 13,750 wet, 11,200 dry. Normal Rated Thrust: 9500. Fuel Consumption: 0.765 TSFC cruise at 75 to 90 percent normal rated thrust. Oil Consumption: 0.234 gal. per hr. average.

Remarks

Current production installation: Boeing B-52; Boeing KC-135 and military.

- **MODEL: JT3C-6**

Data

Type: Twin-spool, axial-flow turbojet. FAA Type Certificate 290.

Specs

Diameter: 38.88 in. Fuel Grade: JP-4/JP-5. Dry Weight: 4234 lb. Compressor Stages: 16. Turbine Stages: 3.

Performance

Maximum Thrust: 13,500 wet, 11,200 dry. Normal Rated Thrust: 9500. Fuel Consumption: 0.765 TSFC at maximum cruise rating. Oil Consumption: 0.4 gal. per hr. maximum. Maximum continuous thrust 10,000; maximum cruise thrust 8100.

Remarks

Current production installation: Boeing 707; Douglas DC-8 and commercial.

- **MODEL: JT3C-7**

Data

Type: Twin-spool, axial-flow turbojet. FAA Type Certificate: 290.

Specs

Diameter: 38.88 in. Fuel Grade: JP-4/JP-5. Dry Weight: 3495 lb. Compressor Stages: 16. Turbine Stages: 3.

Performance

Maximum Thrust 12,000. Normal Rated Thrust: 10,000. Fuel Consumption: 0.765 TSFC at maximum cruise rating. Oil consumption: 0.4 gal. per hr. maximum. Maximum continuous thrust 10,000; maximum cruise thrust 8500.

Remarks

Current production installation: Boeing 720 and commercial.

- **MODEL: JT3C-12**

Data

Type: Twin-spool, axial-flow turbojet.

Specs

Diameter: 38.88 in. Fuel Grade: JP4, JP5. Dry Weight: 3550 lb. Compressor Stages: 16. Turbine Stages: 3.

Performance

Maximum Thrust: 13,000. Normal Rated Thrust: 11,500. Maximum Continuous Thrust: 11,500. Maximum Cruise Thrust: 10,200.

Remarks

Current production installation: Boeing 720.

- **MODEL: JT3C-26 (J57-P-20)**

Data

Type: Twin-spool, axial-flow turbojet.

Specs

Diameter: 38.9 in. Fuel Grade: JP4. Dry Weight: 4750 lb. Compressor Stages: 16. Turbine Stages: 3.

Performance

Maximum Thrust: 18,000 with afterburner. Normal Rated Thrust: 9150. Military Rated Thrust: 10,700.

Remarks

Current production installation: Chance Vought F8U-2N.

- **MODEL: JT3D-1**

Data

Type: Twin-spool, axial-flow turbofan. FAA Type Certificate 1E8.

Specs

Diameter: 53.0 in. Fuel Grade: JP-4/JP-5. Dry Weight: 4065 lb. Compressor Stages: 13. Turbine Stages 4. Fan Stages: 2.

Performance

Maximum Thrust: 17,000 to 90° F. Normal Rated Thrust: 14,500. Fuel Consumption: 0.50 TSFC at maximum cruise rating. Oil Consumption: 0.2 gal. per hr. maximum. Maximum continuous thrust 14,500; maximum cruise thrust 12,500.

Remarks

Current production installation: Boeing 707-120B, 720B, Douglas DC-8.

- **MODEL: JT3D-2 (TF33-P-3)**

Data

Type: Twin-spool, axial-flow turbofan.

Specs

Diameter: 53.0 in. Fuel Grade: JP4. Dry Weight: 3900 lb. Compressor Stages: 13. Turbine Stages: 4. Fan Stages: 2.

Performance

Maximum Thrust: 17,000. Normal Rated Thrust: 14,500. Military Rated Thrust: 16,500.

Remarks

Current production installation: military.

- **MODEL: JT3D-3**

Data

Type: Twin-spool, axial-flow turbofan.

Specs

Diameter: 53.0 in. Fuel Grade: JP4, JP5. Dry Weight: 4170 lb. Compressor Stages: 13. Turbine Stages: 4. Fan Stages: 2.

Performance

Maximum Thrust: 18,000 to 90° F. Normal Rated Thrust: 16,400. Maximum Continuous Thrust: 16,400. Maximum Cruise Thrust: 14,800.

Remarks

Current production installation: commercial.

- **MODEL: JT3D-4 (TF33-P-)**

Data

Type: Twin-spool, axial-flow turbofan.

Specs

Diameter: 53.0 in. Fuel Grade: JP4. Dry Weight: 4170 lb. Compressor Stages: 13. Turbine Stages: 4. Fan Stages: 2.

Performance

Maximum Thrust: 18,000 to 90° F. Normal Rated Thrust: 16,400. Military Rated Thrust: 17,000.

Remarks

Current production installation: military.

- **MODEL: JT4A-9 (steel) JT4A-10 (titanium)**

Data

Type: Twin-spool, axial-flow turbojet. FAA Type Certificate 291.

Specs

Diameter: 43.0 in. Fuel Grade: JP4, JP5. Dry Weight: 5050 lb. (-9); 4845 lb. (-10). Compressor Stages: 15. Turbine Stages: 3.

Performance

Maximum Thrust: 16,800. Normal Rated Thrust: 13,000. Maximum Continuous Thrust: 13,500. Maximum Cruise Thrust: 11,850.

Remarks

Current production installation: Douglas DC-8, Boeing 707-320.

- **MODEL: JT4A-11 (steel) JT4A-12 (titanium)**

Data

Type: Twin-spool, axial-flow turbojet. FAA Type Certificate 291.

Specs

Diameter: 43.0 in. Dry Weight 5100 lb. (-11), 4895 lb. (-12). Compressor Stages: 15. Turbine Stages: 3.

Performance

Maximum Thrust: 17,500. Normal Rated Thrust: 14,900. Maximum Continuous Thrust: 14,900. Maximum Cruise Thrust: 13,800.

Remarks
Current production installation: Douglas DC-8.

• **MODEL: JT4A-28 (J75-P-17)**
Data
Type: Twin-spool, axial-flow turbojet.
Specs
Diameter: 43.0 in. Fuel Grade: JP4. Dry Weight: 5875 lb. Compressor Stages: 15. Turbine Stages: 3.
Performance
Maximum Thrust: 24,500 (afterburning). Normal Rated Thrust: 14,300. Military Rated Thrust: 16,100.
Remarks
Current production installation: Convair F-106, military.

• **MODEL: JT4A-29 (J75-P-19W)**
Data
Type: Twin-spool, axial-flow turbojet.
Specs
Diameter: 43.0 in. Fuel Grade: JP4. Dry Weight: 5960 lb. Compressor Stages: 15. Turbine Stages: 3.
Performance
Maximum Thrust: 26,500 (afterburning plus water) 24,500 (afterburning). Normal Rated Thrust: 14,300. Military Rated Thrust: 16,100.
Remarks
Current production installation: Republic F-105, military.

• **MODEL: JT12A-5 (J60-P-3)**
Data
Type: Axial-flow turbojet.
Specs
Diameter: 21.9 in. Fuel Grade: JP4, JP5. Dry Weight: 436 lb. Compressor Stages: 9. Turbine Stages: 2.
Performance
MaximumThrust: 3000. Normal Rated Thrust: 2570. Military Rated Thrust: 3000.
Remarks
Current production installation: military. NAA-UTX.

• **MODEL: JT12A-6**
Data
Type: Axial-flow turbojet. FAA Type Certificate 1E9.
Specs
Diameter: 21.9 in. Fuel Grade: JP4, JP5. Dry Weight: 436 lb. Compressor Stages: 9. Turbine Stages: 2.
Performance
Maximum Thrust: 3000. Normal Rated Thrust: 2300. Maximum Continuous Thrust: 2400. Maximum Cruise Thrust: 2140.
Remarks
Current production installation: commercial, Lockheed JetStar.

• **MODEL: JT12A-7 (J60-P-)**
Data
Type: Axial-flow turbojet.
Specs
Diameter: 21.9 in. Fuel Grade: JP4, JP5. Dry Weight: (steel) 465 lb., (titanium) 440 lb. Compressor Stages: 9. Turbine Stages: 2.
Performance
Maximum Thrust: 3300. Normal Rated Thrust: 2650. Military Rated Thrust: 3000.
Remarks
Current production installation: military.

• **MODEL: JT12A-8**
Data
Type: Axial-flow turbojet.
Specs
Diameter: 21.9 in. Fuel Grade: JP4, JP5. Dry Weight: 465 lb. Compressor Stages: 9. Turbine Stages: 2.
Performance
Maximum Thrust: 3300. Normal Rated Thrust: 2650.

ROCKETDYNE Model H-1 Rocket Engine Thrust Chambers

Maximum Continuous Thrust: 2650. Maximum Cruise Thrust: 2300.
Remarks
Current production installation: commercial.

• **MODEL: JT12A-21 (J60-P-)**
Data
Type: Axial-flow turbojet.
Specs
Diameter: 21.9 in. Fuel Grade: JP4, JP5. Dry Weight: 651 lb. Compressor Stages: 9. Turbine Stages: 2.
Performance
Maximum Thrust: 4025 (afterburning). Normal Rated Thrust: 2350. Military Rated Thrust: 2920.
Remarks
Current production installation: military.

ROCKETDYNE DIVISION
NORTH AMERICAN AVIATION, INC.
Canoga Park, California

• **MODEL: MA-3 ATLAS**
Data
Type: Liquid propellant rocket engine utilizing LOX and RP-1 fuel.
Performance
Rating: 389,000 lb. thrust at sea level.
Equipment
The ATLAS MA-3 rocket engine consists of a regeneratively cooled twin-chamber booster engine, a single-chamber sustainer engine, turbopump, gas generator, and control system.
Remarks
The MA-3 engine is used as the powerplant for the Atlas ICBM. It furnishes the first stage propulsion for the Atlas/Able research vehicle, the Atlas Score satellite, Atlas Agena, and Atlas Centaur. It will provide the booster first stage of Project Mercury.

• **MODEL: H-1 SATURN**
Data
Type: Liquid propellant rocket engine utilizing LOX and RP-1 fuel.

Performance

Rating: Each engine—up to 188,000 lb. thrust. Cluster of eight—1,500,000 lb. thrust.

Equipment

The Saturn H-1 rocket engine consists of a cluster of eight regeneratively cooled single-chamber engines, each operating independently. Each engine has its own gas generator and turbopump, and the four outer engines are mounted on gimbal bearings to maintain directional stability.

Remarks

The Saturn H-1 cluster will be used as the first-stage booster for the ABMA/NASA Saturn project.

• MODEL: MB-3 THOR

Data

Type: Liquid propellant rocket engine utilizing LOX and RP-1 fuel.

Performance

Rating: NA-9—150,000 lb. thrust. NA-11—165,000 lb. thrust.

Equipment

The Thor MB-3 rocket engine consists of a regeneratively cooled single-thrust chamber, turbopump, gas generator, and control system.

Remarks

The MB-3 NA-9 engine is used as the powerplant for the Thor IRBM. It furnishes the booster propulsion for the Discoverer satellites, the Air Force space probes, and the Air Force Thor-Able test vehicles. The NA-11 engine is used as the powerplant for the Air Force space programs.

• MODEL: S-3D JUPITER

Data

Type: Liquid propellant rocket engine utilizing LOX and RP-1 fuel.

Performance

Rating: 150,000 lb. thrust.

Equipment

The S-3D engine has a regeneratively cooled single-thrust chamber, turbopump, gas generator, and control system.

Remarks

The S-3D engine is used as the powerplant for the Jupiter IRBM and as first-stage propulsion for the Juno space probes.

• MODEL: A-7 REDSTONE

Data

Type: Liquid propellant rocket engine utilizing LOX and alcohol fuel.

Performance

Rating: 78,000 lb. thrust.

Equipment

The A-7 engine consists of a double-wall single-thrust chamber, turbopump, and control system.

Remarks

The A-7 is used as the powerplant for the U. S. Army Redstone intermediate range ballistic missile. It furnishes the first-stage propulsion for the Explorer satellites, the Army Jupiter "C" test vehicle, and the NASA Project Mercury program.

Solid Propulsion Operations

McGregor, Texas

• MODEL: 4-NS-130,000 BOOSTER ROCKET MOTOR/M-34

Data

Type: Solid Propellant Rocket Motor.

Specs

Diameter: 27.3 in. Length: 201.0 in. Empty Weight: 2,445 lb.; Loaded Weight: 5,377 lb.

Performance

130,000 lb. thrust for four seconds.

Equipment

The motor consists of a steel cylinder closed on the forward end. The igniter is located on the forward end and a canted nozzle, adjustable for thrust alignment, on the aft end. Thrust is transmitted through two midsection rings and thrust block to the vehicle being boosted. The rings also support the motor when attached to the vehicle.

Remarks

The M-34 rocket motor is used as a booster for zero launching of F-100-D aircraft. The M-34 also is used for zero launching of the KD2U drone, with some attachment fitting modification. The motor can be modified for zero launch of other century series aircraft and military drones.

• MODEL: 10-NS-100,000 MEGABOOM BOOSTER

Data

Type: Solid propellant rocket.

Performance

Rating: 100,000 lb. thrust for 10 seconds.

Equipment

The engine consists of a steel cylinder closed on the forward end. The igniter is located in the forward end and a fixed straight nozzle is on the aft end. Thrust is transmitted to the test vehicle by a forward head closure ring. The unit is held to the test vehicle by clamp rings around the cylinder.

Remarks

The 10-NS-100,000 Megaboom unit is employed to propel high velocity test sleds. A number of variations of this rocket engine with a wide range of thrust-time programs are available for track missions.

• MODEL: 16-NS-1000 AIRCRAFT ROCKET

Data

Type: Solid propellant rocket.

Performance

Rating: 1000 lb. thrust for 16 seconds.

Equipment

The engine consists of a steel cylinder closed on the forward end. The igniter is located on the forward end, and the exhaust nozzle and pressure release diaphragm on the aft end. Thrust is transmitted to the aircraft attachment fittings through three mounting lugs welded on the cylinder.

Remarks

The 16-NS-1000 rocket engine was developed as a smokeless JATO (jet assisted takeoff unit) for the Air Force. It has application for various types of aircraft.

WRIGHT AERONAUTICAL DIVISION

CURTISS WRIGHT CORPORATION

Wood-Ridge, New Jersey

• MODEL: R1300-2A & 2B

Data

Type: 7 cylinder, air-cooled, radial.

Specs

Length: 48.12 in. Width: 50.45 in. Weight: 1067 lb. Displacement: 1300 cu. in. Bore: 6.125 in. Stroke: 6.312 in. Compression Ratio: 6.2:1. Fuel Grade: 91/96.

Performance

Takeoff hp: 800 at 2600 rpm Normal S.L. Normal Rated hp: 700 at 2400 rpm up to 5000 ft. Military Rating: 800 at 2600 rpm at 3500 ft. Fuel Consumption: .72 lb. per bhp per hr. Oil Consumption: .025 lb. per bhp per hr. at normal rated power.

Equipment

Carburetor: Stromberg PD9F1. Magneto: Bosch SF-7LU-3.

Remarks

This engine designed for blimp and helicopter installations: also the R1300-3.

• **MODEL: R1300-3C & 3D**

Data

Type: 7 cylinder, air-cooled, radial.

Specs

Length: 49.68 in. Width: 50.45 in. Weight: 1080 lb. Displacement: 1300 cu. in. Bore: 6.125 in. Stroke: 6.312 in. Compression Ratio: 6.2:1. Fuel Grade: 91/96.

Performance

Takeoff hp: 800 at 2600 rpm Normal S.L. Normal Rated hp: 700 at 2400 rpm. Military Rating: 800 at 2600 rpm at 3500 ft. Fuel Consumption: .700 lb. per bhp per hr., at normal rated power. Oil Consumption: .025 lb. per bhp per hr. at normal rated power.

Equipment

Carburetor: Bendix PD9G1. Magneto: American Bosch S7LU-3.

Remarks

Current production installation is Sikorsky H-19 helicopter. Designed for operation at 39° angle nose-up. Direct drive. Commercial version 990C7BA1 installed in Sikorsky S-55.

• **MODEL: R1300-4**

Data

Type: 7 cylinder, air-cooled, radial.

Specs

Length: 48.12 in. Width: 50.45 in. Displacement: 1300 cu. in. Bore: 6.125 in. Stroke: 6.312. Compression Ratio: 6.20:1. Fuel Grade: 91/96. Total Weight: 1092 lb.

Performance

Takeoff hp: 800 at 2600 rpm Normal S.L. Military Rating: 800 at 2600 rpm at 3500 ft. Normal Rating: 700 at 2400 rpm up to 5000 ft. Specific Fuel Consumption: .720 lb. per bhp per hr. at normal rated power. Oil Consumption: .025 lb. per bhp per hr. at normal rated power.

Equipment

Carburetor: Bendix PD9F1. Magnetos: Bosch S7LU-3.

Remarks

Installation—Goodyear Blimp ZS2G-1. Has high capacity accessory drives.

• **MODEL: R1820-86 & 86A**

Data

Type: 9 cylinder, air-cooled, radial.

Specs

Length: 48.50 in. Width: 54.95 in. Displacement: 1820 cu. in. Bore: 6.125 in. Stroke: 6.875. Compression Ratio: 6.80:1. Fuel Grade: 100/130. Total Weight: 1385 lb.

Performance

Takeoff hp: 1425 at 2700 rpm Normal S.L. Military Rating: 1425 at 2700 rpm at 2000 ft. Normal Rating: 1275 at 2500 rpm up to 3100 ft. Specific Fuel Consumption: .693 lb. per bhp per hr. at normal rated power. Oil Consumption: .025 lb. per bhp per hr. at normal rated power.

Equipment

Carburetor: Bendix PD-12K18. Magnetos: Bosch S9LU-2.

Remarks

Installation: North American T-28C,B. Commercial version 987C9HD1 installed in Learstar Mark 1.

• **MODEL: R1820-82, 82A & 82WA**

Data

Type: 9 cylinder, air-cooled, radial.

Specs

Length: 50.07 in. Width: 55.74 in. Displacement: 1820 cu. in. Bore: 6.125 in. Stroke: 6.875. Compression Ratio: 6.80:1. Fuel Grade: 115/145. Total Weight: 1469 lb.

Performance

Takeoff hp: 1525 at 2800 rpm Normal S. L. Military Rating: 1425 at 2700 rpm at 2400 ft. Normal Rating: 1275 at 2500 rpm up to 3500 ft. Specific Fuel Consumption: .677 lb. per bhp per hr. at normal rated power. Oil Consumption: .025 lb. per bhp per hr. at normal rated power.

Equipment

Carburetor: Bendix PD-12K18. Magnetos: Bendix Scintilla D9LN-2.

Remarks

Installation: Grumman S2F. Similar to Commercial 982C9HE1 which is installed in Hurel-Dubois HD-321 and HD-323. 82A has torquemeter and total weight of 1479 lb. 82WA has wet rating of 1625 hp at 2800 rpm and total weight of 1424.

• **MODEL: R1820-84A & 84B**

Data

Type: 9 cylinder, air-cooled, radial.

Specs

Length: 52.00 in. Widtht: 55.74 in. Displacement: 1820 cu. in. Bore: 6.125 in. Stroke: 6.875. Compression Ratio: 6.80:1. Fuel Grade: 115/145. Total Weight: 1405 lb.

Performance

Takeoff hp: 1525 at 2800 rpm. Military Rating: 1425 at 2700 rpm at 2400 ft. Normal Rating: 1275 at 2500 rpm up to 3500 ft. Specific Fuel Consumption: .677 lb. per bhp per hr. at normal rated power. Oil Consumption: .025 lb. per bhp per hr. at normal rated power.

Equipment

Carburetor: Bendix PD-12R1. Magnetos: Bendix Scintilla D9LN-2.

Remarks

Installation: Sikorsky Helicopter H-34. Commercial version 989C9HE1, 2 installed in Sikorsky S-58 Helicopter. For operation at nominal engine attitudes of 39°, nose up. R1820-90, 90A and commercial equivalents 998C9HE1-2 are similar except have provisions for operation at engine attitudes up to 79°, nose up.

• **MODEL: R1820-88**

Data

Type: 9 cylinder, air-cooled, radial.

Specs

Length: 58.92 in. Width: 55.74 in. Displacement: 1820 cu. in. Bore: 6.125 in. Stroke: 6.875. Compression Ratio: 6.80:1. Fuel Grade: 115/145. Total Weight: 1620 lb.

Performance

Takeoff hp: 1525 at 2800 rpm. Military Rating: 1425 at 2700 rpm at 2400 ft. Normal Rating: 1275 at 2500 rpm up to 3500 ft. Specific Fuel Consumption: .677 lb. per bhp per hr. at normal rated power. Oil Consumption: .025 lb. per bhp per hr. at normal rated power.

Equipment

Carburetor: Bendix PD-12K18. Magnetos: Bendix Scintilla D9LN-2.

Remarks

Installation: Goodyear ZPG-3W Blimp. This engine has strengthened two-piece nose section with 60A prop shaft spline size.

• **MODEL: R1820-103**

Data

Type: 9 cylinder, air-cooled, radial.

Specs

Length: 48.50 in. Width: 54.95 in. Displacement: 1820 cu. in. Bore: 6.125 in. Stroke: 6.875. Compression Ratio: 6.80:1. Fuel Grade: 100/130. Total Weight: 1350 lb.

Performance

Takeoff hp: 1425 at 2700 rpm Normal S.L. Military Rating: 1425 at 2700 rpm at 1000 ft. Normal Rating: 1275 at 2500 rpm up to 3000 ft. Specific Fuel Consumption: .695 lb. per bhp per hr. at normal rated power. Oil Consumption: .025 lb. per bhp per hr. at normal rated power.

Equipment

Carburetor: Bendix PD-12K19. Magnetos: Bosch S9LU-3.

Remarks

Installation: Vertol Helicopter H-21. Commercial version 977C9HD1 installed in Vertol Helicopter V-44.

- **MODEL: R3350-26WB & 26WD**

Data

Type: 18 cylinder, air-cooled, radial.

Specs

Length: 80.81 in. Width: 55.62 in. Weight: 2953 lb. Displacement: 3350 cu. in. Bore: 6.125 in. Stroke: 6.312 in. Compression Ratio: 6.7:1. Fuel Grade: 115/145.

Performance

Takeoff hp: 2700 at 2900 rpm Normal S.L. Military Rating: 2700 at 2900 rpm at 3700 ft. Normal Rated hp: 2300 at 2600 rpm up to 6200 ft. Fuel Consumption: .720 lb. per bhp per hr. Oil Consumption: .025 lb. per bhp per hr. at normal rated power.

Equipment

Carburetor: PR58U1. Magneto: Bendix-Scintilla DLN-9.

Remarks

Installation: Douglas AD7.

- **MODEL: R3350-32W-32WA (TURBO COMPOUND)**

Data

Type: 18 cylinder, air-cooled, radial.

Specs

Length: 91.80 in. Width: 56.59 in. Displacement: 3350 cu. in. Bore: 6.125 in. Stroke: 6.312. Compression Ratio: 6.70:1. Fuel Grade: 115/145. Total Weight: 3560 lb.

Performance

Takeoff hp: 3700 at 2900 rpm. Normal S.L. Military Rating: 3420 at 2900 rpm at 2400 ft. Normal Rating: 2850 at 2600 rpm at 4100 ft. Specific Fuel Consumption: 646 lb. per bhp per hr. at normal rated power. Oil Consumption: .022 lb. per bhp per hr. at normal rated power.

Equipment

Carburetor: CECO 58CPB11. Magnetos: Bendix Scintilla DLN-9.

Remarks

Installation: Lockheed P2V-5-7, Martin P5M-2. Military version of the earlier models Turbo Compound are installed in R7V-1, C119, C and RC-121, WVI, 2 and 3.

- **MODEL: 981TC18EA1 (TURBO COMPOUND)**

Data

Type: 18 cylinder, air-cooled, radial.

Specs

Length: 89.53 in. Width: 56.59 in. Displacement: 3350 cu. in. Bore: 6.125 in. Stroke: 6.312. Compression Ratio: 6.70:1. Fuel Grade: 115/145. Total Weight: 3651 lb.

Performance

Takeoff hp: 3700 at 2900 rpm. Maximum Continuous (Low Blo) (Normal Rated hp): 2850 at 2600 rpm at 4700 ft. Cruise Rated hp: 1910 at 2500 rpm 13,500 ft. Fuel Consumption: .645 lb. per bhp per hr. Oil Consumption: .022 lb. per bhp per hr. at Maximum Continuous.

Equipment

Carburetor: Bendix PR58S2. Magnetos: Bendix-Scintilla DLN-9.

Remarks

Installation CP-107 Bristol Britannia for RCAF.

- **MODEL: 988TC18EA1-2 and 3 (TURBO COMPOUND)**

Data

Type: 18 cylinder, air-cooled, radial.

Specs

Length: 89.53 in. Width: 56.59 in. Weight: 3645 lb. (EA1 and 3); 3745 lb. (EA2). Displacement: 3350 cu. in. Bore: 6.125 in. Stroke: 6.312 in. Compression Ratio: 6.7:1. Fuel Grade: 115/145.

Performance

Takeoff hp: 3400 at 2900 rpm. Maximum Continuous (Low Blo) (Normal Rated hp): 2850 at 2600 rpm at 4700 ft. Cruise Rated hp: 1910 at 2400 rpm at 13,500 ft. (Low Blo). Fuel Consumption: .645 lb. per bhp per hr. at Maximum Continuous. Oil Consumption: .022 lb. per bhp per hr. at Maximum Continuous.

Equipment

Carburetor: Bendix PR58S2. Magnetos: Bendix-Scintilla DLN-9.

Remarks

Reduction gear ratio of EA-1 and 3 is 0.4375:1; EA-2 reduction gear ratio is 0.355:1. Installation: EA-1 in Douglas DC-7C, EA-2 Lockheed 1649, EA-3 Lockheed 1049G and H.

- **MODEL: J65-W-16A**

Data

Type: Axial-flow turbojet.

Specs

Length: 121.9 in. Width: 37.5 in. Total Weight: 2757 max. lb. Compressor Stages: 13 of 29.375. Turbine Stages: 2 of 30.5 in.

Performance

Maximum Thrust: 7700 at 8300 rpm. Normal Rated Thrust: 6780 at 8070 rpm. 75 percent Normal Thrust: 5080 at 7510 rpm. Fuel Consumption at Normal Rated: .895 lb. per hr. per lb. thrust.

Remarks

North American FJ-3 and 4; Douglas A4D.

- **MODEL: J65-W-18**

Data

Type: Axial-flow turbojet.

Specs

Diameter: 37.5 in. Length: 181.4 in. Total Weight: 3485 lb. Compressor Stages: 13 of 29.375 dia. Turbine Stages: 2 of 30.5 in dia.

Performance

Maximum Thrust: 10,500 at 8300 rpm. Military Thrust: 7450 rpm. Normal Rated Thrust: 6470 at 8030 rpm. 75 percent Normal Thrust: 4850 at 7475 rpm. Fuel Consumption at Normal Rated: .920 lb. per hr. per lb. thrust.

Remarks

Current production installation: Grumman F11F-1. This engine is equipped with afterburner.

- **MODEL: 988TC18EA4, 5 & 6 (TURBO COMPOUND)**

Data

Type: 18 cylinder, air-cooled, radial.

Specs

Length: 89.53 in. Width: 56.59 in. Displacement: 3350 cu. in. Bore: 6.125 in. Stroke: 6.312. Compression Ratio: 6.7:1. Fuel Grade: 115/145. Total Weight: 3775 lb. (EA-5); 3675 lb. (EA-4, -6).

Performance

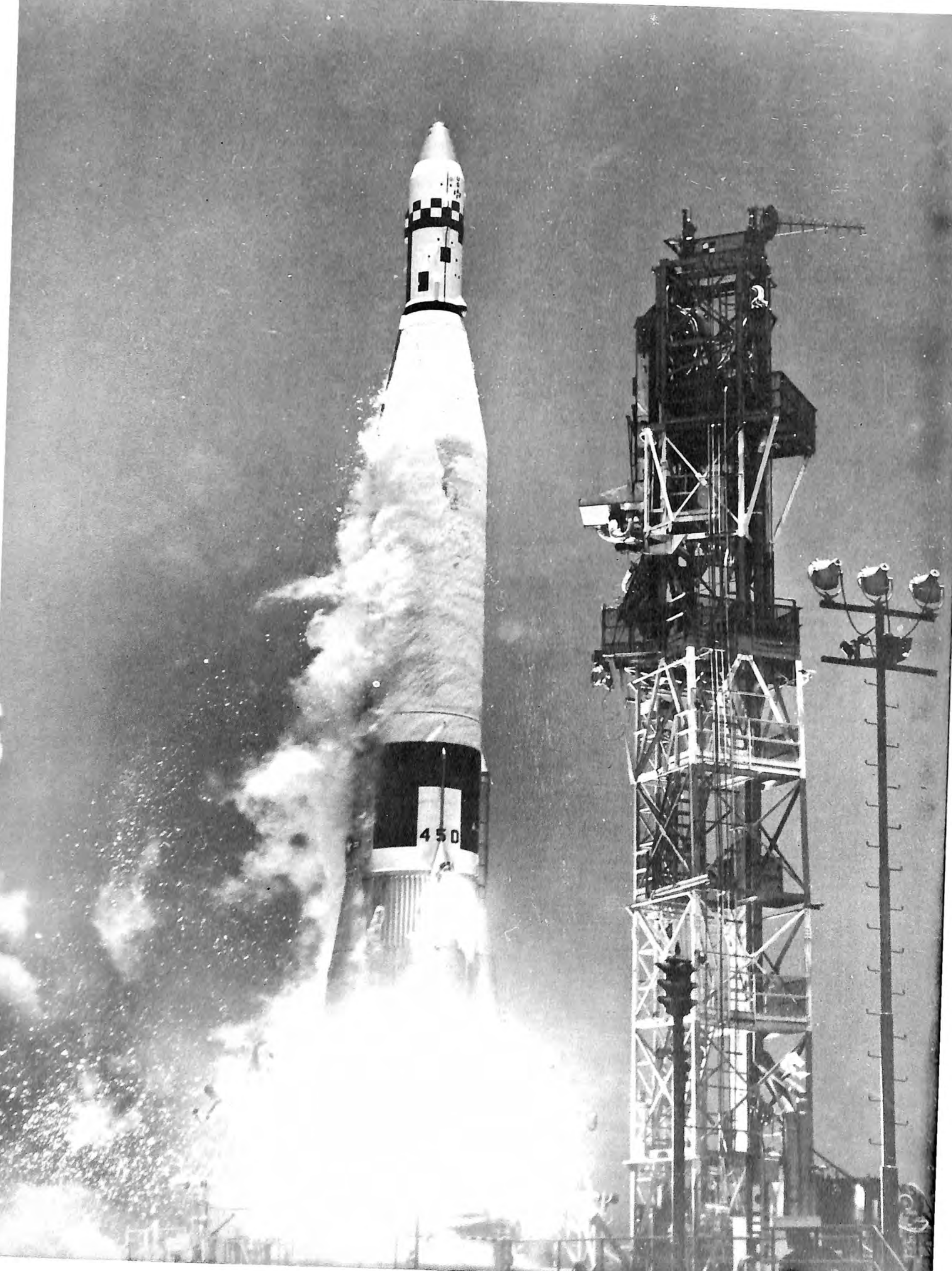
Takeoff hp: 3400 at 2900 rpm Maximum Continuous (Low Blo) (Normal Rated power). 2900 at 2650 rpm at 4800 ft. Cruise Rated hp: 1975 at 2500 rpm at 14,100 ft. (Low Blo). Fuel Consumption: .650 lb. per bhp per hr. at Maximum Continuous. Oil Consumption: .022 lb. per bhp per hr. at Maximum Continuous.

Equipment

Carburetor: Bendix PR58S2. Magnetos: Bendix-Scintilla DLN-9.

Remarks

Reduction gear ratio of EA-5 is 0.355:1; EA-4 and 6 reduction gear ratio is 0.4375:1. Installation: EA-4 in Douglas DC-7C, EA-6 in Lockheed 1049G and H.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SURFACE TO SURFACE

MISSILES

Although manned aircraft continued to be the major element in aerospace weapons expenditures (63 per cent in 1960), missiles made further inroads into the integrated defense structure. In 1960, expenditures for procurement and production of missiles rose above the $4 billion mark. The following pages include an explanatory display of all the missiles, drones and test vehicles cleared for public release.

ATLAS

Atlas, the first U. S. intercontinental ballistic missile, was delivered in greater numbers to operational units of the Air Force during 1960 and at the same time a program was under way to improve performance. The Atlas D series is powered by two 150,000 pound thrust boosters and a 50,000 pound thrust sustainer rocket engine, for a total thrust of 360,000 pounds. It is 82-85 feet long, 10 feet in diameter and weighs 240,000 pounds at launch. It can deliver a thermonuclear warhead 9,000 statute miles and it reaches an apogee of more than 900 miles and a speed of 16,000 miles per hour on its ballistic trajectory.

The Atlas E, a new model powered by MA-3 Rocketdyne engines with a total thrust of 389,000 pounds, is under development. Convair (Astronautics) Division is responsible for Atlas production, testing and base activation. Power plants are built by Rocketdyne Division of North American Aviation. Guidance manufacturers include General Electric Company, Burroughs Corporation for radio-inertial guidance, and American Bosch Arma Corporation for the all-inertial guidance system. Because of its high reliability, Atlas is used as a first-stage booster for a number of space vehicles. Status: operational.

TITAN

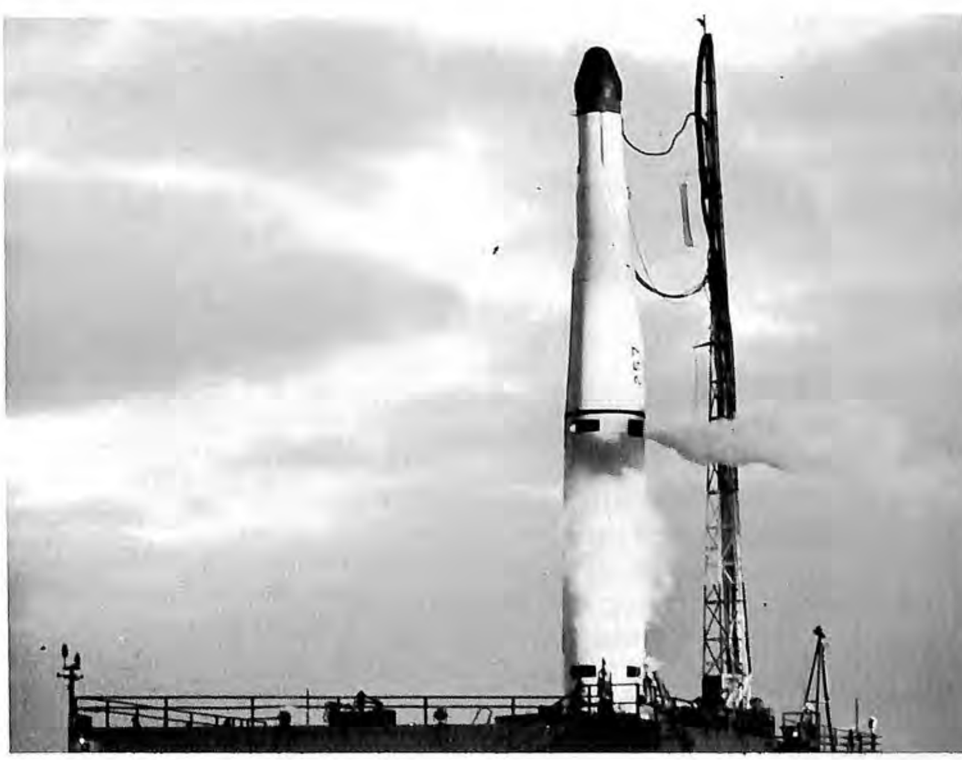
The SM-68 Titan, second of the Air Force's intercontinental ballistic missiles, achieved a remarkable "success ratio" in its 1960 test program. Titan is a two-stage missile designed for launching from underground silos, or "hard sites." It is powered by a 380,000 pound thrust rocket power plant system, which drives the weapon to a speed of more than 17,000 miles per hour. Titan measures 98 feet overall, is 10 feet in diameter in the first stage and eight feet in the second stage, and weighs 110 tons at launch. With range capability similar to that of Atlas, Titan can carry the largest nuclear warhead of any U.S. missile. In addition to its utility as a weapon system, Titan will also power the Dyna-Soar boost-glide space vehicle under development. The Martin Company (Denver) is prime contractor and airframe manufacturer. Aerojet-General builds the power plant and Bell Telephone Laboratories and Remington Rand share responsibility for the radio inertial guidance system. AC Spark Plug Division is developing an all-inertial guidance system for later installation. Status: In production and advanced test.

POLARIS

The major achievement in U.S. missile development in 1960 was the introduction to operational service of the Polaris A-1 Fleet Ballistic Missile. This occurred in November, when the nuclear submarine USS *George Washington* went on patrol duty with a full complement of 16 missiles, following a 13-month flight test program during which 50 A-1 weapons were launched. The A-1 is 28 feet long, solid-propelled and has a range of 1,200 nautical miles. With the A-1 in service, the Navy concentrated on development of Polaris A-2, which will have a range of 1,500 nautical miles, and initiated development of the Polaris A-3, a 2,500 nautical mile range missile. Prime contractor and airframe manufacturer for Polaris is Lockheed Aircraft Corporation's Missiles and Space Division. Inertial guidance is provided by General Electric Company and Aerojet-General produces the power plant. Status: A-1, operational; A-2, advanced development; A-3, early development, scheduled for fleet use in 1965.

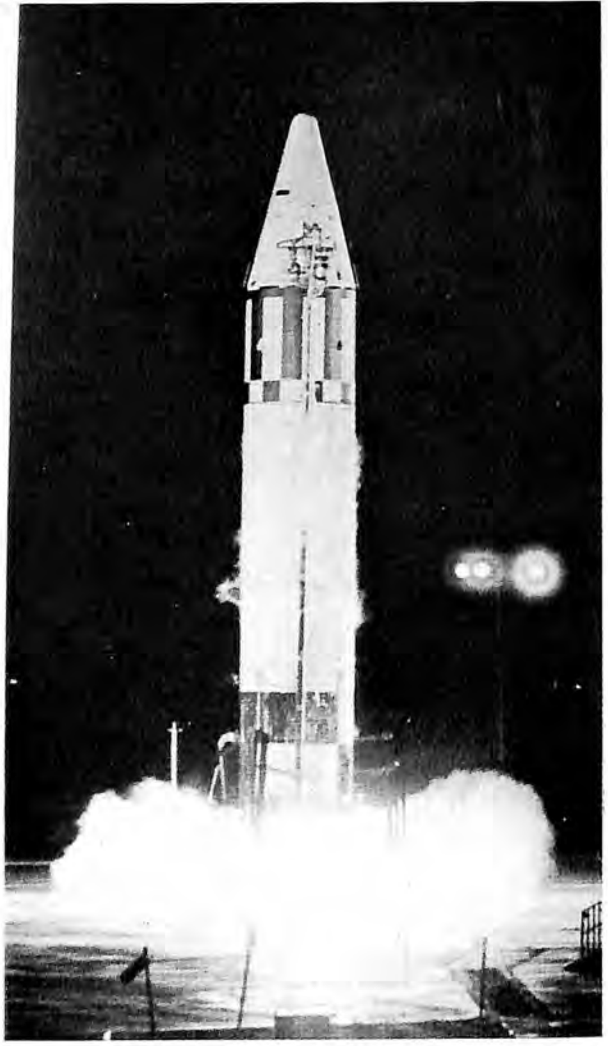
MINUTEMAN

Designed to fill a need for a long-range weapon with more rapid reaction time than the existing liquid-fueled intercontinental ballistic missiles, Minuteman is a second-generation ICBM, lighter, smaller and simpler than Atlas and Titan and powered by a solid-fuel propulsion system. The 1960 Minuteman test program was extraordinarily successful. Results of eight tethered firings at Edwards AFB eliminated the need for 10 additional planned shots and Minuteman moved into the untethered launch portion of its program ahead of schedule. The concept of launching Minuteman from railroad cars for greater mobility was also tested during the year, with the fourth train deployment from Hill AFB, Utah, completed in August. Malmstrom AFB, Montana, was selected as the first hardened and dispersed Minuteman launch site. In September, ground was broken at Hill AFB for an assembly facility to be operated by Boeing Airplane Company, prime and airframe contractor. Other contractors include Aerojet-General, Thiokol and Hercules Powder for power plant development; North American Aviation's Autonetics Division for guidance and control; AVCO Corporation for the nose cone. Status: In development.



THOR

On station in the United Kingdom since September, 1958, Thor was the first American intermediate range ballistic missile to achieve operational capability. Powered by a 150,000 pound thrust liquid rocket, Thor is 65 feet long and has a range of 1,500 nautical miles. Douglas Aircraft Company and Space Technology Laboratories shared prime contractor responsibility and Douglas built the airframes. Rocketdyne supplied the power system and AC Spark Plug manufactured the inertial guidance system. Status: Operational.



JUPITER

Originally developed by the Army and later turned over to the USAF for operational use, Jupiter was the first American IRBM to be successfully fired. With a 1,500 nautical mile range, it is 60 feet long and weighs 110,000 pounds. After development by the Army Ballistic Missile Agency, Jupiter was turned over to Chrysler Corporation for production. Rocketdyne built the 150,000 pound thrust power plants and Ford Instrument Company manufactured the inertial guidance system. Status: Operational.

PERSHING

Designed for general support of the field armies, Pershing is an Army weapon designed to replace Redstone. It is a two-stage missile with both stages solid-fueled. The TEL (transporter-launcher-erector), a unique approach in ground support technology, combined with a track-laying vehicle, gives Pershing full ground mobility. It can be carried by cargo plane or helicopter. The program was moving on an accelerated schedule during 1960 and the first phase of the flight test program was successfully completed. Under overall supervision of the Army Ballistic Missile Agency and the Army Ordnance Missile Command, The Martin Company (Orlando) is prime and airframe contractor and Thiokol is power plant manufacturer. Other members of the team include Bendix Eclipse-Pioneer Division (guidance); Thompson Ramo Wooldridge Corporation (TEL); Collins Radio Corporation (communications); and Bulova Research and Development Laboratories (arming and fuzing). Status: In production, advanced development.

REDSTONE

The first ballistic missile to be deployed overseas, Redstone is an artillery missile which can deliver a conventional or nuclear warhead up to 200 miles. Sixty-three feet long, it is powered by a 75,000 pound thrust Rocketdyne engine. Chrysler Corporation built the airframe and Ford Instrument Company provided guidance. Status: Operational.

SERGEANT

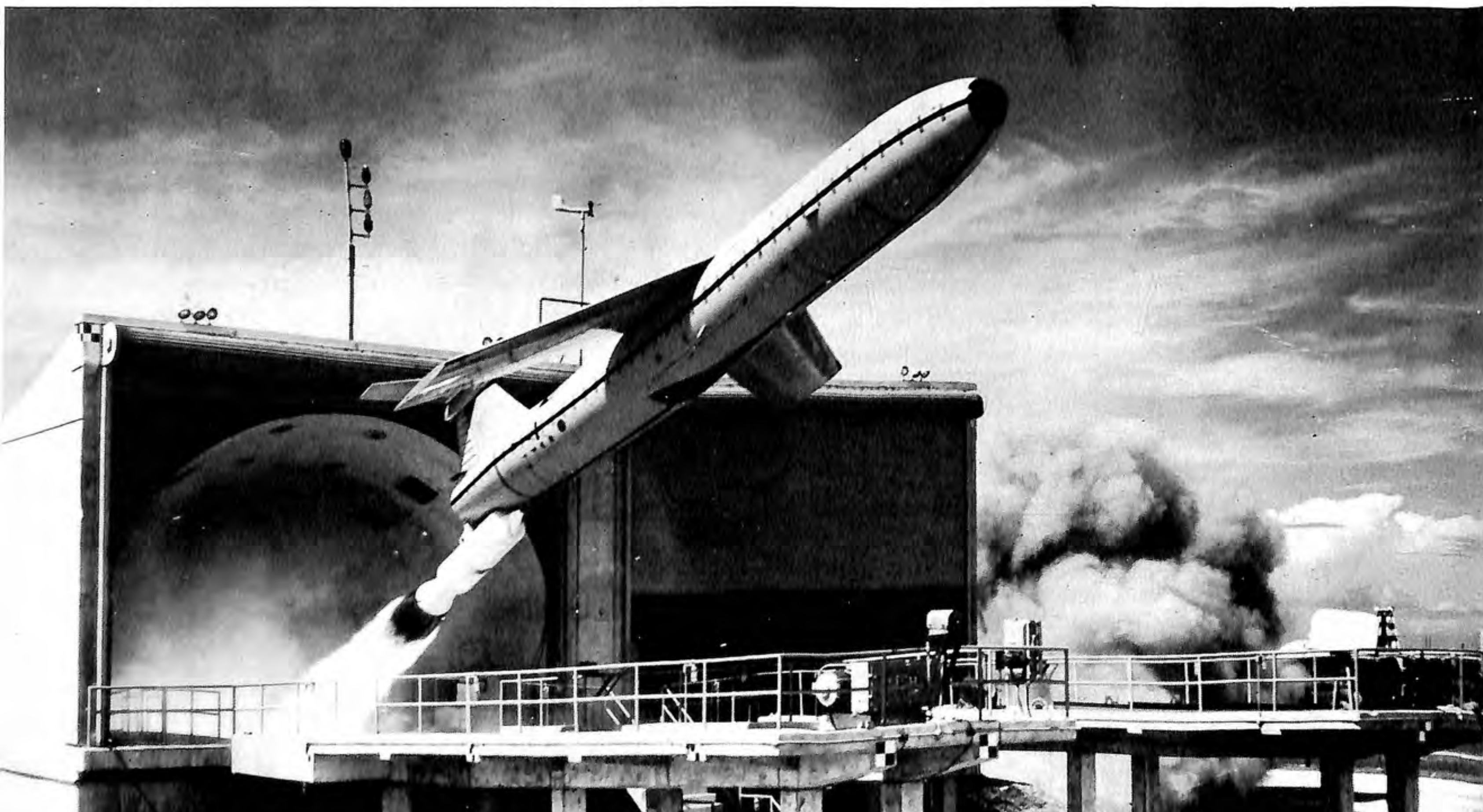
Designed to replace the Army's Corporal, Sergeant is smaller than its predecessor but has greater range, mobility and accuracy. It is 35 feet long, 31 inches in diameter and weighs 10,000 pounds. It has a solid-fuel power plant built by Thiokol Chemical Corporation and an inertial guidance system manufactured by Sperry Utah Engineering Laboratory. Sperry Utah is also prime contractor. Status: In production, advanced development.

CORPORAL

The Army's first ballistic missile, Corporal is still in service and deployed in Europe. Forty-five feet long and weighing 11,000 pounds, it carried either a nuclear or conventional warhead a distance of 75 miles. It employs a preset and command guidance system. The missile was originally developed by Jet Propulsion Laboratory and later named as co-prime contractors were Firestone Tire and Rubber Company and Gilfillan Brothers, Inc. Status: Operational.

SNARK

An air-breathing Air Force missile, SM-62 Snark has intercontinental range, near sonic speed and nuclear capability. Powered in flight by a Pratt & Whitney J57 turbojet engine, it is 67.2 feet long and has a wing span of 42 feet. Initial launch is provided by a pair of rocket boosters. Weighing 59,936 pounds with its boosters, Snark has a self-contained all-inertial guidance system. Prime contractor is Norair Division of Northrop Corporation. Status: Operational.



REGULUS I

Operational since 1954, Regulus was the first attack missile to see Navy service. An air-breather, it is boosted by a solid propellant system and powered by an Allison J33 turbojet engine. It weighs seven tons, is 34 feet long and has a wing span of 21 feet. Speed is about 600 miles per hour and range about 500 miles. Regulus has nuclear capability. Seven ships in commission (one nuclear powered submarine, four conventional submarines and two cruisers) carry Regulus I. Prime contractor is Chance Vought Aircraft, Inc. Status: Operational.

MACE

←

The TM-76 Mace is a replacement for the Air Force's Matador. An air-breathing missile, it has a solid propellant RATO booster and an Allison J33-A-41 turbojet engine for power. Mace is 44 feet long, 54 inches in diameter and weighs 18,000 pounds. Speed is over 650 miles per hour. The TM-76A uses an ATRAN map-matching guidance system and a zero-length Translauncher; it has a range of 650 nautical miles. The improved TM-76B is inertially guided and launched from a fixed hard site; its range is more than 1,100 nautical miles. The Martin Company (Baltimore) is prime and airframe contractor. Thiokol supplies the 100,000 pound thrust booster and Allison Division of General Motors Corporation the 5,200 pound thrust turbojet. Guidance manufacturers are Goodyear Aircraft Corporation for the TM-76A and AC Spark Plug Division of General Motors Corporation for the TM-76B. Status: TM-76A, operational; TM-76B, in production.

MATADOR

The first Air Force missile to attain operational status, Matador is 39.6 feet long, spans 28.7 feet and has a range of about 600 miles at a speed of 650 miles per hour. It is rocket boosted and powered in flight by an Allison J33 turbojet. Matador is electronically ground-controlled. It has been deployed overseas since 1954. Prime contractor is The Martin Company (Baltimore). Status: Operational.

HONEST JOHN

An artillery rocket designed to provide close support for Army ground operations, Honest John is 27 feet long and has a range of 12 miles. It is unguided and carries either conventional or nuclear warheads. Launched from a mobile self-propelled launcher, it weighs 5,800 pounds and is solid propelled. A later version, designated XM-50, has the same warhead capabilities but has greater range and improved accuracy. Contractors associated with the project include Douglas Aircraft Company and Emerson Electric Company. The weapon was developed by Army Ordnance Missile Command. Status: Honest John, operational; XM-50, final development.

LACROSSE

Designed for pin-point accuracy in the close support mission, the Army's Lacrosse carries either nuclear or conventional warheads. It is 19.2 feet long and has a wing span of nine feet. Range is about 20 miles. Power is supplied by a single stage rocket engine built by Thiokol. Launcher is a modified two and one half ton truck, and guidance is by command system, employing a forward station. By the end of 1960, eight Lacrosse battalions had been activated. Components of the airborne package are designed and built by International Telephone and Telegraph's Federal Division. The Martin Company (Orlando) is prime contractor and airframe manufacturer and Martin also builds the ground station. Status: Operational.

LITTLE JOHN

A high degree of accuracy, simplicity of design and ease of operation are the features of Little John, a 10-mile range supplement to Honest John in Army operations. Little John, 14.5 feet long, 12.5 inches in diameter and weighing 760 pounds, is a free flight rocket without electronic controls. It is powered by a solid fuel rocket supplied by Allegany Ballistics Laboratory. Emerson Electric builds the frame, Little John was developed under the supervision of the Army Ordnance Missile Command. Status: Operational.

SS-10, SS-11

Remote-controlled, wire-guided missiles with solid propellant power, SS-10 and SS-11 are Army anti-tank weapons. Both are subsonic and carry conventional warheads. SS-10 is 34 inches long, has a wing span of 30 inches, a diameter of six inches and weighs 33 pounds.

The longer-ranging SS-11 is 46 inches long, has a 20-inch span, a diameter of six inches and weighs 62 pounds. Both are produced by Nord Aviation of France. Status: SS-10, operational; SS-11, under evaluation.

MISSILE A *(No picture)*

Designed for direct support of the Infantry Battle Group, Missile A is a rugged, highly mobile, solid propelled weapon weighing less than 500 pounds. It is the first member of a new family of Army weapons in the second or third generation categories currently known as Missiles A, B, C and D. Missile A is the short range member of the family, transportable by helicopter and usable in airborne operations. Missiles A and B are planned replacements for Honest John, Little John and Lacrosse. Missile C may eventually replace Sergeant for support at corps level. Pershing fills the role of Missile D. Status: Missile A, component development.

SHILLELAGH *(No picture)*

A lightweight missile system being developed for close support of troops, Shillelagh will provide greatly increased firepower against armor, troops and field fortifications. In one application, the weapon will be vehicle mounted. Shillelagh is expected to become operational in the mid-1960's. Prime contractor is Ford Aeronutronics Company. Status: Development.

COBRA *(No picture)*

A man-transportable, anti-mechanized vehicle weapon for Marine Corps use, Cobra is a wire-guided missile with a range of about 2,000 yards. It is solid propelled, 30.7 inches long with a wingspan of 19 inches. Cobra weighs only 20.2 pounds and carries a conventional warhead. It was developed by the German company Boelkow Entwicklungen and Daystrom, Inc., has exclusive rights to sale and manufacture in the U.S. Status: Under evaluation.

UNDERWATER TO UNDERWATER

SUBROC

Designed for antisubmarine warfare, SUBROC is a guided missile fired from a submerged submarine torpedo tube, programmed through the air to re-enter the water for a sub kill. The SUBROC system can detect an enemy submarine at long range, compute its course and speed and fire the missile. The spent rocket power plant drops away and the warhead continues on to the target. Range, though undisclosed in detail, is "greatly in excess of present ASW torpedo ranges." Prime contractor is Goodyear Aircraft Corporation, working under the direction of the Naval Ordnance Laboratory. Status: Development.

SURFACE TO UNDERWATER

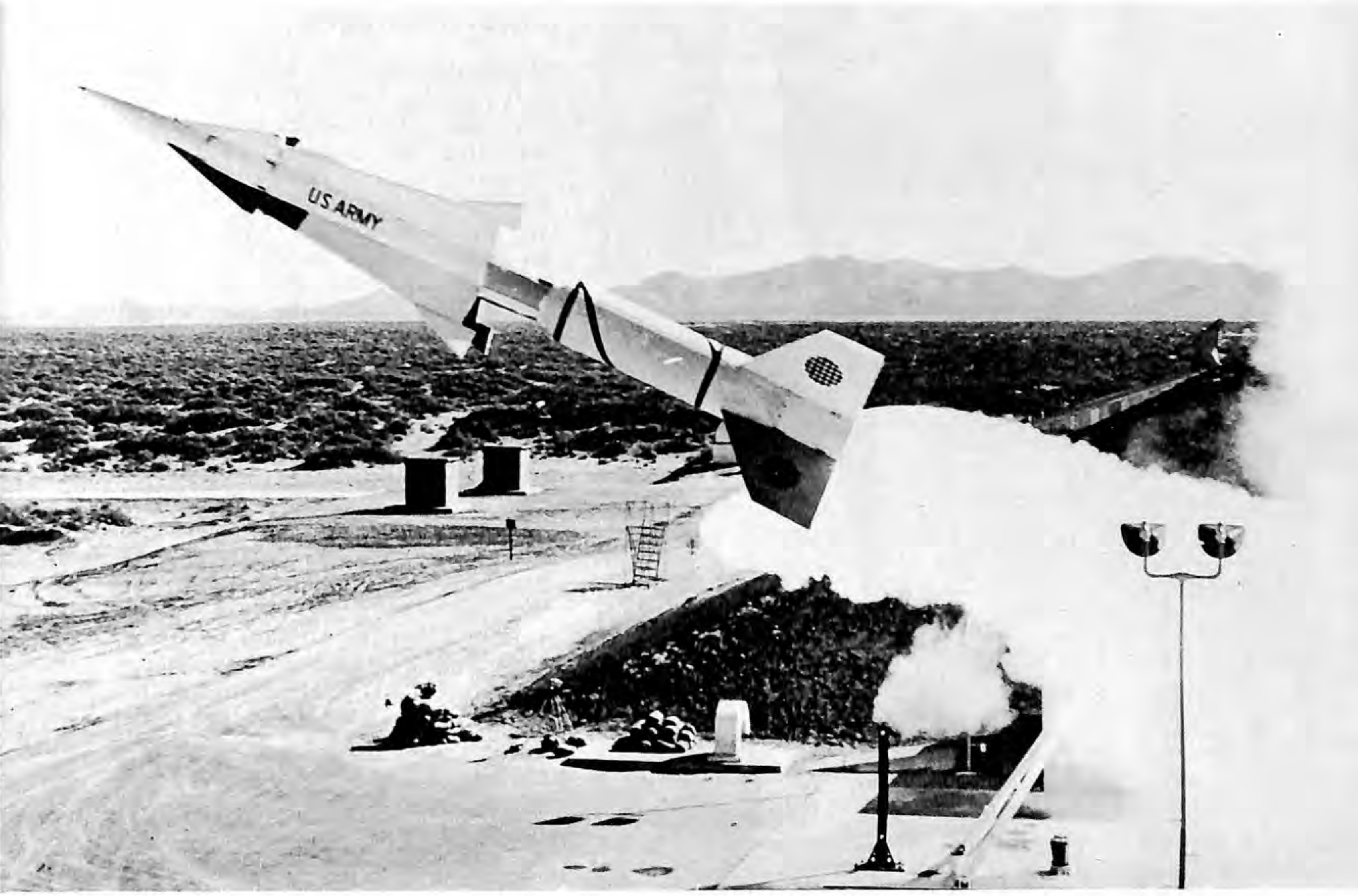
WEAPON ALPHA

Installed on destroyer escorts, Weapon Alpha is fired from a launcher resembling a conventional gun turret. An antisubmarine rocket, it provides greater range and latitude of attack by eliminating the necessity of positioning the ship close to enemy subs as is necessary with depth charges. Alpha is eight and one half feet long, rocket powered, weighs 500 pounds and carries conventional high explosive charge. Status: Operational.

ASROC

Another anti-submarine weapon, ASROC is a solid propellant rocket torpedo. It is fired from surface ships and projected to the target area. Upon striking the water, it is guided to the enemy submarine by acoustic homing. ASROC is scheduled for installation on Navy cruisers and destroyers. Prime contractor is the Ordnance Division of Minneapolis-Honeywell Regulator Company. Status: Development.

SURFACE TO AIR



NIKE-ZEUS

One of the nation's most important weapons projects, the Army's Nike-Zeus was, in 1960, the only anti-missile missile system in the hardware stage of development. Designed to intercept and destroy enemy ballistic missiles traveling at more than 15,000 miles per hour, Nike-Zeus is a three-stage weapon powered by solid propellants. Its booster develops 450,000 pounds of thrust, more than the U.S. intercontinental ballistic missiles. Warhead is nuclear. Range and altitude data have not been released, except for the statement that Zeus "must maneuver within as well as outside the atmosphere to destroy targets at a safe distance from defended territory." The Zeus system, including new, sophisticated, high power radars, data gathering and data processing equipment, and automatic calculating and control equipment, can track a large number of targets simultaneously, guide several missiles from one battery to one or more targets, discriminate between decoys and warheads, and counter the effects of electronic jamming. Initial studies started in 1955, full scale development was authorized in 1957 and the first test missile was fired in 1959. Six of nine tests were successful in 1960. Planned for 1961 were firings from Kwajalein at Atlas missiles launched from the California coast. Bell Telephone Laboratories, Douglas Aircraft Company and Western Electric Company are the major contractors in the program, which also includes 18 major subcontractors. Status: Advanced development and pre-production planning.

NIKE-HERCULES

A command guidance type of missile carrying either conventional or nuclear warheads, Nike-Hercules is capable of destroying any manned aircraft or cruise-type missile known. An Army weapon. Hercules is 27 feet long and 31.5 inches in diameter; with its solid propellant booster attached it is 41 feet, six inches long. The booster consists of four rockets, the second stage has a single solid sustainer. Range is over 75 miles and speed is more than Mach 2.5. The 10,000-pound missile has successfully engaged and destroyed drone targets traveling at 2,000 miles per hour at more than 150,000 feet altitude. It is on station at major U.S. metropolitan centers and Strategic Air Command bases, and is gradually replacing Nike-Ajax. The contractor team includes Western Electric (prime), Douglas Aircraft (airframe) and Bell Telephone Laboratories (guidance). Status: Operational (an improved Nike-Hercules, which scored the first guided missile kill against a Corporal on June 3, 1960, is in final development).

NIKE-AJAX

The first American surface-to-air missile, Nike-Ajax has been in service since 1953, but is gradually giving way to Nike-Hercules. Liquid-propelled, supersonic and guided by radio command, it is 21 feet long and has a range of 25 miles. It is built by the same Western Electric, Douglas and Bell Telephone Laboratories team which handles Zeus and Hercules. Status: Operational.

Nike Ajax left. Nike Hercules right.

HAWK

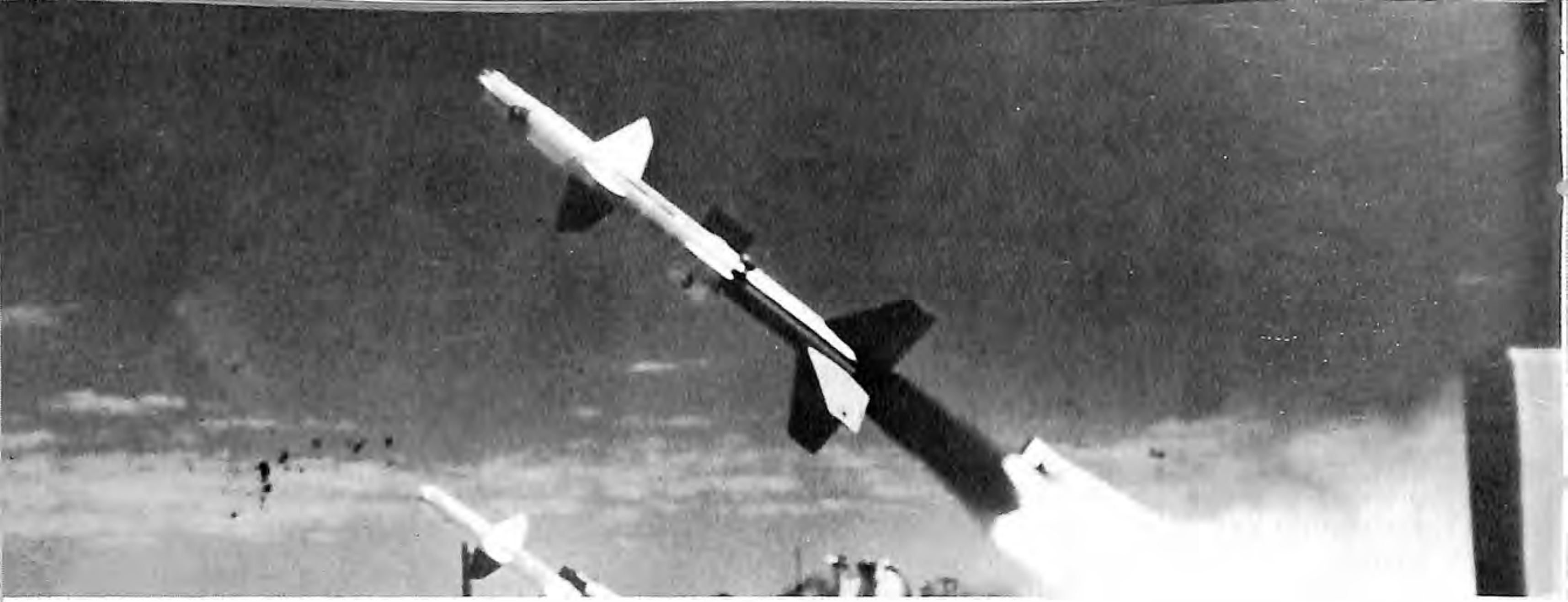
The Hawk missile is a supplementary weapon to the Nike family in Army air defense operations, and it will also be used by the Marine Corps. Designed primarily for defense against low level attack, Hawk is 16.8 feet long and 14 inches in diameter. It is solid-propelled and radar-guided. Three Hawk missiles can be fired from a single launcher; a battery consists of 12 launchers or 36 missiles. Two Hawk battalions have been activated. Nortronics, A Division of Northrop Corporation, is prime contractor. Thiokol Chemical Corporation supplies the rocket power plant and Raytheon Manufacturing Company is guidance manufacturer. Status: Operational with Army, scheduled for early Marine service, entering production for NATO forces in Europe.

MAULER *(No picture)*

Under development by the Army Rocket and Guided Missiles Agency, Mauler is a highly mobile, self-propelled, high-kill-probability missile designed to provide all-weather air defense of forward combat elements of the Army against low flying aircraft and short range missiles. Launched from a tracked vehicle, it will have infrared guidance. Convair is working with the Army on the project. Status: Development.

REDEYE

A shoulder-fired, bazooka-type weapon, Redeye is an Army and Marine Corps missile designed to provide individual troops with defense against low level attack. Four feet long, it weighs only 20 pounds. Fired from its own shipping container, it is infrared guided. Convair (Pomona) Division of General Dynamics Corporation is prime contractor and Philco Corporation supplies the guidance system. Status: Development.



TALOS

Employing a bream-rider guidance system and using either nuclear or conventional warheads, Talos is a Navy weapon designed to destroy enemy aircraft penetrating at high altitudes. It is boosted by a solid rocket and sustained by a 40,000 horsepower ram-jet engine. It has a 65 mile range and a speed of Mach 2.5. Talos is 30 feet long, 30 inches in diameter and weighs 3,000 pounds (7,000 pounds with booster). Bendix Aviation Corporation is Prime contractor. Status: Operational.

BOMARC

The Air Force's IM-99 Bomarc is an intermediate range pilotless interceptor designed to engage attacking aircraft some distance from the intended target. Bomarc weighs 15,000 pounds, is 47 feet long and has a wing span of 18 feet. It is powered by twin Marquardt ramjet engines and an Aerojet-General solid rocket booster. Warheads are either nuclear or conventional; speed is Mach 2.7. The Bomarc A has a range of 200 miles; the advanced "B" model has a range of 500 miles. In October, 1960, a Bomarc B destroyed a target 345 miles from launch point. The weapon is ground controlled by the SAGE system during mid-course, with a seeker system used for terminal guidance. Boeing Airplane Company is prime contractor; Westinghouse supplies guidance equipment. Status: IM-99A, operational; IM-99B, development.

TARTAR

The smallest missile of the surface-to-air category for Navy use, Tartar is a supersonic, homing, solid propelled weapon 15 feet long and one foot in diameter. Range is more than 10 miles. Production versions are scheduled for use on 21 destroyers and three cruisers. Prime contractor is Convair (Pomona). Status: Operational.

TYPHON *(No picture)*

The Typhon weapon system includes two missiles, the Typhon Long Range and Typhon Medium Range, previously called Super-Talos and Super-Tartar. Under development by Johns Hopkins University, the Navy missiles will be powered by solid boosters with ramjet sustainers. They will be supersonic and carry conventional warheads. Bendix Aviation and Westinghouse Electric are associated contractors. Status: Early development.

TERRIER

An anti-aircraft weapon for use by the Navy and Marine Corps, Terrier is 15 feet long, 27 feet with booster, solid propelled and carries a conventional warhead. The original Terrier had a 10-mile range; an advanced model of the missile provides "substantial improvements in coverage." Weighing about 1,100 pounds, it employs a radar beam riding guidance system. Convair (Pomona) is prime contractor, the rocket power plant is built by Allegany Ballistics Laboratory and guidance is provided by Convair and Motorola, Inc. Status: Operational.

AIR TO SURFACE

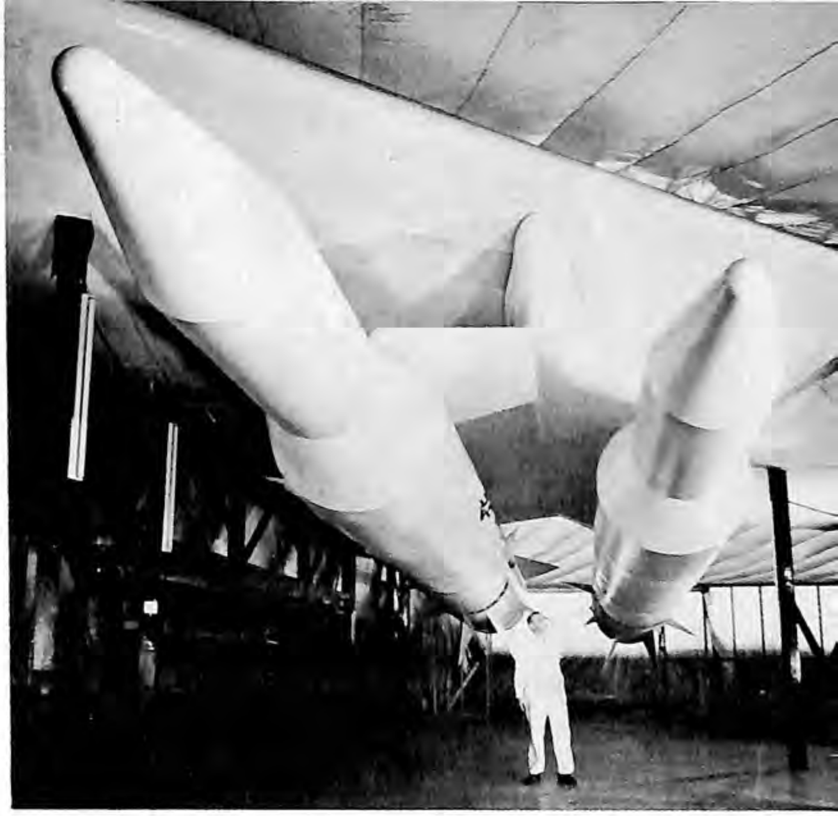
ZUNI

A folding-fin attack rocket for Navy and Marine aircraft, Zuni is used against small targets. Up to 48 Zunis can be carried by the AD type aircraft. Solid propelled, it weighs 107 pounds and is 110 inches long. It carries a conventional warhead and is unguided. Zuni was developed by the Naval Ordnance Test Station, China Lake, California. Status: Operational.

BULLPUP

Used on Navy FJ-4B and A4D aircraft, Bullpup is a simple, relatively inexpensive and high accurate weapon for use against comparatively small defended targets, such as pillboxes, tanks, truck convoys, bridges and railroad tracks. It is 126 inches long and weighs about 600 pounds. Speed is more than Mach 2 and range is more than 15,000 feet. Power is supplied by a pre-packaged liquid propellant rocket and guidance is by radio command link. Navy version is ASM-7A; an Air Force version, GAM-83A, has been tested on F-100 aircraft and is scheduled for use with F-105 fighter-bombers. In 1960, ASM-7A was successfully tested in helicopter use. The Martin Company is prime contractor and airframe and guidance manufacturer. Thiokol builds the power plant. Status: ASM-7A (Navy), operational; GAM-83A, in production.

SKY BOLT



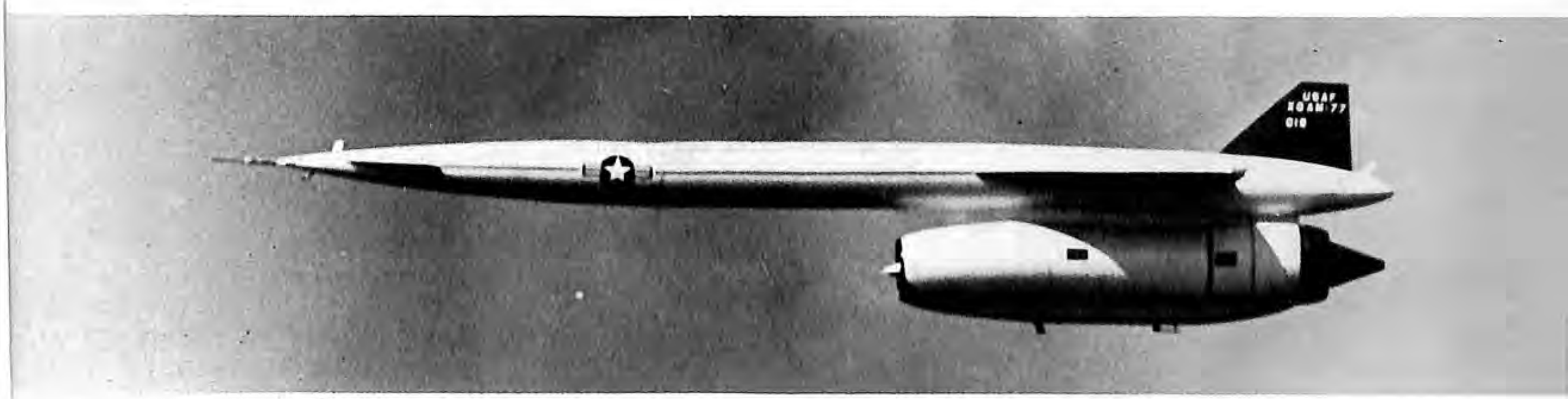
Designated GAM-87, Sky Bolt is a medium range ballistic missile designed for launching from the B-52 bomber in Air Force service, the British Vulcan bomber and the forthcoming B-70. It provides maximum combat effectiveness through mobility, command control, combat range and force survivability. Sky Bolt carries a nuclear warhead more than 1,000 miles from launch point. It is hypersonic and inertially guided, powered by a two stage solid fuel rocket. Douglas Aircraft Company is prime contractor, Aerojet-General supplies power, guidance is by Nortronics and General Electric Company will manufacture the re-entry vehicle. Status: Development.

QUAIL *(No picture)*

A diversionary, or decoy, missile, the GAM-72 Quail is designed to assist in SAC target penetration by diverting attention of enemy defenses from the bomber force. Launched from B-52 bombers, Quail is 12.9 feet long, has a wing span of 5.4 feet. Subsonic, it is powered by a General Electric J85 turbojet engine. It is guided by a gyro autopilot. McDonnell Aircraft Corporation is prime contractor, airframe and guidance manufacturer. Status: Development.

WAGTAIL *(No picture)*

Designed for greater penetration effect through low altitude launch, Wagtail is a solid propelled Air Force weapon which entered test status during 1959. It employs a gyro reference guidance system. Minneapolis-Honeywell's Aeronautical Division is prime contractor, airframe and guidance manufacturer, while Thiokol builds the rocket power plant. Status: Development.



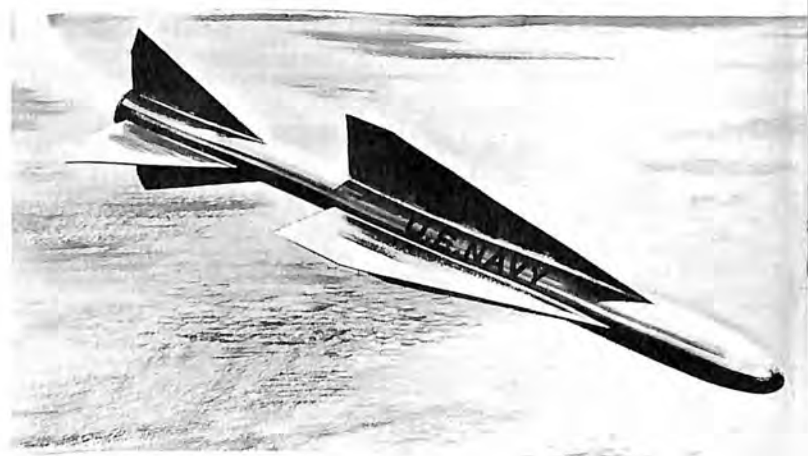
HOUND DOG

Designed to extend the capability of SAC's manned bombers, Hound Dog can deliver a nuclear warhead more than 500 miles after launch from a B-52. Supersonic, it is powered by a Pratt & Whitney J52 engine of 7,500 pounds thrust. It is 42.5 feet long and has a diameter of 28 inches. North American Aviation is prime contractor. NAA's Autonetics Division manufactures the inertial guidance system and the NAA Missile Division builds the airframe. Status: Operational.

AIR TO AIR

FALCON

Among the smallest missiles in production, the Air Force's Falcon family (Gar-1, -2, -3, -4 and others in development) are fired and guided automatically by either radar or a heat-seeking homing device. They can be carried internally or under the wings of interceptor aircraft. The basic Falcons are about six feet long and 6.4 inches in diameter. They weigh about 100 pounds and are solid propelled. Hughes Aircraft Company is prime contractor. Status: Operational.

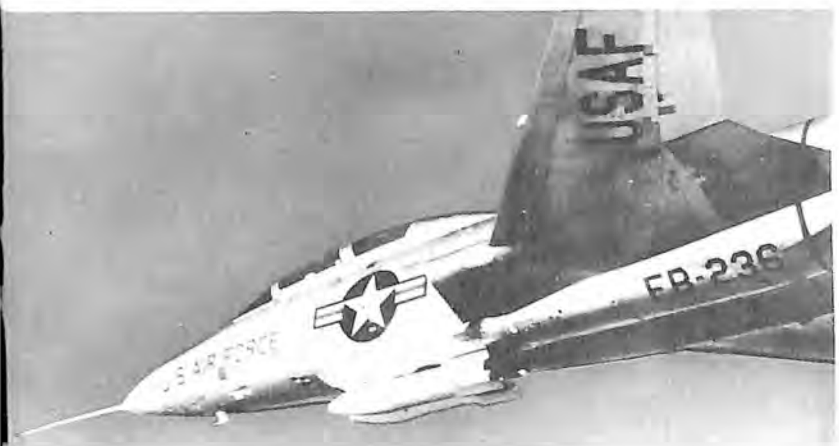


EAGLE

A Navy project, Eagle represents a new trend in air-launched missiles in that the launching aircraft may be relatively slow since the high performance is built into the missile instead of the aircraft. A special aircraft design, called Missileer, is under development by Douglas Aircraft as an Eagle launcher. Eagle is 15 feet long, weighs about a ton and is solid propelled. It will carry a nuclear warhead about 100 miles from launch point. Bendix Aviation Corporation is prime contractor and also responsible for Eagle's flight control, guidance and support equipment. Grumman Aircraft Engineering Corporation will produce the airframe and Aerojet-General will provide a new high performance propulsion system. Status: Early development.

SIDEWINDER

A rugged, inexpensive missile for Navy fighter aircraft, Sidewinder is a simple aluminum tube powered by a solid rocket. It is nine feet long, five inches in diameter and has a Mach 2.5 speed capability. With a conventional warhead, Sidewinder is infrared guided and has a range of six to seven miles. A new IC version of the missile will have interchangeable infrared and radar guidance heads, higher speed and greater range. Philco Corporation is prime contractor and General Electric provides guidance. Status: Basic Sidewinder, operational; IC, development.



GENIE

The first air-to-air weapon to be equipped with a nuclear warhead, Genie is an Air Force missile first tested in 1957. Unguided, it is powered by an Aerojet-General solid rocket. It is carried by F-89's, F-101's and F-106's of the Air Defense Command. Douglas Aircraft Company is prime manufacturer. Status: Operational.

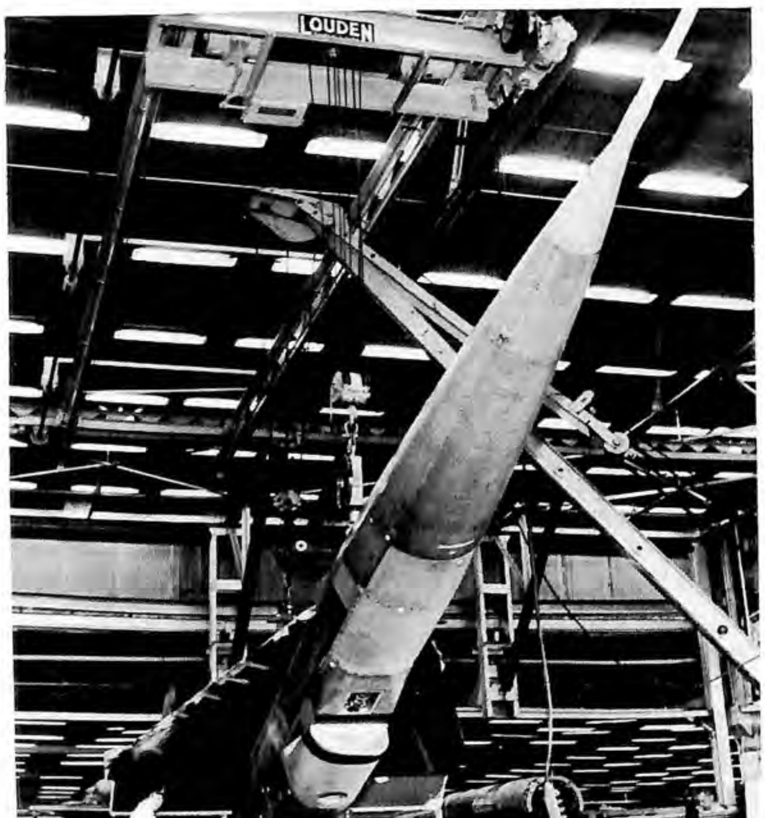
SPARROW III

Twelve feet long, weighing 380 pounds and having a speed capability of more than 1,500 miles per hour within seconds after launch, Sparrow III is a Navy and Marine Corps air defense weapon. It is solid-propelled and has electronic controlled homing. Warhead is conventional. A new version under development will have a prepackaged liquid fuel power plant which can be stored aboard ship for indefinite periods; this version will be used on F4H aircraft. Raytheon Manufacturing Company is prime contractor and guidance manufacturer. Aerojet-General provides the power plant. Status: Operational.

DRONES, TARGETS AND SURVEILLANCE

Q-4B

Northrop Corporation's Radioplane Q-4B supersonic target drone made its first flight in September, 1960. Thirty-five feet long, the drone was launched from a Lockheed GC-130A at Holloman AFB, N.M. A USAF vehicle, the Q-4B is powered by J85 engine.



SD-4

The SD-4 is a combat surveillance drone being built by Republic Aviation Corporation for the Army. Jet-propelled, it was equipped with photographic, radar and infrared devices to keep watch on enemy installations and movements. Project canceled in December, 1960.

SD-5

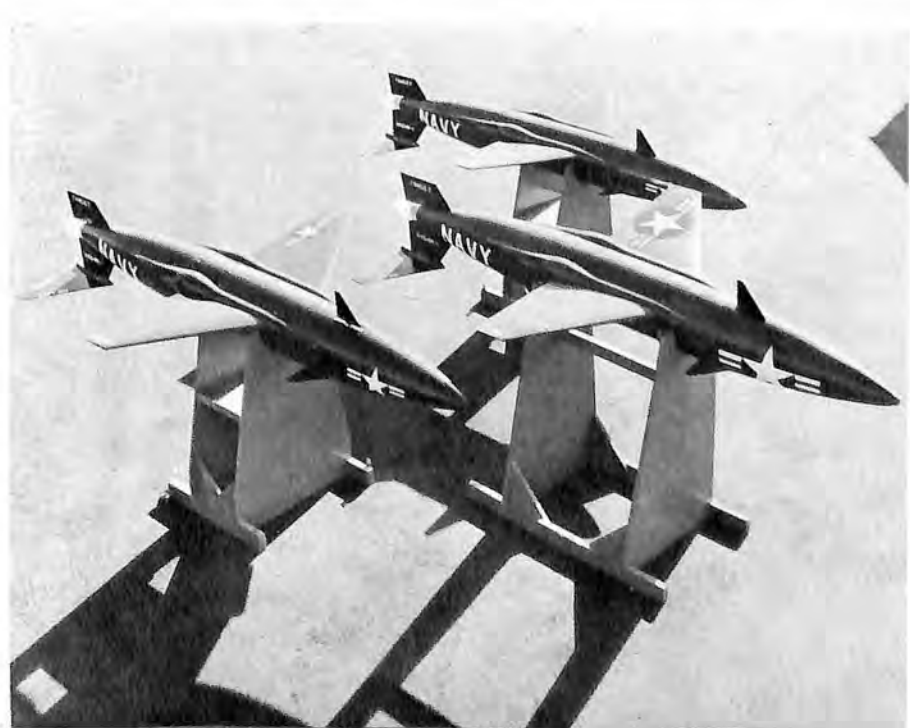
Another of a new series of intelligence-seeking drones, the SD-5 is an airborne surveillance system equipped with a number of sensory devices for reporting battlefield reconnaissance information. It is under development by Fairchild's Aircraft and Missile Division.

SD-2

An Army surveillance drone, the SD-2 is zero launched by means of solid propellant rocket boosters from a standard military vehicle and recovered by parachute. The drone was developed by Rheem Manufacturing Company and taken over by Aerojet-General when the latter company acquired a portion of Rheem. It is now manufactured by Aerojet-General's Aeronautical Division, which is working on an improved version of the SD-2.

RP-76

Built by Radioplane Division of Northrop Corporation, the RP-76 is a target drone for surface-to-air missiles. Speed is in the high subsonic range. Power is supplied by a solid fuel rocket. Air launched and radio controlled, it is operable up to 40,000 feet.

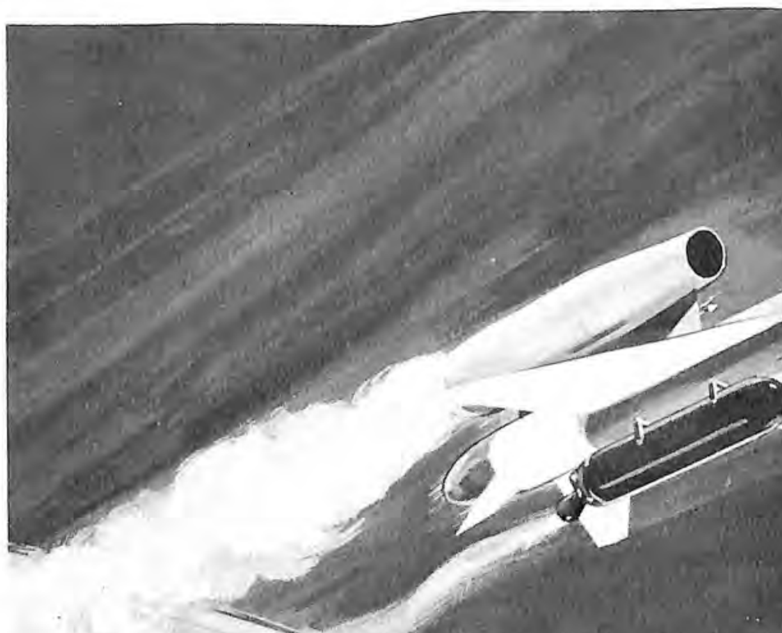


Q2C FIREBEE

Used by both the Air Force and the Navy as a target drone, the Q2C weighs 2,500 pounds and is powered by a Continental J69 turbojet engine of 1,700 pounds thrust. It is 23 feet long and has a wing span of about 13 feet. Remote controlled, it contains equipment to score "miss distance" automatically. Speed is 500 knots and endurance is about one hour. Manufacturer is Ryan Aeronautical Company.

KDA FIREBEE *(No picture)*

A jet target missile with a speed of 500 knots, the KDA is 17½ feet long and has a wing span of 11 feet. Remote controlled, it is powered by a Fairchild J44 turbojet of 1,000 pounds thrust. It is air launched and weighs 1,896 pounds. Lear, Inc. supplies the AN-ARW-59 guidance system. The target is manufactured by Ryan Aeronautical Company.



REDHEAD-ROADRUNNER

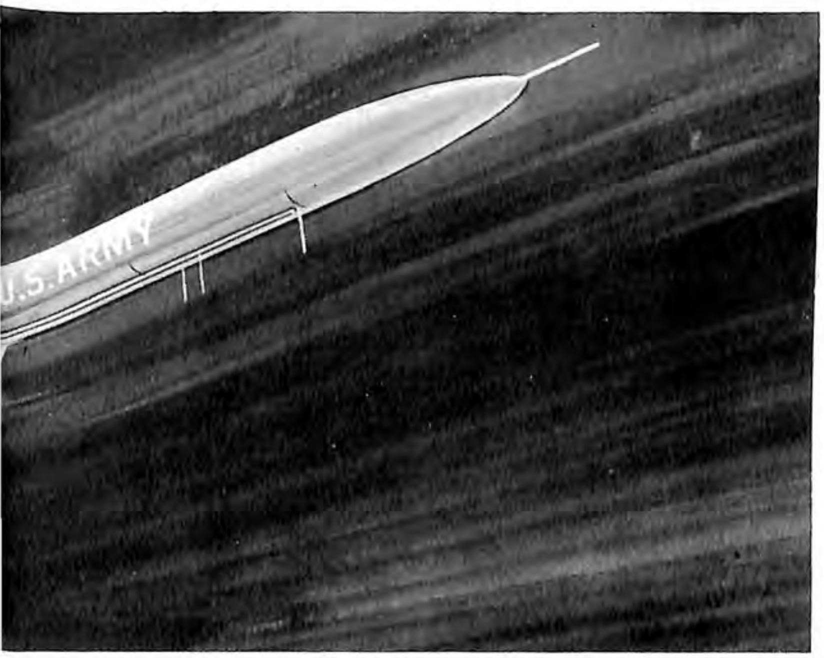
For use by the Army as a low-cost training device, Redhead-Roadrunner will be used to simulate high performance aircraft and missiles at the Army's Air Defense Training Center, McGregor Range, New Mexico. Powered by a booster rocket and a ramjet engine, it is 19

KDT-1

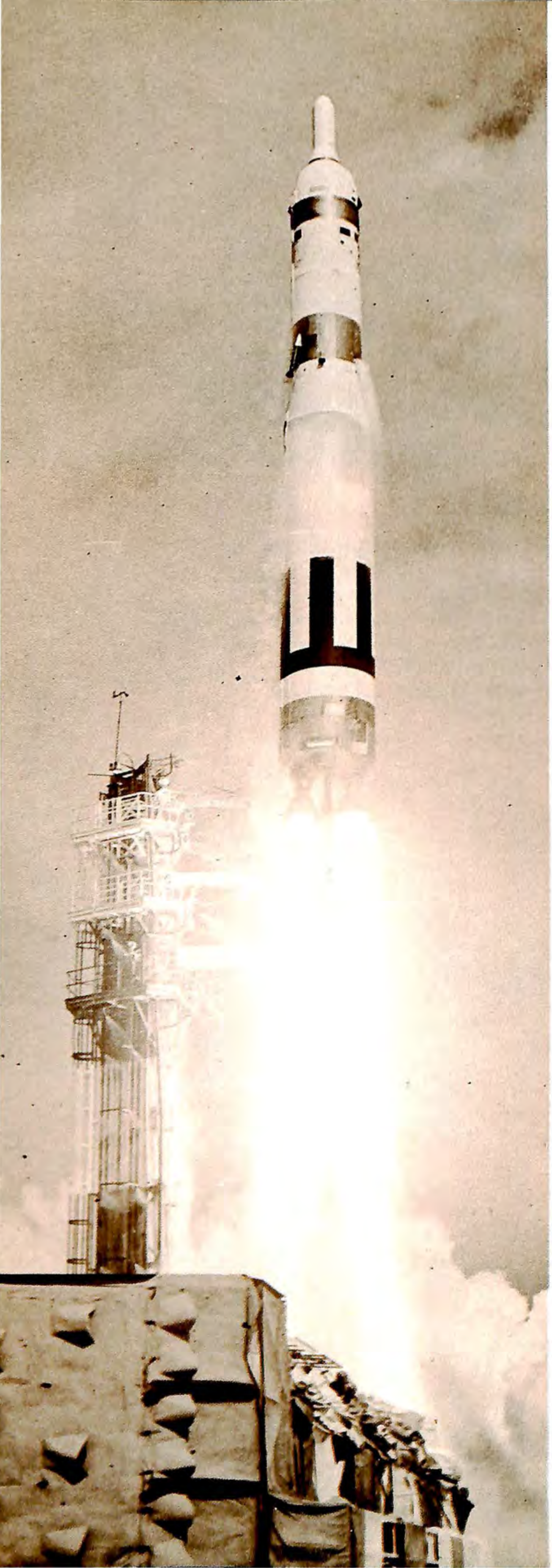
A low cost, expendable drone for use in air-to-air target, the KDT-1 is used by the Navy for training jet fighter pilots. Shown here on the wing of a McDonnell F3H, it emits a flare to permit visual tracking. It is 12 feet long and has a 59-inch wing span. The drone is built by Temco Aircraft Corporation.

KDB-1

In production for both the Air Force and the Navy, the KDB-1 is a radio-commanded missile target built by Beech Aircraft Corporation. It is 15 feet long, spans 12 feet and weighs 600 pounds. Power is a 120 horsepower McCulloch turbo-supercharged engine, which gives the drone a top speed of 300 knots.



feet long and has a span of six feet. It weighs about 400 pounds and has a Mach 2 speed capability. North American Aviation (Columbus) builds the missile, the solid rocket booster is by Rocketdyne and Marquardt supplied the ramjet.



1960 DAY BY DAY CHRONOLOGY

JANUARY

• *January 3*

American Airlines 707 sets new Los Angeles-Baltimore record of 3 hours, 39 minutes and Los Angeles-Boston record of 4 hours, 24 minutes; TWA 707 sets Los Angeles-New York mark of 3 hours, 57 minutes; Eastern Air Lines sets DC-8 Long Beach-Miami record of 3 hours, 58 minutes.

United Air Lines inaugurates daily jet service between Washington-Baltimore and Chicago and San Francisco in DC-8s.

• *January 7*

Passenger miles flown by scheduled air carriers in 1959 totalled more than 29 billion, an increase of nearly 15% over 1958, the U.S. Chamber of Commerce reports.

American Airlines Electra sets new Chicago-Washington record of 1 hour, 11 minutes, 30 seconds. The plane reached a top speed of 540 miles per hour.

• *January 11*

President Eisenhower sends to Congress the nomination of Thomas S. Gates, Jr. as Secretary of Defense; James H. Douglas as Deputy Secretary of Defense; Franklin B. Lincoln, Jr. as Assistant Secretary of Defense; and Dudley C. Sharp as Air Force Secretary. Alan S. Boyd and Whitney Gillilland are nominated to be members of the Civil Aeronautics Board.

• *January 20*

Norair T-38 Talon trainer reaches a speed of mach 1.07 at 30,000 feet in early flights with the afterburner-equipped GE J85-5 engines.

• *January 29*

Lockheed GV-1, tanker-type version of the C-130 Hercules being built for the Marine Corps, makes first flight.

Guided missile destroys ballistic missile for first time as Raytheon Hawk knocks down an Honest John at White Sands. Army reports two missiles were travelling at a combined speed of about 2000 miles per hour at the time of the kill.

TITAN ICBM first full-range complete systems launch in February.

FEBRUARY

• *February 2*

A Titan ICBM is fired successfully for the first time in nine months at Cape Canaveral, achieving its main test objective—separation and ignition of its second stage for the first time.

• *February 4*

Last research and development Jupiter is fired successfully at Cape Canaveral, bringing overall test record to 22 successes, five partial successes, two failures, in 29 attempts.

• *February 5*

Deliveries of utility and executive aircraft during 1959 increased 20 percent over 1958, the Aerospace Industries Association reports. Units totaled 7689 with manufacturers' net billing price of $129,876,000.

• *February 8*

Beech Aircraft Corporation flies six-place Model 65 Queen Air to about 35,400 feet for new national and international record for light airplanes in the Class C-1.d category.

• *February 10*

Douglas Aircraft Company and Sud Aviation of France announce agreement on U.S. marketing of Sud's twin-jet Caravelle, with Douglas also having option to go into production of Caravelle in the United States.

• *February 12*

Delta Air Lines' first Convair 880 sets transcontinental San Diego-Miami record on its delivery flight of 3 hours, 31 minutes, 54 seconds.

• *February 18*

Air Force orders Douglas Aircraft Company to begin development of the Sky Bolt ALBM GAM-87A. Boeing, Northrop, General Electric and Aerojet-General have subcontracts.

• *February 23*

General Electric's CJ-80523 engine powers RB-66 in successful flight, marking the first time "an engine manufacturer has test-flown a turbofan engine as the primary powerplant of an aircraft."

• *February 24*

Titan ICBM is launched from Cape Canaveral and fired 5000 miles in its longest flight to date.

• *February 25*

Army successfully fires Martin Pershing missile over programmed range of 35 miles in first shot.

• *February 29*

First North American X-15 is accepted by the Air Force and turned over to National Aeronautics and Space Administration Research Center, Edwards Air Force Base, California, for research flight test program.

MARCH

• *March 9*

Air Force releases partial specifications for an optimum military cargo aircraft it hopes can be developed jointly with commercial cargo carriers for use by both MATS and commercial airlines.

• *March 11*

Pioneer V Sun Satellite is launched by NASA; the 90-pound payload is placed into solar orbit by three-stage Thor-Able.

• *March 14*

Four-engine Lockheed JetStar powered by Pratt & Whitney JT12s makes first flight at Marietta, Georgia.

Chicago's Midway Airport was the nation's busiest in 1959 with 431,600 landings and takeoffs, Federal Aviation Agency reports.

• *March 15*

Navy's Corvus, supersonic air-to-surface missile, successfully completes its first guided flight at Pacific Missile Range.

• *March 16*

A 69-foot "flying TV station" Redstone missile is fired by Army; it carries a camera in a small capsule ejected during flight to photograph the impact of the warhead and resulting damage.

• *March 22*

Slightly over ten percent of revenue passenger-miles flown in scheduled domestic operations by trunklines in 1959 were performed in pure jet aircraft, CAB report reveals.

Titan is fired from Cape Canaveral, being the seventh success in 11 tries; heat data capsule ejected from nose cone is recovered several days later.

- *March 23*

With Maj. Frank Forsyth as passenger, a Convair F-106 flies itself nonstop from Palmdale, California to Jacksonville, Florida.

- *March 29*

Polaris successfully ground-launched from Observation Island off Cape Canaveral.

- *March 31*

McDonnell's GAM-72 Quail decoy missile completes its first free flight with General Electric J85-7 production jet engine.

APRIL

- *April 1*

Tiros I, a 270-pound meteorological satellite, equipped with two long-range television cameras, is lanched by BASA from Cape Canaveral.

- *April 8*

Aero Design and Engineering Corp. unveils four new models of the Aero Commander, designated 500A, 500B, 560F and 680F.

- *April 12*

Vickers-Armstrongs begins procedures to foreclose its chattel mortgage Capital Airlines' fleet of Viscounts.

- *April 13*

IM-99B Bomarc B is test fired successfully for first time at Eglin Air Force Base.

Navy navigation satellite, Transit II, is successfully launched into orbit.

- *April 19*

Grumman Aircraft & Engineering Corporation flies its Navy A2F attack aircraft for the first time in a 58-minute flight.

- *April 21*

Whitney Gillilland is appointed chairman of CAB, succeeding James R. Durfee who has been named a U.S. Court of Claims judge.

- *April 22*

United States Court of Appeals upholds an FAA order grounding airline pilots over 60 years of age.

MAY

- *May 10*

Convair TB-58, trainer version of B-58 supersonic bomber, makes first flight from Fort Worth.

- *May 14*

Vertol YHC-1A light tactical transport helicopter makes first public appearance during Armed Forces Day demonstrations at Andrews Air Force Base, Maryland.

- *May 17*

Trans World Airlines and Northeast Airlines set in motion the first major trunkline merger in recent years.

- *May 19*

North American X-15 is flown to its highest altitude, 100,000 feet, by Capt. Robert White, USAF.

- *May 20*

An Atlas ICBM is successfully fired over 9000 miles, the greatest distance ever covered by a ballistic missile.

- *May 21*

Hiller 12E sets new aviation altitude records in rescue of two mountain climbers from Mount McKinley with six landings and takeoffs being made at 18,000 foot level, several thousand feet higher than has been attempted previously.

- *May 24*

Air Force fires two-and-a-half ton Midas into orbit; the satellite is designed to detect missiles within seconds after they are fired.

JUNE

- *June 14*

Navy's first hydrofoil contract is awarded to Boeing Airplane Company's Aerospace division, calling for construction of a 110-foot patrol craft displacing 115 tons.

- *June 17*

CAB says it will allow trunklines to raise their passenger fares by 2½ percent plus $1.00 per one way ticket.

- *June 21*

Navy unveils ASROC, an anti-submarine missile system that can fire an acoustic homing torpedo or a depth charge at an enemy submarine from a launching ship thousands of yards away.

- *June 23*

Navy's Transit II-A, an experimental satellite to develop accurate system of navigation, and a solar radiation measuring device are launched by Navy-Johns Hopkins from Cape Canaveral.

Boeing's turbofan powered jet transport, an American Airlines 707-120B, makes first flight from Renton to Boeing Field, Seattle.

JULY

- *July 6*

The single-turbine Sikorsky S-62, an amphibious helicopter built with a boat hull, is certified by the FAA for commercial operations for use in its passenger and mail routes.

- *July 19*

E. Clinton Towl is named new president of Grumman Aircraft Engineering Corporation, succeeding the late Leon A. Swirbul.

- *July 20*

Two tactical Polaris missiles are successfully fired from under water off Cape Canaveral from submarine, USS George Washington.

- *July 22*

Douglas Aircraft Company wins competition for development of Navy's Missileer subsonic aircraft which will carry Navy's Eagle missile; the aircraft will be powered by Pratt & Whitney TF30-2 turbofan engine.

- *July 25*

Lockheed C-130 makes record paradrop of 40,500 pounds at altitude of 5000 feet.

- *July 26*

Army Pershing missile is fired for first time from mobile launcher.

- *July 28*

Capital Airlines and United Air Lines announce plans to merge.

- *July*

Max Conrad flies a Piper Comanche sixty hours and 6,921.38 nonstop miles from Minneapolis to Chicago to Des Moines, more than double the past world record for a nonstop distance record in a closed circuit.

AUGUST

- *August 4*

Rocket-powered X-15, piloted by Joe Walker, sets speed record of 2150 miles per hour over the California desert; record speed was made at 66,000 feet and the craft was powered with two XLR-11 engines.

- *August 10*

Operational configuration Titan missile is fired 5000 miles down the Atlantic Missile Range from Cape Canaveral, marking the first completely successful launching of the Mark I version.

- *August 11*

Air Force successfully recovers 300-pound space capsule ejected from a Discoverer satellite.

- *August 12*

X-15 sets second world record within a week when Air Force Major Robert White flies the craft to 131,000 feet; top speed reached is 1700 miles per hour.

National Aeronautics and Space Administration launches 100-foot visible plastic balloon satellite, Echo I, into orbit to reflect radio communications signals.

- *August 19*

Air Force makes aerial retrieve of Discoverer XIV capsule 8000 feet above the Pacific.

- *August 27*

Air Force Captain Joseph W. Kittinger makes record parachute jump from a balloon approximately 102,800 feet over the New Mexico desert.

SEPTEMBER

- *September 5*

McDonnell F4H Phantom II claims new world class record of 1216.78 miles per hour over a 500 kilometer closed course.

- *September 7*

Army and The Martin Company conduct successful first test firing of the two-stage Pershing ballistic missile.

Sikorsky Aircraft delivers first turbine-powered helicopter, the S-62, to Los Angeles Airways for use in scheduled airline service.

- *September 21*

Air Force Blue Scout Junior is fired an estimated 17,000 miles into space; first-stage solid rocket engine, Aerojet Senior, produces more than 100,000 pounds of thrust over a 40-second period.

- *September 25*

Navy claims new world speed record when McDonnell F4H-1 Phantom II fighter, powered by two General Electric J-79 engines and piloted by Commander John F. Davis flies at 1390.21 miles per hour over a 100-kilometer closed circuit course.

- *September 30*

General Nathan Twining retires as chairman of the Joint Chiefs of Staff; he is succeeded by General Lyman L. Lemnitzer.

OCTOBER

- *October 4*

Air Force places 500-lb. Courier earth satellite radio station into orbit to receive and record high-speed radioteletype and voice messages from one station and relay them to another when triggered by a coded signal.

NASA fires Scout rocket 3500 miles into space and 5800 miles downrange in a test of radioactivity in the Van Allen belt.

- *October 7*

First production model General Electric J79-8 is delivered to Navy and will power McDonnell F4H Phantom II and North American A3J Vigilante aircraft.

- *October 12*

Air Force drops record load of 41,740 lbs. from a Lockheed C-130 turbo-prop cargo transport.

Civil Aeronautics Board approves Eastern Air Lines proposal for air bus service between Pittsburgh and Miami for a four-month trial period.

- *October 13*

Three mice are recovered alive from the nose cone of an Atlas missile which has been boosted 700 miles into space and tracked by the Azusa Mark II missile tracking system.

- *October 24*

Boeing-Vertol 107 twin-turbine transport helicopter makes first successful flight.

- *October*

Thor becomes the first intermediate-range ballistic missile to reach the 100-launch milestone.

NOVEMBER

- *November 14*

Air Force successfully snares capsule of Discoverer XVII satellite that had circled the earth 31 times covering nearly one million miles.

- *November 15*

X-15 makes successful first flight with upgraded 57,000-lb. thrust Thiokol XLR-99 engine.

Polaris is deployed on schedule with USS George Washington casting off from Charleston (S.C.) depot carrying 16 missiles armed with nuclear warheads.

- *November 16*

Beech Aircraft Co. unveils new light twin, Model 55 Baron, powered by Continental 260-hp fuel injection engines.

- *November 23*

Tiros II weather satellite is successfully launched into orbit.

- *November 24*

Convair rolls out first 990 jet transport (previously designated the 600) which is powered by GE CJ805-23 engines and cruises at 640 mph.

DECEMBER

- *December 6*

Boeing Airplane Co. announces plans to produce the three-jet 727 short-to-medium transport and reveals that it has signed contracts with United and Eastern for 40 each.

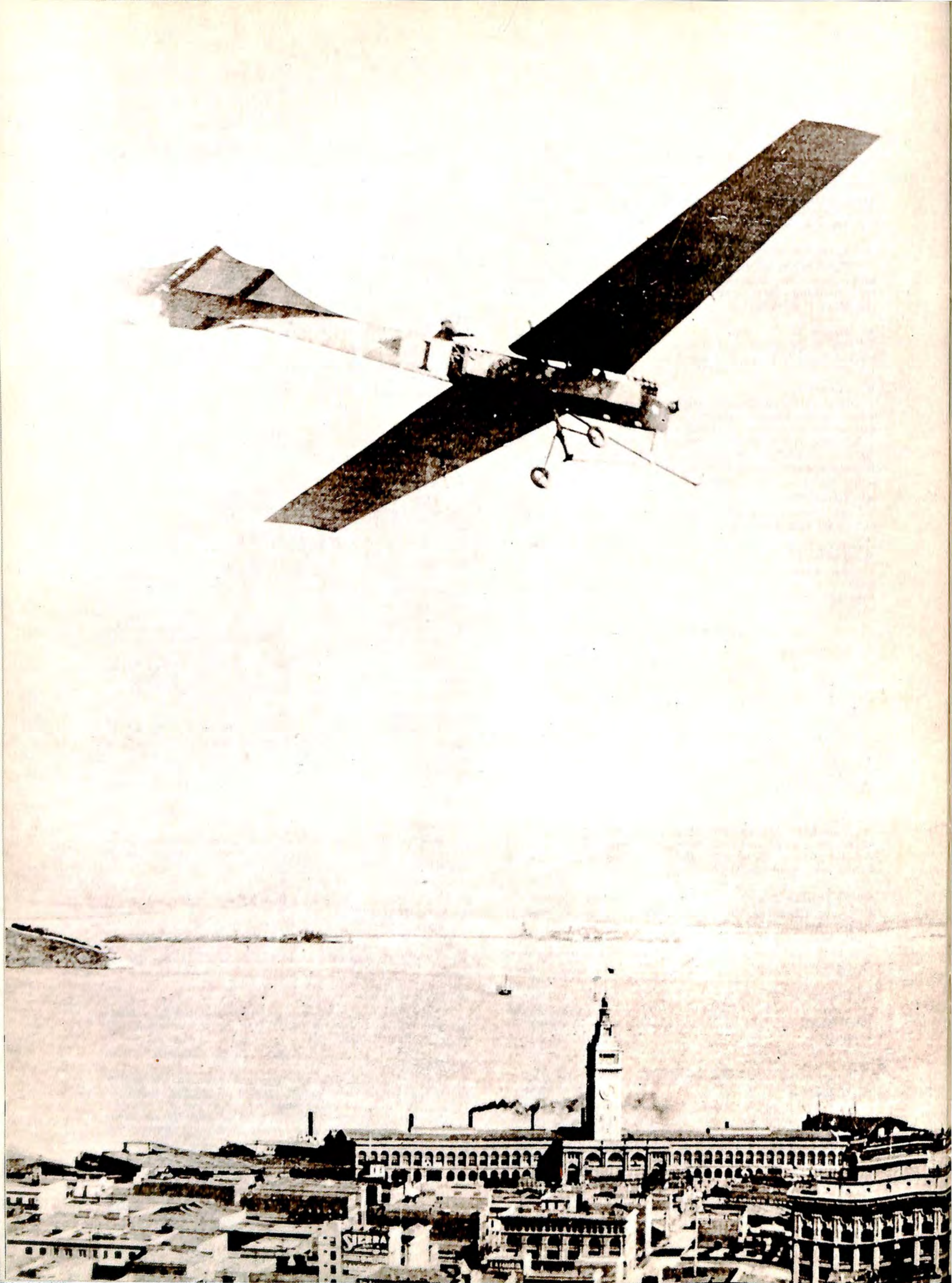
- *December 13*

Navy claims new world altitude record for jet aircraft carrying a 1000 kilogram payload in North American A3J flight to 91,450.8 feet.

- *December 19*

Empty Project Mercury capsule is launched 235 miles downrange from Cape Canaveral by a modified Redstone booster for first successful flight.

Discoverer XIX satellite, designed to measure radiation to aid in detecting nuclear armed missiles, is lofted into polar orbit.


SIERRA

UNITED STATES CHRONOLOGY

1784, January 16—Airborne troops proposed by Benjamin Franklin in reporting on the first balloon ascents.

1784, June 24—First U.S. balloon flight in Peter Carnes' captive balloon, Baltimore, Md.

1784, November 30—First ascent by an American abroad, by Dr. John Jefferies, physician, with French aeronaut Blanchard, at London. On January 7, 1785, they made the first Channel crossing by air.

1793, January 9—Balloon flight by Jean Pierre Blanchard from Philadelphia, Pa., to Woodbury, N.J. (Letter from George Washington carried on this flight.)

1837, September 18—Parachute demonstration in America when John Wise drops animals from a balloon at Philadelphia.

1838, August 11—John Wise safely lands with his parachuted balloon at Easton, Pa.

1840, September 8—Col. John H. Sherburne urges Secretary of War to use night balloons to locate Seminoles.

1842, October 22—John Wise proposes to capture Vera Cruz by air.

1844, October 16—America's first air patent to Muzio Muzzi in direction of balloons.

1845, September 18—Rufus Porter proposes steam airship line, New York-California, to carry goldseekers at $100 a trip. Stock sales unsatisfactory. His 1849 booklet illustrates a jet-propeller passenger rocket.

HUBERT LATHAM pilots Antoinette in first flight over Golden Gate, January 7, 1911.

1859, July 2—World record balloon trip, 809 miles, St. Louis to Henderson, N.Y., by John Wise and three companions.

1859, August 16—Airmail carried by John Wise in balloon flight from Lafayette to Crawfordsville, Ind.

1860, August 21—Capt. E. B. Hunt, Corps of Engineers, U.S.A., advocates balloon telegraphy.

1860, October 13—Successful aerial photos taken by William Black from a balloon, Boston, Mass.

1861, June 10—Military flight by James Allen, first Rhode Island State Militia, in balloon over Washington, D.C.

1861, June 18—Balloon telegraph demonstrated by T. S. C. Lowe. (Message to Abraham Lincoln.)

1861, June 22-24—Military reconnaissance by T. S. C. Lowe and Army officers from balloon using telegraph, over Arlington and Falls Church, Va. Military air observation continues into 1863.

1861, August 3—Civilian aeronaut La Mountain inaugurates aircraft carrier operations with his war balloon. Lowe follows.

1861, September 24—Air Artillery adjustment from Lowe's Army balloon near Washington.

1861, November 7—Helicopter proposed for Union Army. After experiments, a machine is partly built before Appomattox ends the project.

1862, March 9—War helicopter bomber designed and urged by William C. Powers of Mobile, Ala.

1866, May 25—Solomon Andrews' airship maneuvers over New York with 4 passengers.

1873, October 6—Unsuccessful trans-Atlantic flight by W. H. Donaldson, Alfred Ford and George A. Lunt in balloon, *Graphic*, from Brooklyn, N.Y., to New Canaan, Conn.

1877—Prof. William H. Pickering, Harvard University, begins experiments with model helicopters. In 1903 a rabbit is sent aloft.

1880—Thomas A. Edison conducts helicopter experiments for James Gordon Bennett.

1883, March 17—First of a series of glider flights by John Joseph Montgomery, Otay, Cal.

1885, January 7—Russell Thayer, C. E., a graduate of West Point, urges on Secretary of War Robert T. Lincoln a compressed-air airship of his design. No action.

1887, January 30—Thomas E. Baldwin makes his first parachute jump at San Francisco.

1886, July—W. E. Irish, publisher of *Aeronautical World*, proposes balloon radio.

1887—American altitude record made by aeronaut Moore and Prof. H. A. Hazen of U.S. Signal Service, at St. Louis; 15,400 feet, in balloon of St. Louis *Post Dispatch*.

1890, July 31—During the month, L. Gathmann, of Chicago, explodes a shell at high altitude in attempt to produce rain.

1890, October 1—President Harrison approves legislation creating the Weather Bureau and re-establishing the Signal Corps which is charged with collection and transmission of information, among other duties. Military aeronautics is then considered as among such means, and Army aeronautics is revived.

1892, October 10—Balloon section is being organized with each telegraph train by Chief Signal Officer, General A. W. Greely, who anticipates military airships and airplanes.

1892, November 5—Wingless aerial torpedo suggested by Prof. A. F. Zahm.

1893, August 1-4—International Conference on Aerial Navigation held at Chicago; Octave Chanute, Chairman; Dr. A. F. Zahm, Secretary.

1893, October 9—The Chief Signal Officer, General Greely reports the purchase of a Lachambre balloon for the Signal Corps balloon section. First ascents since the war are made at the Chicago exposition from October 31, 1893.

1896, April 29—First American wind tunnel begins operation at M.I.T.

1896, May 6—Steam-powered airplane model flown by Samuel Langley, Washington, D. C.

1898, April 29—War and Navy Departments examine Langley's work, approve, and Board of

LOWE BALLOON used for

Ordnance and Fortification makes two allotments of $25,000 each to build his airplane.

1898, December 22—The Secretary of War approves a Fort Myer site for barracks, officer quarters, administration building and a balloon house to concentrate Signal Corps schools at one point.

1901, September 1—Simon Newcomb, Ph.D., LL.D., writes in *McClures* for September: "The first successful flyer will be the handiwork of a watchmaker and will carry nothing heavier than an insect."

In December, Rear Admiral Melville, USN says in the *North American Review:* "A calm survey . . . leads the engineer to pronounce all confident prophecies at this time for future success as wholly unwarranted, if not absurd."

1902, September 15—A. Leo Stevens sails his airship *Pegasus* over Manhattan Beach in a race with Edward C. Boyce in the latter's Santos Dumont airship.

1903, March 23—Orville and Wilbur Wright apply for patent on their flying machine. (Patent issued May 22, 1906.)

1903, December 8—Samuel Langley's flying machine, piloted by Charles Manly, plunges in the Potomac and is wrecked on its second test, Washington, D. C.

1903, December 17—First sustained controllable flight of powered heavier-than-air machine by Orville and Wilbur Wright, Kitty Hawk, N. C.

1904, August 3—Circuit flight in airship (Curtiss motor) by Capt. Thomas S. Baldwin at Oakland, Cal.

1904—Wright brothers make 104 flights, covering 20 miles. British representative visits the Wrights in November.

1905, January 18—Wright brothers open negotiations with U. S. War Department for disposi-

military observation during Civil War.

tion of their invention. Correspondence is had through 1907.

1905, April 29—Daniel Maloney begins series of glides with Montgomery glider, taking off from captive balloon. Later killed.

1905, August 5—Charles K. Hamilton begins series of kite flights, towed by cars and boats.

1905, September 26-October 5—Wright brothers make 55 flights, the longest being 24 miles in 38 min. 3 sec. Frank S. Lahm, in France, obtains report on Wrights' flying from Ohio relative. French remain skeptical. In October the French government is negotiating along with British.

1905—Lt. Frank P. Lahm becomes first Army balloon pilot.

1906, January 13-20—First indoor aero exposition, New York.

1906, March—French and British visit Wright brothers at Dayton.

1906, September 30—First Bennett international balloon race won by Lt. F. P. Lahm—Paris to England.

1906, December 1-8—Second indoor air exhibition of Aero Club of America.

1907, June 8—Building devoted exclusively to aeronautics dedicated at Jamestown (Va.) Exposition.

1907, August 1—Aeronautical Division established, Army Office of Chief Signal Officer.

1907, September 2—Walter Wellman airship *America* fails in polar attempt.

1907, September 30—Ornithopter of H. C. Gammeter, multigraph inventor, lifts temporarily.

1907, October 1—Aerial Experiment Association formed by Dr. A. Graham Bell, F. W. Baldwin, J. A. D. McCurdy, Glenn H. Curtiss and Thomas E. Selfridge.

1907, October 3—Record altitude of 23,110 feet by U. S. Weather Bureau meteorological kite.

1907, October 18—Air bombing prohibition signed at second Hague conference.

1907, October 21—Second Bennett international balloon race, St. Louis, won by Oscar Erbsloh of Germany. Airship races are held Oct. 22-23.

1907, October 28-29—International Aeronautic Congress held in New York.

1907, October 28—Admiral C. M. Chester urges anti-submarine airships and shipboard airplanes at International Aeronautic Congress.

1907, December 6—Seven-minute towed flight from motor boat tug in Dr. Bell's kite, flown by Lt. T. E. Selfridge.

1907, December 16—Chief Signal Officer advertises for airship bids, resulting in purchase of Baldwin airship.

1907, December 23—Chief Signal Officer advertises for airplane bids, after visit of Wrights.

1908, February 10—First Army plane contract signed by Signal Corps with Wright brothers. (Other contracts signed with A. M. Herring and J. F. Scott.)

1908, March 12—First Aerial Experiment Association's plane, *Red Wing*, flown by F. W. Baldwin. Later, three other machines fly.

1908, May 6-18—Wright brothers renew flying preliminary to delivery of Army airplane. Charles Furnas is first airplane passenger.

1908, May 13—Balloon radio reception demonstrated by Signal Corps.

1908, May 31—G. H. Curtiss Manufacturing Company announces planes for sale.

1908, June 10—Aeronautical Society formed in New York and Morris Park Airfield shortly obtained—first of kind in U. S.

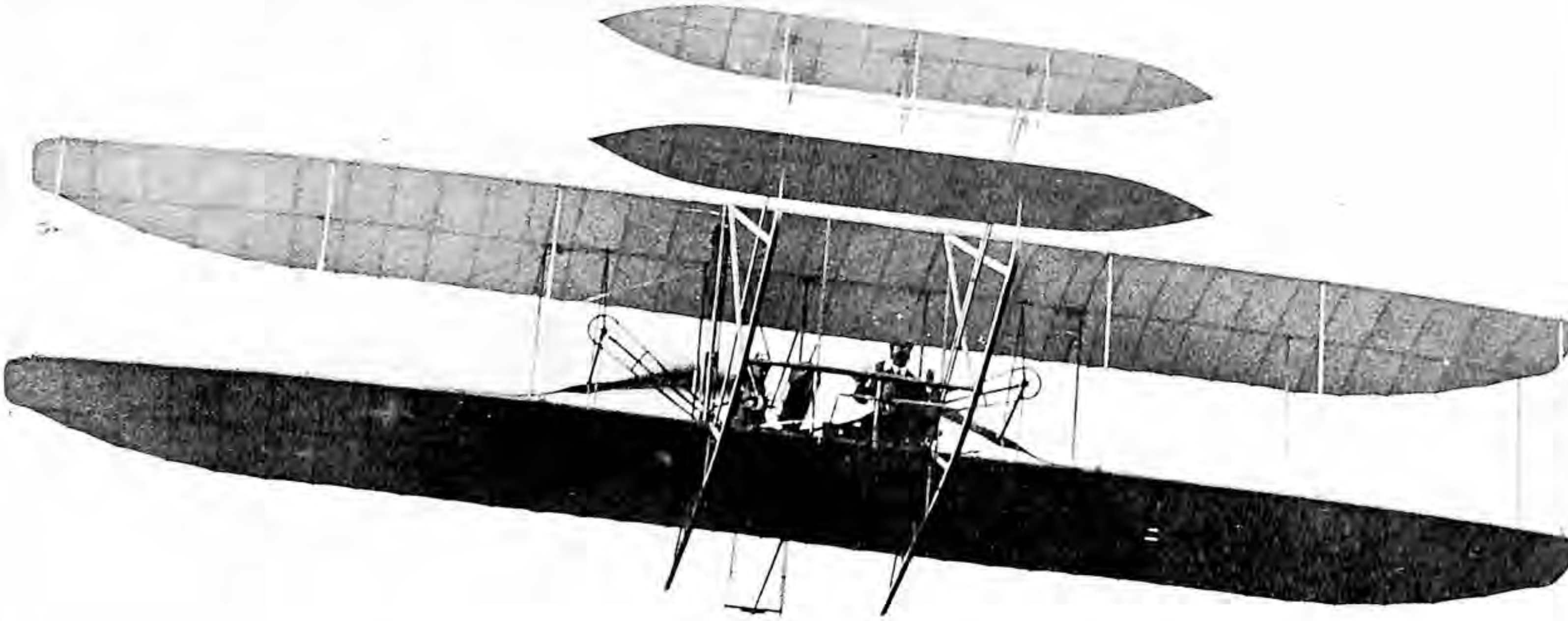
1908, June 20—Anthony radio-controlled airship model demonstrated.

1908, July 4—*Scientific American* Trophy awarded Glenn H. Curtiss for first public flight of one kilometer circuit in his biplane, *June Bug*, Hammondsport, N. Y.

1908, July 17—First air ordinance passed by Kissimmee, Fla., with registration and regulation.

1908, August 8—Demonstration flights under French Syndicate control begin near LeMans, France, by Wilbur Wright, continuing through December, making a number of astounding records. Training of students follows.

1908, July 31-August 8—Henri Farman of France makes first exhibition airplane flights in U. S.



WRIGHT 1908 military airplane flight 1 hour, 2¼ minutes, Fort Myer, Virginia

1908, August 22—First Army Baldwin airship accepted.

1908, September 17—First plane fatality, killing Signal Corps Lt. Thomas E. Selfridge and severely injuring Orville Wright, in delivery of first Army airplane, Fort Myer, Va.

1908, December 28—Matthew B. Sellers makes several flights with 7 hp quadroplane.

1909, January 22—Commercial airplane, built by Glenn Curtiss, sold to Aeronautic Society of New York.

1909, April 16-28—Wilbur Wright delivers an airplane in Italy and teaches pupils.

1909, June 10—President Taft presents Aero Club of America medal to Wright brothers. Congressional medal presented at a celebration at Dayton, June 17-18.

1909, June 26—Glenn H. Curtiss demonstrates at the Aeronautical Society's meet, Morris Park, New York, the machine ordered January 22. Further flights are made at the Society's meet July 5, before removal of the machine to Mineola and the instruction of member Charles F. Willard.

1909, July 17—Curtiss flies 52 mins. in longest U. S. flight except Wrights and wins *Scientific American* trophy for second time. On this success in the Mineola flights the Aero Club of America names him as America's entry in the Bennett international race.

1909, August 22-29—Glenn H. Curtiss wins first Bennett international airplane race and other events of first International Flying Meet, Rheims, France. Speed: 45.7 mph.

1909, August 25—First Army airfield leased at College Park, Md.

1909, August 28—After instruction by Glenn H. Curtiss and subsequent practice in the machine contracted by the Aeronautical Society, Charles F. Willard gives his first exhibition at Scarsborough Beach, Toronto—America's first exhibition pilot. His exhibitions continue over several years.

1909, September 7-October 15—At Berlin, Orville Wright makes flights under German contract, with more records.

1909, September 30—Inception of Wright-Curtiss patent litigation.

1909, September 30—Emile Berliner describes a proposed guided missile.

1909, October 3—At Zurich, Switzerland, E. W. Mix wins the Bennett International balloon race the second time for America.

1909, October 4—Wilbur Wright makes sensational flight, Governors Island to Grant's Tomb and return. Glenn H. Curtiss makes a short flight Sept. 29 and Oct. 3.

1909, October 7—Glenn H. Curtiss flies his first exhibition at St. Louis. Chicago is next. The same month, Charles K. Hamilton and Otto Brodie learn to fly, followed by others. An exhibition company is formed and Curtiss returns to his development work.

1909, October 8-November 5—First Army aviators taught to fly by Wilbur Wright, College Park, Md.: Lt. Frank P. Lahm, Lt. Frederic E. Humphreys, and Lt. B. D. Foulois.

1909, November 27—Anti-aircraft firings begin at Sandy Hook by Ordnance Department.

1909, November 22—The Wright Co. formed with $1,000,000 capital. In 1914, Orville Wright buys the company back. On Oct. 13, 1915, a syndicate buys the company and adds the Simplex Co. In 1916 it becomes the Wright-Martin Co.

1910, January 10-20—First flying meet held at Los Angeles; Louis Paulhan, of France, the star performer.

1910, May 29—Record flight from Albany to New York by Glenn Curtiss, 142.50 mi. in 2 hr., 50 min.

1910, March 25—Wright patent condemnation urged by William M. Page, attorney for C. F. Bishop, president, Aero Club of America.

1910, June 13—Charles K. Hamilton flies New York-Philadelphia and return for N. Y. *Times* and Philadelphia *Public Ledger* and $10,000 prize—149.5 miles in flying time 3 hr. 27 min.; elapsed time, 6 hr. 57 min.

1910, June 13-18—First show of Wright exhibition team, Indianapolis, Ind., where Walter Brookins is star and make new records. Exhibitions by single pilots or groups continue about the country until the Wright exhibition business is discontinued in Nov. 1911.

1910, June 30—Dummy bomb demonstration made by Glenn H. Curtiss to Army and Navy officers.

1910, August 4—Plane-ground radio demonstrated by E. N. Pickerill.

1910, August 8—Tricycle landing gear installed by Lt. B. D. Foulois on Army Wright at San Antonio.

1910, August 27—Air-land plane radio used by J. A. D. McCurdy, Sheepshead Bay, N. Y.

1910, September 2—First American woman pilot solos: Blanche Stuart Scott. First exhibition at Fort Wayne, Oct. 22.

1910, October 8-10—Former President Theodore Roosevelt is flown at St. Louis exhibition by Arch Hoxsey.

1910, October 15-17—Wellman airship, *America,* abandons trans-Atlantic trip after some 800 miles.

1910, October 22-31—Second Bennett international airplane race won by C. G. White (Bleriot) at 61 mph during Belmont Park meet where numerous records are made.

1910, November 14—First battleship takeoff by Eugene Ely from U.S.S. *Birmingham* in Hampton Roads, Va.

1910—Night flights by Walter R. Brookins (Montgomery, Ala., Apr. 18) and Charles Hamilton (Camp Dickenson, Nashville, Tenn., June 21-26).

1911, January 7—Didier Masson flies Los Angeles-San Bernardino to deliver *Times* newspapers. Mail and papers delivered Feb. 17 by Fred J. Wiseman.

1911, January 7-25—Dive bombing, aerial photography, airplane radio demonstrated by Army officers in San Francisco meet.

1911, January 27-28—Lieut. T. G. Ellyson, U.S.N., is first U. S. naval aviator when he takes his Curtiss off at San Diego during Curtiss exhibitions.

1911, January 30—J. A. D. McCurdy attempts Key West-Havana flight but lands in water ten miles short and is rescued by Navy destroyer. In 1913 Domingo Rosillo makes the entire distance.

1911, February 17—Curtiss flies tractor seaplane from North Island to cruiser *Pennsylvania.* Plane hoisted on board and return flight later made.

1911, March 3—Lt. B. D. Foulois and P. O. Parmalee fly record cross-country Laredo-Eagle Pass, Tex., 106 mi. in 2 hr. 10 min. in Wright plane loaned Army by R. J. Collier. Messages dropped en route, radio received and sent.

1911, March 13—Capt. W. Irving Chambers, U.S.N., is assigned the Bureau of Navigation to devote exclusive efforts to naval aeronautics.

1911, March 31—About this date Missouri National Guard Signal Corps establishes air section and members taught flight and ballooning.

1911, May 8—First Navy airplane ordered, Curtiss Triad, amphibian. By July the three 1911 planes of the Navy are delivered—Curtiss A-1, A-2; Wright B-1.

1911, May 13—Lieuts. H. H. (Hap) Arnold and Thomas DeWitt (Tommy) Milling complete flying training at Wright School: 7th and 8th Army pilots.

1911, June 7—Lieut. John P. Kelley, Med. Res. Corps, assigned Army School at College Park—first U. S. air medical officer.

1911, June 8—Connecticut state air regulation is first state air law.

1911, June 21—Short-lived Aeronautical Manufacturers Ass'n incorporated; Ernest L. Jones, president.

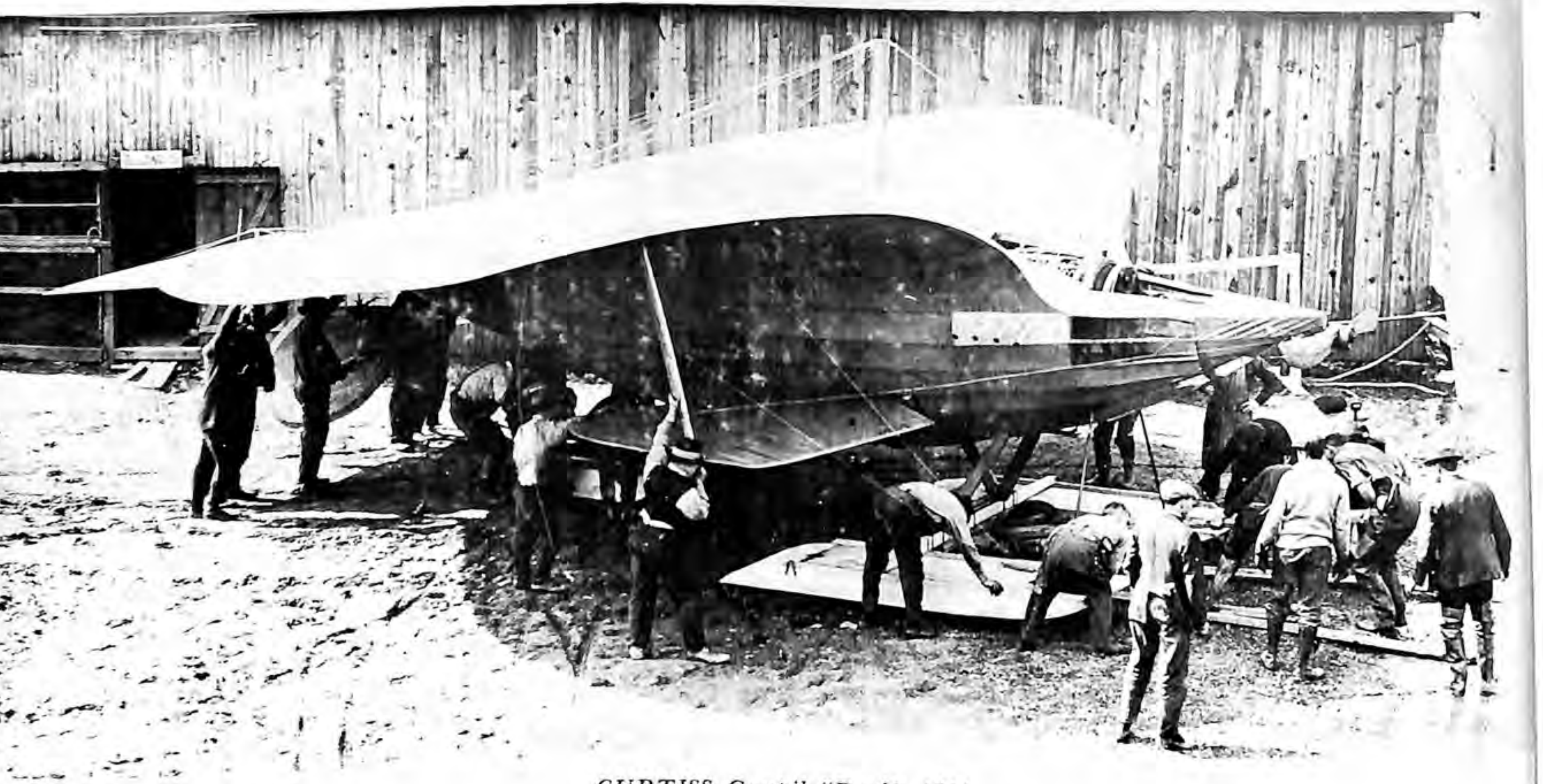
1911, June 30-July 11—Boston-Washington flown by Harry N. Atwood. Charles K. Hamilton flies with him most of way—longest continuous air journey to this date.

1911, July 1—Third Bennett plane race won for U. S. by Charles T. Weyman (Nieuport-Gnome 100) at 78 mph.

1911, July 31—During the month, Frank E. Boland begins flying his tailless, allegedly non-infringing airplane.

1911, August 5—Lincoln Beachy wins over Eugene Ely and Hugh Robinson in New York-Philadelphia race for Gimbel $5000 purse. Elapsed time: 1 hr. 50 min. 18 sec.; one stop for fuel.

1911, August 14-25—Harry N. Atwood flies St. Louis-New York, 1155 miles by route; longest cross-country flight to this date.



CURTISS Goupil "Duck', 1914.

1911, August 20—World altitude record set at 11,642 ft. by Lincoln Beachy in Curtiss biplane.

1911, September 4—Earle L. Ovington (Bleriot-Gnome 70) wins over Lieut. T. D. Milling (Burgess-Wright-Wright 30) in 160-mile tri-state race during Boston meet, in 3 hr. 6 min. 22 sec.

1911, September 7—Lt. T. G. Ellyson, U.S.N., demonstrates shipboard launching by taking off from aerial cable at Hammondsport, N. Y.

1911, September 17-November 5—Transcontinental flight by Calbraith P. Rodgers from New York to Pasadena, Calif.—3,390 mi., 49 days.

1911, September 23-30—Earle L. Ovington appointed Airmail Pilot No. 1, flying mail from Nassau Boulevard to Mineola, L. I., N. Y.

1911, September 30—Lt. H. H. Arnold is "stunt man" for the lead in pioneer air movies at Nassau Boulevard meet where Army pilots compete.

1911, October 9—Demonstration of Tarbox automatic pilot made before officers at College Park. Other similar inventions follow.

1911, October 10—Bombsighting and dropping device demonstrated by Riley Scott, College Park, Md.

1911, October 19-February 12, 1912—Eastbound transcontinental flight of Robert G. Fowler (Wright B), Los Angeles-Pablo Beach, Fla., 2520 mi. in 116 days.

1911, October 24—Orville Wright makes soaring record of 9 min. 45 sec. at Kitty Hawk.

1912, February 12—Frank T. Coffyn takes automatic movie aerials over New York harbor.

1912, February 17—First pilot physical exam published by U. S. Army.

1912, March 1—Attached type parachute jump by Bert Berry from Benoist pusher plane, St. Louis.

1912, April 16—First U. S. licensed woman pilot, Harriet Quimby, flies English Channel. (Killed at Boston Aviation Meet, July 1.)

1912, May 24—Paul Peck makes American duration record of 4 hr. 23 min. 5 sec. in biplane with Berliner Gyro engine.

1912, May 30—Death of Wilbur Wright by typhoid.

1912, June 7-8—Machine gun fired from Wright biplane by Capt. Charles DeForest Chandler, College Park, Md.

1912, July 2—Vaniman airship *Akron* crashes off Atlantic City in renewed trans-Atlantic attempt.

1912, July 31—Plane launched from sea wall by catapult, Navy Lt. T. G. Ellyson in Curtiss AH-3.

1912, August 12—First Army tractor plane, Burgess, received; flown by Lts. H. H. Arnold and Roy C. Kirtland from Marblehead, Mass.

1912, October 6—In night flight, Lt. J. H. Towers, U.S.N., (Curtiss A-2) makes world seaplane duration record, 6 hr. 10 min. 35 sec. at Annapolis; American record for any plane.

1912, October 8—First Navy physical exam for pilots published by Bureau of Medicine and Surgery.

1912, October 9—First competition for Mackay Trophy won by Lt. H. H. Arnold.

1912, November 5-13—First U. S. airplane artillery adjustment, Ft. Riley, Kans., Lt. H. H. Arnold and observer Lt. Follett Bradley.

1912, November 6-December 15—Antony Jannus (Benoist seaplane Roberts 2-cycle 100 hp) flies Omaha-New Orleans, with mail and merchandise, carrying passengers at stops en route —1835 mi., flying time: 31 hr. 43 min.

1913, January 13-March 31—Air parcel post flight, Boston-New York, by Harry M. Jones (Wright B).

1913, February 11—James Hay bill in Congress inaugurates the project of a separate air service.

1913, February 13—Langley Field Aerodynamical Laboratory project inaugurated.

1913, April 27—First cross-Isthmus flight by Robert G. Fowler and cameraman R. A. Duhem, Panama-Cristobal. Publication of story and pictures results in arrest.

1913, May 10—Didier Masson and bomber Dean attack Mexican federal gunboats in Guayamas Bay. A number of other Americans fly for Villa in this and subsequent years.

1913, May 28—Lt. T. D. Milling and Lt. W. C. Sherman make 2-man duration and distance record of 4 hr. 22 min. and 220 miles (Burgess tractor-Renault 70), Texas City-San Antonio.

1913, May 30—About this date is instituted M.I.T.'s aerodynamics course under Asst. Naval Constructor Jerome C. Hunsaker.

1913, June 20—First Naval aviator killed when Ensign W. D. Billingsley is thrown from seaplane.

1913, July 19—Sky writing initiated by Milton J. Bryant over Seattle.

1913, October 12—Eighth Bennett international balloon race won for U. S. for fourth time at Paris by R. H. Upson and R. A. D. Preston, landing in England.

1913, November 27—First exhibition loop by Lincoln Beachy in Curtiss biplane, Coronado, Cal.

1913, December 4—Tactical Air Unit, First Aero Squadron, set up as provisional organization, San Diego, Cal.

1913, December 12—Wright pilot Oscar Brindley reports at San Diego as Army's first civilian instructor. Scores of others subsequently employed through 1918.

1913, December 31—Orville Wright demonstrates automatic pilot; awarded Collier Trophy.

1914, January 1—First scheduled airline begins operations with Benoist flying boat between St. Petersburg and Tampa, Fla.; Tony Jannus, pilot.

1914, January 31—During the month first U. S. Navy air station established at Pensacola, following temporary camps at San Diego and Annapolis, 1911-1912.

1914, February 17—Seaplanes and flying boats classed as "vessels" by the Department of Commerce and the license No. 1 is issued to Antony Jannus.

1914, February 24—Army Board condemns all pusher type airplanes.

1914, April 15—Electric self starter fitted to Anzani 200-hp engine of Collier flying boat.

1914, June 23—Curtiss' Wanamaker trans-Atlantic flying boat tested. With outbreak of World War I the project is abandoned.

1914, July 2—Lawrence Sperry wins French War Dept. prize for "stable airplane" flown by early automatic pilot over Seine River in Paris.

1914, July 18—Aviation Section of Signal Corps created by Congress, authorizing 60 officers and students and 260 enlisted men.

1914, December 1-16—Two-way plane-ground radio demonstrated by Lt. H. A. Dargue and Lt. J. O. Mauborgne, Manila, P. I.

1915, March 3—National Advisory Committee for Aeronautics established by Congress.

1915, May 14—Contract let for first Navy airship D-1 to Connecticut Aircraft Co. In July is contracted a floating airship shed.

1915, June 22—Wisconsin State Forester, E. M. Griffith, flown by Jack Vilas, in first air forest patrol.

1915, September 17—Joseph Dolgos of Philadelphia demonstrates air incendiary bombs.

1916, February 9—Cpl. A. D. Smith (Martin S-Hall Scott 125) makes world seaplane duration record of 8 hr. 42 min.

1916, February 12—Invitation for bids on airmail issued by Post Office in Massachusetts and Alaska.

1916, March 15—First Aero Squadron, under command of Capt. B. D. Foulois, begins operations at Columbus, N. M., with Gen. Pershing's Punitive Expedition.

1916, April 5—The Governors Island Training Corps organized by Philip A. Caroll.

1916, April 14—A power-driven turret is proposed without result by Col. F. P. Cobham.

1916, June 3—National Defense Act increases strength of Aviation S. C. from 60 to 148 officers over 5-year period. President may fix increase of enlisted men from old figure of 260.

1916, June 18—U. S. aviator H. Clyde Balsley shot down. (Member of Lafayette Escadrille, flying for France.)

1916, August 29—First U. S. Coast Guard Aviation Division organized.

1916, October 2—Allocation airship development to Army or Navy raised by Chief Signal Officer. Rigids later assigned Navy.

1916, November 2—Chicago-New York commercial airmail line asked by Glenn Muffly. Sponsored by New York *Times*, Victor Carlstrom flies mail demonstration, November 2-3.

1916, November 14—More than 60 civilians are sent to Curtiss contract school at Newport News, Va., beginning this date and before Apr. 6, 1917. Others are sent to Curtiss school at Miami. Gen. Mitchell learns to fly here at this period.

1916, November 18-20—Group National Guard cross-country flight under Capt. R. C. Bolling from New York to Princeton, N. J., and return. On December 30, another is made to Philadelphia.

1916, November 19-20—Ruth Law flies her 1914 Curtiss pusher Chicago-New York, with 2 stops en route, for new cross-country record.

1916, December 17—To this date the Aero Club of America has certified 636 airplane pilots. In addition are many other pilots who have never flown for the Aero Club certificate. On Dec. 31, the Army has graduated 122 pilots since 1909.

1916, December 18—Non-exclusive licenses are offered by Wright-Martin Aircraft Corp. on royalty basis. Terms are considered prohibitory and in 1917 Congress appropriates $1,000,000 to acquire basic patents. Solution is the cross-license agreement of the Aircraft Manufacturers Association.

1917, February 13—Capt. Francis T. Evans, U.S. M.C., loops and spins a seaplane at Pensacola.

1917, February 15—Aircraft Manufacturers Association completes organization.

1917, March 14—Navy places orders for 16 non-rigid B-type airships, the first Navy dirigibles.

1917, April 6—U. S. declares war on Germany.

1917, April 6—Official strength of the Aviation Section, S. C., is 131, including regular and reserve. Of these, 112 are airplane pilots or student pilots. Enlisted strength is given variously from 1087-1800. At armistice the figures are: total officers, 20,708 (pilots and student pilots, 12,449); enlisted, 174,315. Airplane strength, "less than 300." Produced in U. S., Apr. 6, 1917—Nov. 1, 1919: 13,894; received from Allies, 5,229; total: 19,123.

1917, May 10—Arrangements made for eight ground schools for theoretical training Reserve officer candidates.

1917, May 16—Aircraft Production Board created. Superseded by the Aircraft Board Oct. 1. Dissolved May 19, 1919.

1917, May 23—French Premier Ribot asks U. S. to furnish 5,000 pilots, 50,000 mechanics, 4,500 planes for active service by spring 1918.

1917, May 29—Liberty engine project inaugurated. An 8-cylinder Liberty is flown in an L.W.F., July 25. The 12-cylinder production Liberty follows in December.

1917, June 1—Barlow robot bomber urged. Armistice ends project.

1917, July 13—Fiske torpedo plane tested with dummy missile. Experiments continue.

1917, July 24—First great U. S. air appropriation, $640,000,000. Act also provides for increase in organization of Aviation Section, S. C.

1917, July 27—Secretary of Navy authorizes a Naval Aircraft Factory at Philadelphia.

CAPT. Eddie Rickenbacker in his Spad XIII, first American Ace.

1917, July 27—First British DH-4 arrives to be the first American service plane put into production, with Liberty engine. First American DH-4 completed is flown Oct. 29 by civilian test pilot H. M. Rinehart.

1917, August 5—Original First Aero Squadron leaves Columbus, N. M., for overseas under Maj. Ralph Royce.

1917, August 13—First AEF squadron program calls for 89 wings and 508 squadrons. One wing equals six squadrons (5 airplanes, 2 balloons). A brigade comprises two or more wings.

1917, September 5—Bristol fighter project started. Condemned July 20, 1918, after 27 planes are built.

1917, September 22—Montgomery heirs sue Wright-Martin Aircraft Corp. for infringement. Suit withdrawn June 6, 1921. Suit of same date against U. S. is dismissed May 28, 1928.

1917, October 16—Airplane to airplane radiophone conversation is demonstrated.

1917, October 18—McCook Field established as Signal Corps Experimental Laboratory.

1917, October 18—Aviation Medical Research Board established by Signal Corps.

1917, November 15—J. Newton Williams' helicopter proposal results in recommendation of N.A.C.A. for Government prize of $20,000, not accomplished.

1917, November 21—Robot bomber demonstrated to Army and Navy officers.

1917, November 27—Brig. Gen. B. D. Foulois made Chief of Air Service, AEF.

1917—Gen. William Mitchell claimed as first officer to fly over enemy lines.

1918, January 19—U. S. School of Aviation Medicine begins operations under Signal Corps Maj. William H. Wilmer, Hazelhurst Field, Mineola, L. I., N. Y.

FIRST CONTINUOUS scheduled air mail between Washington and New York in Curtiss J. N. plane, 1918.

1918, February 28—Under President Wilson's proclamation, licenses are required for civilian pilots or owners; more than 800 are issued.

1918, March 8—Maj. Edward C. Schneider and Maj. James L. Whitney, in simulated altitude flight, reach artificial altitude of 34,000 ft. in 24 min. at Signal Corps, Mineola, N. Y. laboratory.

1918, March 11—First D.S.C. awarded Army air service personnel goes to Lt. Paul Baer of 103rd Squadron for his performance this date.

1918, March 14—Two pilots of First Pursuit Group (95th Squadron) go on patrol.

1918, May 9—Flight Surgeons are organized at flying fields.

1918, May 11—U. S.-built DH-4 Liberty planes received by AEF.

1918, May 15—Congress establishes Air Mail Flyer's Medal of Honor. First award is to M. F. Freeburg, 1932.

1918, May 15—Regular airmail service flown by Army between New York and Washington, D. C.

1918, May 20—Army aeronautics severed from Signal Corps; two departments created: Bureau of Military Aeronautics and Bureau of Aircraft Production.

1918, June 26—A trans-Atlantic flight is urged by Gen. William L. Kenly, Director Military Aeronautics as "most necessary." On August 8, Roy N. Francis is assigned to study project. Experiments continue to 1919 when Navy's NC4 makes the flight.

1918, July 4—Plan to distribute tons of propaganda by balloon over Germany this day fails attainment. Previously extended experiments had been conducted and contracts let.

1918, August 2—First DH Liberty patrol by 135th Aero Squadron.

1918, August 17—First Martin bomber flown at Cleveland by Thomas Eric Springer.

1918, September 7—First U. S. demonstration of troop transport by air.

1918, September 12-13—Greatest air concentration of history at St. Mihiel under Gen. William Mitchell—1481 planes.

1918, September 16—German attached type parachutes being in use at least as early as May 1, 1918, the AEF cables need and suggests Floyd Smith, test pilot, prosecute development. Smith develops free type 'chute. Leslie L. Irving makes first free jump Apr. 28, 1919.

1918, September 18—Altitude of 28,899 ft. reached by Maj. R. W. Schroeder.

1918, September 25—First Congressional Medal of Honor awarded for air activity voted 1st Lt. Edward V. Rickenbacker of 94th Aero Squadron.

1918, September 26—First phase of Meuse-Argonne attack.

1918, September 28—Pilotless airplane maneuvered from another airplane by radio, after some months of experiment. Various automatic pilots and radio controllers tried over the years.

1918, October 2—First successful flights of Army's guided missile. Its prototype had been flown by H. M. Rinehart in July, substituting for the explosive load and the automatic controls.

1918, October 3—Flight refueling demonstrated by Lt. Godfrey L. Cabot, U.S.N.R., continuing into 1920.

1918, October 12—Use of oxygen tanks ordered all pilots over German lines.

1918, October 25—Charles E. Hughes reports on his investigation of dishonesty in aircraft production.

1918, November 11—Armistice signed.

1918, December 4—First Army transcontinental flight made by Major Albert D. Smith's group of JN4 planes, San Diego-Jacksonville-New York-San Diego. Major Smith's plane alone completes the full round trip.

1919, January 2—Maj. Gen. Charles T. Menoher becomes Director of Air Service.

1919, January 21-30—Army second transcontinental flight; Major T. C. Macauley (DH-4 Liberty), Ft. Worth-San Diego-Miami-Ft. Worth. Repeated in April.

1919, January 24—At Issoudun, France, 1st Lt. Temple M. Joyce (Morane) makes 300 consecutive loops.

1919, March 3—U. S.-Canada airmail flown by Edward Hubbard in Boeing seaplane, Type C.

1919, April 26—Lt. Comdr. H. B. Grow, U.S.N. in F5L flying boat makes non-stop endurance record: 20 hr. 10 min.

1919, April 28—Leslie L. Irving makes first free type manually operated airplane parachute jump over McCook Field. (See 9/16/18.)

1919, May 8-31—Trans-Atlantic crossing by Lt. Albert C. Read and crew from Rockaway Beach, N. Y., to Plymouth, England, in NC-4, 53 hr. 58 min.

1919, May 14—Navy airship C-5 makes American non-stop record of 25 hr. 50 min., Montauk Pt., L. I. to St. Johns, N.F.

1919, May 18—In first trans-Atlantic takeoff, H. C. Hawker and McKenzie Grieve alight in ocean 1200 miles and 14½ hours out with engine trouble. Rescued.

1919, May 19—First award of DFC made to M/Sgt. Ralph W. Bottriell for first jump by Army personnel with free-type 'chute.

1919, June 1—First organized and sustained forest fire patrol inaugurated at Rockwell.

1919, June 14—First non-stop Atlantic crossing by Capt. John Alcock and Lt. A. W. Brown (Vickers-2 Rolls 375) St. Johns to Clifden, Ireland: 1890 mi. in 16 hr. 12 min.

1919, June 28—Treaty of peace with Germany signed at Versailles.

1919, July 1—Aerial fish patrols inaugurated at San Diego by Comdr. E. W. Spencer, Jr., U.S.N.

1919, July 2-6—First airship ocean crossing, British R-34, E. Fortune, Scotland, to Mitchel Field, N. Y., 3270 mi. in 108 hr. 12 min.; Lt. Comdr. L. Lansdowne, U.S.N. on board. Return made July 9-12, Col. William M. Hensley, representing Air Service.

1919, August 14—Airmail from Aeromarine flying boat to White Star liner, *Adriatic*.

1919, August 27-29—New York-Toronto race of military and civilian pilots.

1919, August 28-September 19—Lawson "air liner," 26-passenger, twin Liberty biplane, makes demonstration trip Milwaukee-Washington via Chicago, New York and other cities. It returns Sept. 25-Nov. 6.

1919, September 1—Dive bombing demonstrated about this date at Aberdeen Proving Ground.

1919, September 16—Flood relief provided by four JN4D's from Corpus Christi to stranded inhabitants.

1919, September 18—Roland Rohlfs (Curtiss triplane-K12 Curtiss 400) makes world altitude record of 31,420 ft.

1919, October 8-31—Army transcontinental reliability and endurance test New York-San Francisco and return. Forty-four compete westbound; 15 eastbound. Ten planes make round trip.

1919, October 30—Reversible pitch propeller tested at McCook Field, Dayton, Ohio.

1919, November 12-June, 1920—Six Navy F-5L's cruise New York to West Indies and return, covering 12,731 nautical miles.

1920—Moon eclipse observed by Lts. J. H. Tilton and W. H. Cushing of Rockaway Naval air station from height of some three miles.

1920, February 27—World altitude record of 33,113 feet set by Maj. R. W. Schroeder (Le Pere-Liberty).

1920, March 29-April 22—Marine Corps group flight Washington-San Domingo and return, 4842 miles.

1920, June 7—Lt. John H. Wilson makes unofficial world parachute jump record of 19,800 ft.

1920, June 4—Army Reorganization Bill approved, creating Air Service in Army.

1920, July 7—FP-5L Navy seaplane flown by radio compass from Hampton Roads, Va., to U.S.S. *Ohio,* at sea.

1920, July 15-October 20—New York-Alaska flight; Capt. St. Clair Street, 1st Lt. Clifford Nutt, 2nd Lts. Ross C. Kirkpatrick, Eric H. Nelson and C. E. Crumrine, Sgts. James Long and Joseph E. English, Capt. Howard Douglas, advance officer; Mitchel Field, N. Y., to Nome and return.

1920, September 8—Transcontinental mail route, combination plane-train, New York-Chicago-San Francisco, completed.

1920, November 1—U. S. international passenger service started by Aeromarine West Indies Airways between Key West, Fla., and Havana, Cuba.

1920, November 25—1st Lt. C. C. Moseley (Verville-Packard 600) wins first Pulitzer race at 156.54 mph; 24 contestants finish, 13 others start but do not finish.

CROSS-COUNTRY non-stop flight in Fokker T-2, 1923.

1920, December 13-14—Navy balloon of Lts. L. A. Kleer, Walter Hinton and S. A. Farrell land beyond Moose Factory, Ont., after 25 hours, 852 miles from start at Rockaway, N.Y.

1921, February 18—First U.S. airplane parachute escape by C. C. Eversole, airmail pilot.

1921, February 22-23—Night airmail flown by Jack Knight from North Platte, Neb., to Chicago, Ill.

1921, February 24—Lt. W. D. Coney completes transcontinental flight, San Diego-Jacksonville, 2180 mi. in 22 hr. 27 min.; 57 hr. 24 min. elapsed time.

1921, March 23—Lt. A. G. Hamilton drops 23,700 ft. by parachute, Chanute Field.

1921, June 21—Navy F5L planes sink German sub U-117 in demonstration.

1921, July 18-21—Sinking of captured German cruiser, *Frankfurt,* and battleship, *Ostfriesland,* by U. S. bombs proves vulnerability of naval craft to aerial attack.

1921, August 10—Navy Bureau of Aeronautics formed with Rear Admiral W. A. Moffett as Chief.

1921, September 28—New world altitude record of 34,508 ft. set by Lt. J. A. Macready.

1921, November 5—Bert Acosta (Curtiss Navy-C12 Curtiss 400) wins Pulitzer race at 176.7 mph.

1921, November 12—Refueling in air: Earl S. Daugherty transfers *Wesley May* with can of gasoline from wing of another plane.

1921, November 15—Italian airship *Roma* makes initial ascent in U. S. at Langley Field.

1921, December 1—Helium airship, Navy dirigible C-7, flown from Hampton Roads, Va. to Washington, D. C.

1921, December 29—World endurance record of 26 hr. 18 min. 35 sec. made at Roosevelt Field by Edw. Stinson and Lloyd Bertaud (CJL6 BMW 185).

1922, January 1—Underwriters Laboratories starts registration of aircraft for benefit of insurance companies.

1922, January 1—Aeronautical Chamber of Commerce organized, New York, with I. M. Uppercu, president.

1922, February 21—Airship *Roma* destroyed.

1922, March 20—Airplane carrier U.S.S. *Langley,* commissioned at Norfolk, Va.

1922, June 16—Helicopter demonstrated by Henry Berliner, Washington, D.C.

1922, July 14—Aeromarine Airways starts Detroit-Cleveland flying boat service.

1922, August 5-7—Lt. Clayton Bissell completes first model airway flight, Washington-Dayton-Washington.

1922, August 16—Sperry airway light beacon demonstration, McCook Field.

1922, September 4-5—Transcontinental speed flight by Lt. James H. Doolittle, Pablo Beach, Fla.-San Francisco, Cal., in 22 hr. 35 min. elapsed time.

1922, September 14-23—Transcontinental Army airship flight with Maj. H. A. Straus commanding crew of Capt. G. W. McEntire and others, from Langley Field, Va. to Arcadia, Cal.

1922, October 5-6—World endurance record, 35 hr. 18 min. 30 sec., Rockwell Field, by Lts. J. A. Macready and O. G. Kelly (Fokker T2 Liberty 375.)

1922, October 14—Lt. R. L. Maughan wins Pulitzer race at 206 mph (Army Curtiss-D12-Curtiss 375.)

1922, October 18—World speed record of 222.97 mph set by Brig. Gen. William Mitchell in Curtiss racer.

1922, October 22—Harold R. Harris becomes first pilot to use parachute after plane failure in flight. Event occurred over Dayton, O.; plane was an experimental Loening Monitor Plane Fighter.

1922, October 23—American Propeller Co. demonstrates reversible propeller at Bolling Field.

1922, December 18—Army's De Bothezat helicopter makes first successful flight, 1 min. 42 sec., Dayton, Ohio.

1923, March 29—Lt. R. L. Maughan makes world speed record 236.58 mph (Curtiss R6-Curtiss 465), Dayton, Ohio.

1923, April 16-17—World duration—distance records by Lts. J. A. Macready and O. G. Kelly (Fokker T2 Liberty 375), 36 hr. 4 min. 34 sec. 2516.55 miles.

1923, May 2-3—Cross-country non-stop flight by Lts. J. A. Macready and Oakley G. Kelly in Fokker T-2, from New York to San Diego, 2,520 miles in 26 hr. 50 min. 3 sec.

1923, August 27-28—Lts. L. H. Smith and J. P. Richter (DH-4E Liberty 400) made world duration-distance refueled records: 3293.26 miles, 37 hr. 15 min. 14.8 sec.; Rockwell Field.

1923, September 5—Smoke screen demonstrated by Thomas Buck Hine during naval bombing maneuvers, Cape Hatteras, N. C.

1923, September 5—Langley Field bombers sink naval vessels *New Jersey* and *Virginia*.

1923, October 6—Lt. A. S. Williams, U.S.N. wins Pulitzer race (Curtiss R2C1-D12 Curtiss 460) at 243.68 mph.

1923, October 25-27—Barling bomber makes series weight-carrying records with greatest weight 3000 kg.; duration, altitude records, 1 hr. 19 min. 11.8 sec., 5,344 ft. Pilot, Harold R. Harris.

1923, November 4—Lt. A. J. Williams, U.S.N. (Curtiss R2C1-D12A Curtiss 500) makes world speed record 266.59 mph.

1923, December 18—For $100,000 the Christmas Aeroplane Co. assigns its aileron patent to U. S. Government.

1924, January 16—Navy airship *Shenandoah* tears loose from mast in storm and rides it out during the night.

1924, February 21—Alaskan airmail flown by Carl B. Eielson from Fairbanks to McGrath.

1924, February 22—Lt. J. A. Macready (Lepere-supercharged Liberty 400) reaches 41,000 ft. indicated altitude.

1924, April 6-September 28—Round-the-world flight by Lts. Smith, Nelson, Arnold, and Harding, Seattle to Seattle, 26,445 miles, 175 days (368 hours flying time.)

1924, June 2—Lt. James T. Neely and storm-riding meteorologist Dr. C. L. Meisinger, Weather Bureau, killed by lightning in balloon near Monticello, Ill.

1924, July 1—Through transcontinental airmail service begun by U.S. Post Office.

1924, October 4—Lt. H. H. Mills wins Pulitzer trophy (Verville Sperry-Curtiss HC D12A) at 216.55 mph.

1924, October 7-25—Navy airship *Shenandoah* makes record cross-country cruise over 7080 miles in 235 hr. 01 min. Air hours total of 422 hr. 23 min. includes time moored.

1924, October 12-15—U. S. Navy's German airship *ZR3 (Los Angeles)* makes fourth aircraft Atlantic crossing, Friedrichshafen-Lakehurst, in delivery under reparations.

1924, October 29—Fog dispersal by electrified silica and sand demonstrated at Bolling Field.

1925, January 29—Eclipse pictures and astronomic data secured at high altitudes by Air Service pilots.

1925, February 2—Kelly Bill signed by President Coolidge authorizing private contract air transport of mail.

1925, March 1—San Diego Airline service started by Ryan Airlines, Inc.—first daily scheduled service on all-season basis.

1925, April 7—Navy carrier *Saratoga* launched.

1925, May 21-July 6—Amundsen-Ellsworth polar flight.

1925, July 15—Dr. A. Hamilton Rice Expedition, first to employ planes in exploration, returns from Amazon; Lt. Walter Hinton, pilot, in Curtiss Seagull.

1925, August 1—Survey flight of Pacific Air Transport flown by T. Claude Ryan and Vern Gorst in first Ryan M-1 mail plane.

1925, August 4-22—MacMillan polar expeditions with Navy assistance.

1925, August 5—Seven American pilots leave Paris to fly for the French in the Riff campaign in Africa. Others follow to a total of 17 pilots, 5 observers.

1925, August 31-September 8—In Navy's attempted San Francisco-Honolulu flight, Commander

John Rodgers and crew (PN9-2 Packard 500 flying boat) alight short of mark, making non-stop cross-country seaplane record of 1,841 miles.

1925, September 3—Navy dirigible, *Shenandoah,* collapsed in storm over Ava, O., killing 14 of 43 on board.

1925, September 12—Morrow Board appointed by President Coolidge. (Laid down U. S. air policy.)

1925, October 12—Lt. Cyrus Bettis wins 6th Pulitzer race (Curtiss R3C1-V1400 Curtiss 619) at 248.97 mph.

1925, October 26—Lt. J. H. Doolittle wins 8th international Schneider Seaplane Trophy race in first contest in America (Curtiss R3C2-V1400 Curtiss 619) at 232.57 mph.

1925, December 17—Gen. William Mitchell found guilty of violating 96th Article of War; had risked insubordination by demanding unrestricted use of air power. Sentenced five years suspension of rank, pay and command. Resigned.

1926, January 18—A $2,500,000 air promotion fund established by Daniel Guggenheim.

1926, January 29—Lt. J. A. Macready (XCO5A-Liberty 400) makes American altitude record: 38,704 ft.

1926, February 11—Strip bombing tests made at Kelly Field.

1926, April 16—First cotton dusting plane purchased by Department of Agriculture.

1926, April 30—Capt. G. H. Wilkins and Lt. Carl B. Eielson complete third round trip Fairbanks-Pt. Barrow-Fairbanks.

1926, May 8-9—Flight over North Pole by Richard Byrd, navigator, and Floyd Bennett, pilot, in Fokker monoplane.

1926, May 20—Air Commerce Act (Bingham-Parker Bill) signed by President Coolidge; Aeronautics Branch, Department of Commerce, established.

1926, May 30—Bennett international balloon race, Brussels, brought to America by the win of W. T. Van Orman and W. W. Morton in Goodyear III balloon. Capt. H. C. Gray, Air Service, second.

1926, July 2—Army Air Service renamed Army Air Corps.

1926, July 2—First reforesting by airplane, Hawaii.

1926, July 14—Armstrong seadrome model demonstrated at Wilmington, Del. to Air Service.

1926, August 18—Metal-clad airship contract let at not over $300,000.

1926, August 25—JN training plane dropped by parachute, San Diego Naval Air Station.

1926, September 15—Pacific Air Transport begins operation of contract air mail service with Ryan M-1 monoplanes between Los Angeles and Seattle.

1926, December 7—Airway beacon erected by Aeronautics Branch, Department of Commerce, on Chicago-Dallas route.

1927, March 9—American balloon altitude record of 28,508 ft. made by Capt. H. C. Gray.

1927, April 12—New American duration record of Clarence D. Chamberlin and B. B. Acosta (Bellanca-15 Wright 200) 51 hr. 11 min. 25 sec.

1927, May 4—Record balloon altitude attempt by Capt. H. C. Gray, 42,470 ft.

1927, May 15-19—Greatest concentration since World War I (109 planes) in maneuvers under Brig. Gen. J. E. Fechet.

1927, May 20-21—Non-stop trans-Atlantic solo flight by Charles A. Lindbergh, New York-Paris, 3,610 miles, 33 hr. 30 min. (13th aircraft to make completed crossing.)

1927, May 25—Outside loop demonstrated by Lt. James H. Doolittle.

1927, June 4—First nonstop flight to Germany, Clarence D. Chamberlin and passenger (Bellanca-15 Wright 200), 3,911 miles, 43 hr. 49 min. 33 sec.

1927, July 25—World airplane altitude record by Lt. C. C. Champion, U.S.N. (Wright-P & W 425 supercharged) 38,484 ft.

1927, August 16-17—A. C. Goebel and Lt. W. V. Davis. U.S.N. (Travelair-15 Wright 200) win Dole Oakland-Honolulu race. One team finishes. Two teams lost.

1927, September 1—Air express operations begun by American Railway Express and major airlines.

1927, September 10—Bennett international balloon race, Dearborn, Mich., won by E. J. Hillard and A. G. Schlosser with 745 miles; 15 contestants.

1927, October 12—Wright Field dedicated.

1928, February 3-**December** 28—Lt. H. A. Sutton conducts a series of spin tests; awarded Mackay Trophy.

1928, March 1-9—Transcontinental amphibian flight by Army Lt. Burnie R. Dallas and civilian Beckwith Havens in Loening.

1928, March 28-30—Edw. A. Stinson and George Holderman (Stinson-Wright 200) make endurance record of 53 hr. 36 min. 30 sec.

1928, April 12-13—First non-stop westbound North Atlantic airplane crossing made by Baron G. von Huenefeld, Capt. Hermann Koehl and Maj. James Fitzmaurice (Junker-Junker 280/

LOADING MAIL for 1st night flight from Hadley Field, New Jersey to Chicago.

FOKKER TRIMOTOR "Southern Cross" being conditioned for its flight across the Pacific, 1928.

CREW OF "Question Mark", continuous flight record. L. to R. Sgt. Roy Hooe, Lt. Elwood Quesada, Lt. Harry Halverson, Capt. Ira C. Eaker and Maj. Carl Spaatz, 1928.

310 metal cabin land monoplane) from Baldonnel, Ireland to Greenly Island, N.F., 2,070 miles in 37 hours.

1928, April 15-21—First eastbound Arctic crossing made by Capt. G. H. Wilkins and Lt. C. B. Eielson (Lockheed-Wright 225) Pt. Barrow-Green Harbor, Spitzbergen, 2,200 miles, 20 hr. 20 min.

1928, May 24—Gen. Umberto Nobile's airship is over the Pole in trip from Spitzbergen. It is wrecked May 25, with loss of lives of crew and rescuers.

1928, May 31-June 8—First U.S.-Australian flight, by Capt. C. Kingsford-Smith, Capt. C. T. P. Ulm, H. W. Lyon and James Warner (P7 Fokker-3 Wright 200) Oakland-Brisbane, 7,410 miles; 83 hr. 19 min.

1928, June 11-12—Mexico-Washington flight by Capt. Emilio Carranza (Bryan-Wright 200.)

1928, June 17-18—First woman to fly Atlantic, Amelia Earhart with Wilmer Stultz, pilot, from Trepassey Bay, N. F., to Burryport, England, in trimotored Fokker, 2,140 miles, 20 hr. 40 min.

1928, July 30-31—Twenty-second Bennett international balloon race, Detroit, won by Capt. W. E. Kepner and Lt. W. O. Fareckson; 460 miles, 43 hr.

1928, September 19—First Diesel engine to power heavier-than-air craft; designed by I. M. Woolson, manufactured by Packard Motor Car Co.; flight-tested at Utica, Mich.

1928, October 19—Parachute troop demonstration at Brooks Field.

1928, November 11—First Antarctic flight made by Lt. C. B. Eielson and Sir Hubert Wilkins (Lockheed-Wright 22). Other flights subsequently.

1928, November 23-December 30—New York-Girardot, Colombia, flight by Capt. Benjamin Mendez, 4,600 miles.

1928, December 19—Autogiro flight by Harold F. Pitcairn, Pitcairn Field, Willow Grove, Pa.

1929, January 1-7—Refueling endurance record set by Maj. Carl Spaatz and Capt. Ira C. Eaker, Lt. Elwood R. Quesada, Lt. Harry A. Halverson, S/Sgt. Roy W. Hooe in 150 hr., 40 min., 51 sec.

1929, April 3—Floyd Smith trap-door parachute demonstrated.

1929, April 30—Jack Barstow makes duration glider record of 15 hr. 13 min. at Point Loma, Calif.

1929, June 28-29—Round transcontinental flight by Capt. Frank M. Hawks (Lockheed-P & W) in 40 hr. 4 min. 32 sec. Capt. E. G. Harper repeats the performance July 11-26.

1929, July 13-30—World endurance record of 420 hr. 17 min. by Forrest O'Brien and Dale Jackson (Curtiss Robin-Curtiss 70.)

1929, July 18-20—N. Y.-Alaska flight by Capt. Russ G. Hoyt. Return flight ends at Edmonton, after covering 6,000 miles out of 8,469 itinerary.

1929, August 5-6—Group transcontinental flight of 9 Keystone bombers under Major Hugh J. Knerr.

1929, September 24—Demonstration by Lt. James H. Doolittle results in Guggenheim report blind flying solution.

1929, October 21—Air Ambulance Service organized by Colonial Flying Service and Scully Walton Ambulance Co., New York.

1929—Bennett international balloon race won by W. T. Van Orman and aide, 341 miles, 9 contestants.

1930, March 15—Glider, piloted by Capt. Frank Hawks, released from seaplane, Port Washington, N.Y.

1930, April 6—Transcontinental glider in tow, piloted by Capt. Frank Hawks; San Diego to New York; 2,860 miles in 36 hr., 47 min.

1930, May 20—Dirigible-launched Vought observation plane, flown by Lt. Comdr. Charles A. Nicholson from U.S.S. *Los Angeles* to U.S.S. *Saratoga,* Lakehurst, N. J.

1930, June 4—New world altitude record of 38,560 ft. set by Navy Lt. Apollo Soucek, Anacostia, D.C.

1930, June 11-July 4—World endurance record of 553 hr. 41 min. 30 sec. established by John and Kenneth Hunter (Stinson-Wright 200).

1930, July 21-August 17—Refueling endurance record raised to 647 hr., 28 min. by Forrest O'Brien and Dale Jackson in a Curtiss Robin, St. Louis, Mo.

1930, July 22—German air mail plane catapulted 250 miles out en route to New York; 198 such ship-shore flights 1929-1938.

1930, September 1—Bennett international balloon race again won for U. S. by W. T. Van Orman and aide, 542 miles.

1931, February 14-19—Lts. W. W. Lite, Clement McMullen fly New York-Buenos Aires, 6,870 miles, 5 days, 5 hours elapsed time; 52:15:00 flying.

1931, March 30—Airplane-airship mail transfer at Scott Field.

1931, April 10—Airship sub-cloud observation car demonstration by Lt. W. J. Paul.

1931, May 25-28—World endurance record, non-refueled, set by Walter E. Lees and F. A. Brossi, Bellanca, Packard Diesel 225 hp.; 85 hr., 32 min., 38 sec., Jacksonville, Fla.

1931, May 14-28—Transcontinental autogiro flight by John M. Miller, from Philadelphia to San Diego.

1931, June 4—Rocket glider flown by William G. Swan; remained aloft for 30 min. with 10 rockets, Atlantic City, N.J.

1931, June 23-July 1—World flight by Wiley Post and Harold Gatty (Lockheed-PW 550), New York-Harbor Grace-Berlin-Moscow-Irkutsk - Khabarovsk - Solomon Beach-Fairbanks-Edmontin-Cleveland-New York, 8 days 16 hours, 16,500 miles.

1931, July 25-26—Glider duration record of 16 hr. 38 min. by 2nd Lt. John C. Crain, Honolulu.

1931, July 28-August 6—Herndon and Pangborn (Bellanca-PW 420) left New York July 28 on world trip and had reached Japan Aug. 6, abandoning attempt to better Post-Gatty record.

1931, October 3-5—Trans-Pacific non-stop airplane flight by Clyde Pangborn and Hugh Herndon, Samushiro Beach, Japan, to Wenatchee, Wash.

1931, October 6-9—Navy bomber tests on U.S.S. *Pittsburgh* in Chesapeake Bay.

1931, November 3—Dirigible, *Akron,* carried record number of 207 persons in flight over New York and Philadelphia.

1931, December 17-18—Glider duration record of 21 hr. 34 min. by Lt. Wm. A. Cocke, Honolulu.

1932, May 9—First solo blind flight, by Capt. Albert F. Hegenberger, Wright Field, Dayton, O.

1932, May 20-21—Amelia Earhart solos across Atlantic, St. Johns, New Brunswick to Londonderry, Ireland, in Wasp-powered Lockheed Vega.

1932, August 25—First woman to complete non-stop transcontinental flight, Amelia Earhart, Los Angeles to Newark.

1932, December 1—Teletypewriter weather map service inaugurated by Department of Commerce.

1933, January 19—Rocket guided by sound waves from enemy aircraft proposed.

1933, January 23—Steam airplane project launched by Great Lakes Aircraft and General Electric Co. Later Besley brothers fly their steam airplane.

1933, April 4—Navy dirigible, *Akron,* crashes into sea, killing 73; Comdr. Herbert V. Wiley, commanding.

1933, May 3-26—Airborne troop logistics part of West Coast maneuvers, with 283 aircraft.

1933, July 15-22—Solo round-the-world flight by Wiley Post in Lockheed Vega monoplane, *Winnie Mae,* in 7 days, 18 hr., 49 min.

1933, September 4—World speed record for land planes set at 304.98 mph by James R. Wedell in Wasp-powered Wedell-Williams racer.

1933, November 20-21—World balloon altitude record set at 61,237 ft. by Lt. Comdr. T. G. W. Settle and Maj. C. L. Fordney over Akron, O.

1934, January 10-11—Longest non-stop over-water mass flight completed by six P2Y-1 Navy flying boats under command of Lt. Comdr. Knefler McGinnis, San Francisco to Honolulu.

1934, February 9—Postmaster General Farley cancels certain mail contracts. Air Corps flies the mail Feb. 19-Mar. 10; Mar. 19-May 5.

1934, June 12—Howell commission to study airmail act and report on all phases of aviation by Feb. 1, 1935.

1934, December 31—War Department announces instruction governing GHQ Air Force organization and operation.

1935, January 3—Antarctic flight by Ellsworth and Kenyon (Northrop-PW 600).

1935, February 12—Navy dirigible, *Macon*, crashes into sea, killing 2.

1935, June 12-August 14—Washington-Alaska-Washington flight (Douglas Amphibian-2 Wasps) in test of practicability of such flight with standard equipment and as any ordinary flight. Capt. Hez McClellan and crew of two.

1935, August 15—Will Rogers and Wiley Post killed in take-off crash near Point Barrow, Alaska.

1935, November 11—Balloon altitude record of 72,394 ft. by Capt. O. A. Anderson and Capt. Albert Stevens.

1935, November 21-December 5—Antarctic flights renewed by Ellsworth and Kenyon (Northrop-PW 600).

1935, November 22-29—Trans-Pacific airmail flight by Capt. Edwin C. Musick, Pan American Airways, from San Francisco to Honolulu, Midway Island, Wake Island, Guam and Manila, in Martin *China Clipper*.

1936, June 7—All-instrument transcontinental flight by Maj. Ira C. Eaker, between New York and Los Angeles.

1936, September 10-October 20—Regular trans-Atlantic flying boat service by Deutsche Lufthansa. (Dornier twin Diesel engine 600.) Continued in 1937 and 1938.

1936, September—Trans-Atlantic round-trip flight by Henry (Dick) Merrill and Harry Richman. New York to London and return.

1937, May 6—German dirigible, *Hindenburg*, burned on mooring, killing 36, Lakehurst, N. J.

1937, May 20-July 3—Amelia Earhart Putnam and Fred Noonan lost in Pacific in round-the-world attempt.

FIRST SIKORSKY VS-300 in

1937, June 25—Non-stop transcontinental amphibian flight by Richard Archbold in PBY-1, Catalina, from San Diego to New York.

1937, July 3-September 3—Regular trans-Atlantic service test by Pan American Airways. Imperial Airways also similarly operate July 5-Aug. 2 and continue in 1938.

1937, August 12—In joint coast defense exercise, Navy patrol planes locate target ship *Utah* 300 miles off San Francisco; Air Corps planes attack.

1937, August 23—Wholly automatic landings made, "first in history," at Wright Field by Capt. Carl J. Crane with 2 passengers; awarded DFC.

1938, February 26—Government acquires monopoly on helium by purchasing production facilities at Dexter, Kan.

1938, April 22—Capt. E. V. Rickenbacker purchases Eastern Air Lines from North American Aviation, Inc., for \$3,500,000.

1938, June 23—Civil Aeronautics Authority with five members, an administrator, and a three-man Safety Board, created under Civil Aeronautics Act signed by President. This supersedes Aeronautics Branch, Department of Commerce.

1938, July 10-14—Howard Hughes and crew of four fly short northern course around world in 3 days, 19 hr., 8 min.

1938, July 17-18—Douglas (Wrong-Way) Corrigan

flight with Igor Sikorsky at the controls.

flies from New York to Ireland in nine-year-old Curtiss Robin.

1938, August 10-11—First Berlin-New York non-stop flight by Capt. Alfred Henke and crew (Focke-Wulf Condor 200), 4,577 miles, 24 hr. 54 min.

1938, August 22—Civil Aeronautics Act becomes effective.

1939, February 4-6—Langley Field-Santiago Red Cross flight by Major C. V. Haynes in XB bomber with medicinal supplies.

1939, March 5—Non-stop airmail system by pick-up demonstrated by Norman Rintoul and Victor Yesulantes in Stinson Reliant planes, Coatesville, Pa.

1939, April 3—The National Defense Act, providing for aerial rearmament, signed by President Roosevelt.

1939, April 17—Inclined runways for assisted take-off studied by Air Corps Board.

1939, June 27—Bill authorizing Civilian Pilot Training Program signed by President.

1939, July 6—Army Air Corps adopts monoplane type for primary training for first time by ordering quantity of Ryan PT-16 military trainers.

1939, September 1-3—Germany invades Poland, England and France declare war on Germany.

1940, March 26—U. S. commercial airlines complete a full year of flying without a fatal accident or serious injury to a passenger or crew member.

1940, July 1—Air Safety Board abolished with its functions delegated to the Civil Aeronautics Board. Civil Aeronautics Administration transferred to Department of Commerce.

1940, September 23—House committee asks $80 million for airport development, in $500 million program; $40 million voted.

1941, March 17—Milwaukee renames its airport as General Mitchell Field.

1941, April 15—First officially-recorded rotor helicopter flight in western hemisphere, Vought-Sikorsky VS-300A, piloted by Igor I. Sikorsky; flight time, 1 hr., 5 min., 14.5 sec., Stratford, Conn.

1941, May—Barrage balloon defense transferred from Air Corps to Coast Artillery.

1941, June 5—Ferry Command, for delivery of planes to Britain, organized by Army Air Corps.

1941, June 20—Army Air Force, comprising office of Chief of Air Corps and Air Force Combat Command, created.

1941, June—First woman to ferry bomber across Atlantic, Jacqueline Cochran, Canada to British Isles.

1941, September 5—Mass trans-Pacific flight of heavy bombers completed by nine Army B-17 Flying Fortresses.

1941, December 7—Pearl Harbor.

1942, April 8—First flight of Ferry Command over Himalayan "Hump" made by Lt. Col. William D. Old, between Assam, India and Kunming, China.

1942, April 18—First bombing attack on Japanese mainland by 16 B-25 Mitchell bombers from Navy carrier, *Hornet;* Lt. Col. James H. Doolittle commanding.

1942, May 4-9—Battle of Coral Sea.

1942, June 20—Ferry Command redesignated Air Transport Command under Maj. Gen. Harold L. George.

1942, June 3-7—Battle of Midway.

1942, June 17—AAF tow planes successfully pick up gliders in tests at Wright Field.

1942, August 17—First official bombing raid of Eighth Air Force, 12 Flying Fortresses, Brig. Gen. Ira C. Eaker commanding, Rouen, France.

1942, September—Fifty American Eagle squadron pilots, RAF, all Americans, transferred to Eighth Air Force. (Fourth Fighter Group.)

ENOLA GAY, Boeing B-29 Super-Fortress, first to drop atomic bomb, Hiroshima, Japan, 1945.

1942, October 1—First U. S. jet plane built and flown by Robert M. Stanley; Bell Airacomet (XP-59A), Muroc Dry Lake, Cal.

1942, October 2—First non-stop cross-country flight of a fighter airplane. Jack Woolams flies Bell P-39 from March Field, Calif., to Bolling Field, Wash.

1943, March 1-4—Battle of Bismarck Sea.

1943, March 19—Lt. Gen. Henry H. Arnold, commanding general of the AAF, advanced to full four-star general, the first in air history.

1943, June 24—World's longest parachute drop, 40,200 ft., made by Lt. Col. W. R. Lovelace at Ephrata, Wash.

1943, June 11—First ground victory by air power when Pantelleria, Italy, surrenders unconditionally to Lt. Gen. Carl Spaatz. First case in history of a well-fortified citadel being defeated without aid of ground forces.

1943, October—World's longest freight line opened by Capt. J. L. Okenfus and crew of five in 28,000-mile round-trip flight, Ohio to India.

1944, June—Army Air Force reaches peak with 78,757 aircraft.

1944, June 7—Delivery of Ryan FR-1 Fireball fighters to U. S. Navy marks first Navy jet airplanes and world's first composite aircraft using jet and piston engines.

1945, May 8—War in Europe ends.

1945, August 6—Atomic bomb dropped on Hiroshima from B-29; *Enola Gay*, under command of Col. Paul W. Tibbets, Jr.

1945, August 14 Japan's surrender ends World War II.

1945, October 3—Ensign Jake C. West of Navy VF-66 Squadron makes first jet landing aboard an aircraft carrier.

1945, September 28-October 4—Round-the-world air service begun by Air Transport Command, Douglas C-54E, Globester, 9 passengers, 23,147 miles in 149 hr., 49 min.

1946, January 26—Jet-propelled P-80, flown by Col. William H. Councill, sets non-stop transcontinental record of 4 hr., 13 min., 26 sec., between Long Beach, Cal.,-and New York.

1946, March 12—First commercial helicopter license granted by Civil Aeronautics Administration for Bell 2-place Model 47.

1946, March 22—First American-built rocket to escape earth's atmosphere, reaches 50-mile height. Constructed by Douglas.

1946, July 21—The McDonnell XFH-1 Phantom is first U.S. jet to operate from carrier, U.S.S. *Franklin D. Roosevelt.*

1946, August 6—Two B-17 radio-controlled bombers with stand-by crews, fly non-stop, Hilo, Hawaii, to Muroc, Lake, Cal.

1946, October 1—The "Truculent Turtle," a Lockheed P2V Neptune Navy patrol bomber, sets new world record for a long-distance nonstop flight, flying from Perth, Australia, to Columbus, O., an unofficial distance of 11,822 miles, in slightly over 55 hr.

1946, October 5—Col. C. S. Irvine flies Boeing B-29 "Pacusan Dreamboat" from Honolulu to Cairo, 9,500 miles, in 39 hr. 36 min.

1947, February 28—Lt. Col. Robt. E. Thacker and Lt. John M. Ard, in a North American F-82 (Rolls Royce V-1650) fly longest known flight by fighter aircraft, Honolulu to N.Y., 4,968 miles in 14 hr. 31 min. 50 sec.

MESSERSCHMITT ME-262, jet fighter

1947, July 18—Air Policy Commission established by President.

1947, July 26—Army-Navy Merger Bill signed by President, making Department of the Air Force co-equal with Army and Navy, and creating Department of Defense.

1947, October 14—First faster-than-sound flight by Capt. Charles E. Yeager in rocket-powered Air Force research plane, Bell XS-1, betters 760 mph. (Not announced officially until June 10, 1948.)

1948, June 18—Air parcel post system established by Congress; to begin Sept. 1.

1948, June 26—Berlin Airlift begins "Operation Vittles" with Douglas C-47's carrying 80 tons of supplies the first day. During first five months, Airlift tops cargo volume of all U.S. airlines by flying 93,000,000 ton-miles.

1948, September 15—USAF recaptures world speed record with North American F-86 jet fighter at 670.981 mph, flown by Maj. Richard L. Johnson.

1948—Northrop's YB-49 Flying Wing, first eight-jet bomber in the U. S. Air Force, makes longest jet-propelled flight on record of approximately 3,400 miles at average speed of 382 mph.

1949, January 7—Air Force announces a new unofficial climbing speed record set by the Bell X-1 at Muroc Air Force Base with Capt. E. Yeager at the controls, climbing more than 13,000 ft. per min., compared with 8-10,000 ft. per min. for jet planes.

1949, January 14—Capt. William Odom, flying a specially modified Beechcraft Bonanza, sets a new light-plane distance record, crossing from Honolulu to Oakland, Calif.

1949, February 7—Eastern Air Lines reports new trans-continental speed record for transport aircraft set February 5 by new-type Lockheed Constellation on delivery flight from Los Angeles to La Guardia Field in 6 hr. 17 min. 39-2/5 sec.

1949, February 8—Boeing XB-47 jet bomber sets cross-country speed record to Andrews Field, Washington, D.C. from Moses Lake, Wash. in 3 hr. 46 min.

1949, March 2—Air Force completes the first non-stop round-the-world flight in history, as a Boeing B-50 bomber, *Lucky Lady II,* lands at Carswell AFB, Ft. Worth, Tex. at 9:30 CST, after a 94-hour trip; piloted by Capt. James Gallagher, assisted by a crew of 13, the B-50 flew a total of 23,452 miles at an average speed of 249 mph. Four refueling contacts were made with Flight Refueling, Ltd.'s Probe and Drogue System from B-29 tankers.

1949, March 8—New world distance record for light planes set by Capt. William Odom in a Beechcraft *Bonanza,* flying 5,273 miles from Honolulu to Teterboro, N.J., in 36 hr. 2 min.

1949, May 3—The Martin *Viking,* 45-ft. research rocket, is fired successfully at White Sands Proving Ground, Las Cruces, N.M., reaching an altitude of 51½ miles and a speed of 2,250 mph.

1949, May 6—Sikorsky S-52-1 helicopter sets new international speed record of 122.75 mph.

1949, October 3—Navy jet-rocket special research plane, the Douglas D-558-II Skyrocket, reaches a top speed of slightly over 700 mph at an altitude of 25,000 ft. in test flight at Muroc, Calif.

1950, January 3—Jacqueline Cochran sets new official F.A.I. 500 kilometer closed course record flying a North American F-51 (Packard-built Merlin V1650) at 444 mph.

1950, January 22—Paul Mantz sets new transcontinental record flying a North American F-51 Mustang (Allison) from Burbank, Calif., to La Guardia Field, N.Y. in 4 hr. 52 min. 58 sec.

1950, February 9—Navy Lockheed P2V Neptune (Wright 3350) patrol bomber completes 5,156 mile flight in 25 hr. 57 min.

1950, March 31—Ana Louisa Branger, flying a Piper Cub Special powered by a Continental C-90-8F engine, sets official new lightplane international altitude record of 24,504 feet.

1950, September 5—North American Aviation announces successful completion of tests at Edwards AFB in which heavy bombs were dropped for first time at speeds over 500 mph with a B-45 Tornado (GE-J47).

1950, September 22—Col. David C. Schilling and Lt. Col. William D. Ritchie fly London-New York nonstop with three in-flight refuelings in two Republic F-84E (Allison J-35A-17) jet fighters. (Schilling completed flight; Ritchie bailed out over Newfoundland and was later rescued by helicopter.)

1950, November 10—A Lockheed F-80 shoots down a Russian-built MiG-15 in first jet aerial combat, Korea.

1951, January 17—Convair RB-36D reconnaissance bomber makes 51 hr. 20 min. non-stop flight without refueling.

1951, February 2—First successful air-to-air refueling of a U.S. jet bomber is carried out by a North American RB-45C Tornado and a Boeing KB-29P tanker at Edwards AFB, Calif.

1951, April 24—Piper Super Cub, piloted by Mrs. Ana Louisa Branger, sets an international altitude record of 26,820 feet in the minus 1,103-pound category.

1951, May 15—Max Conrad sets non-stop lightplane record in Piper Pacer (125 hp Lycoming), crossing the country in 23 hr. 4 min. 31 sec.

1951, Aug. 8—Navy's Martin Viking VII sets new altitude record for single stage missiles, flying 135 miles up from White Sands Proving Ground, N.M., reaching a top speed of 4,100 mph.

1951, August 18—North American F-86A Sabrejet, piloted by Col. Keith K. Compton, flies from Edwards AFB, Calif, to Detroit, Mich., in 3 hr. 27 min. 56 sec. at an average speed of 553.761 mph.

1952, January 2—A Sikorsky H-19 helicopter completes 1,800-mile flight from Great Falls, Mont., to Ladd AFB, Fairbanks, Alaska, in five days—probably the longest flight ever made by rotary wing craft.

1952, March 18—Two Republic F-84 Thunderjets land in Neubiberg, Germany, after a 2,800-mile flight without refueling—believed to be the longest sustained jet fighter flight in history. The jets crossed seven countries, averaged 585 mph, and were in the air 4 hr. 48 min.

1952, April 30—For the first time in aviation history, air passenger-miles (10,679,281,000) in 1951 exceeded the total passenger-miles traveled in Pullman cars (10,224,714,000).

1952, May 10—Transcontinental lightplane record is set by Max Conrad in a Piper Pacer, traveling from Los Angeles to New York (2,461 mi.) non-stop in 24 hr. 54 min.

1952, August 1—Two Sikorsky H-19 helicopters complete first trans-Atlantic helicopter crossing and break non-stop distance record for rotary wing aircraft.

1952, September 17—Official world's long-distance, non-stop helicopter record established by Elton Smith in Bell Model 47D-1 flying from Fort Worth, Texas, to Wheatfield, N.Y. (Niagara Falls, N.Y., airport), a distance of 1,217.14 miles in 12 hours 57 minutes.

1952, November 19—New record set by North American F-86D (GE J-47 GE-17) Sabrejet, piloted by Capt. J. Slade Nash, flying at 699.92 mph. (Previous world speed record—670.981 mph.)

1953, January 26—Chance Vought Aircraft completes final F4U Corsair, bringing to an end the longest production record of any airplane ever built.

1953, May 18—Jacqueline Cochran Odlum flies at record speed of 652.337 mph over a 100 km. course, in a Canadair F-86 swept-wing Sabre.

1953, October 3—LCdr. James B. Verdin establishes new world speed record of 753.4 mph in Douglas XF4D-1 Skyray, Navy carrier fighter.

1953, October 20—TWA Lockheed Super Constellation completes first scheduled nonstop transcontinental passenger trip from Los Angeles to New York in 8 hr. 17 min.

1953, October 29—North American YF-100 Super Sabre establishes new world's speed record of 754.98 mph, piloted by Lt. Col. F. K. Everest.

1953, December 12—Maj. Charles E. Yeager, USAF pilot, establishes new world speed record of more than 1650 mph in the Bell X-1A.

1954, January 5—Air National Guard Col. Willard W. Millikan sets New York-Washington speed mark of 24 minutes in North American F-86F.

1954, March 1—Peak is reached in number of U.S. airports: 6,760.

1954, March 29—American Airlines DC-7 sets official Los Angeles-New York commercial speed record: 6 hrs. 10 mins.

1954, May 24—Martin Viking II, single stage rocket, sets altitude record soaring 158 miles high (834,240 feet) at 4300 mph at White Sands Proving Ground, New Mexico.

1954, May 25—Goodyear ZPG-2 non-rigid airship sets new record for flight without refueling, landing at Key West, Fla., after 200 hrs. 4 mins. in the air.

1954, August 21—New altitude record of 90,000 feet set in rocket-powered Bell X-1A by Major Arthur Murray, USAF, at Edwards Air Force Base, Calif.

1954, August 27—Adm. DeWitt C. Ramsey, president of Aircraft Industries Association, reports that U.S. aircraft manufacturers are now building 900 to 1,000 military planes per month.

1955, February 16—Longest non-stop flight by a jet fighter-bomber—2,390 miles—made by Republic F-84-F from George AFB in California to Langley AFB, Virginia. Speed averaged 605 mph.

1955, March 9—Republic's F-84F Thunderstreak sets a new official transcontinental speed record, flying 2,445 miles non-stop from Los Angeles to New York in 3 hrs. 44 mins.

1955, May 24—A North American F-86 sets two transcontinental records: (1) as first aircraft to cross the U.S. round trip in daylight and (2) by flying east-west leg in 5 hrs., 27 mins., 37 secs., breaking previous record.

1955, August 1—White House announces that U.S. plans to launch a small unmanned satellite about the size of a basketball sometime after July, 1957. Satellite will circle earth at altitudes between 200 and 300 miles.

1955, August 17—Republic's Thunderstreak sets a new world's non-stop jet fighter distance record of 5,118 mi. from London, England to Texas.

1955, August 20—North American F-100C sets the first supersonic world speed record of 822.135 mph, 70 miles faster than the previous record set in 1953.

1955, October 15—Douglas A4D Skyhawk sets a new closed course world speed record of 695.163 mph.

1956, April 2—Air Force reportedly fires an air-breathing guided missile (Northrop SM-62 Snark) a distance between 1,500 and 5,000 miles from Patrick Air Force Base, Fla.

1956, July 23—Rocket-powered Bell X-2 sets new speed record of 1,900 miles an hour, flown by Lt. Col. Frank K. Everest, USAF.

1956, August 10—McDonnell XV-1 convertiplane sets unofficial speed record for helicopters of 200 mph.

1956, August 11—Vertol H-21C helicopter sets new world record for distance in a closed circuit without payload by flying 1,199.07 mi. non-stop in 11 hrs. 58 min.

1956, August 24—An Army Vertol H-21 helicopter completes first nonstop transcontinental flight over a 2,610-mile route from San Diego, Calif., to Washington, D.C., with aerial refuelings from Flight Refueling, Inc. system.

1956, September 5—Chance Vought F8U-1 captures Thompson Trophy for Navy by flying 1015.428 mph to establish new national speed record.

1956, September 7—Capt. Iven C. Kincheloe, USAF, sets new altitude record of 126,200 feet in Bell X-2.

1956, September 21—Capt. Milburn Apt sets speed record of 2180 miles per hour in Bell X-2. Plane was in subsequent crash on this flight.

1956, October 11—NACA discloses that four-stage research rockets, fired in connection with development of the ICBM and the North American X-15, have hit speeds of 6864 mph or Mach 10.4.

1956, October 16—Bell 47J, flown by Joseph Mashman, makes first helicopter flight across Andes between Santiago, Chile and Mendoza, Argentina.

1956, November 13—North American F-107 reaches Mach 2 speed in flights at Edwards Air Force Base, Calif.

1956, November 27—Eight B-52's break the jet bomber's record by staying aloft an estimated 32½ hours, covering 17,000 miles.

1957, January 18—Three of five B-52 jet bombers land in Calif., culminating the first nonstop jet flight around the world. The 24,325-mile flight is accomplished in 45 hr. 20 min., slashing by one-half the previous record.

1957, January 28—Lockheed YC-121F Constellation sets new west-to-east record of 4 hr. 41 min.

1957, February 19—First hovering flight of Bell X-14 jet-powered VTOL at Niagara Falls, N.Y., airport.

1957, March 12—Boeing 707 Stratoliner, America's first jet airliner, spans continent in record-breaking flight of 3 hr. 48 min.

1957, March 15—Goodyear Aircraft Co. Navy ZPG-2 blimp sets new world records for continuous flight, 264.2 hr., 9,448 miles.

1957, March 24—Navy Douglas A3D twin jet attack bomber cracks two speed records, flying round-trip, Los Angeles-New York in 9 hr. 35 min. 48 sec. for one mark, and east-west in 5 hr. 14 min. 58 sec.

1957, June 6—Chance Vought F8U-1 Crusaders make first nonstop ocean-to-ocean flight. Pacific to the Atlantic, refueled by Flight Refueling, Inc. system.

1957, July 12—President Eisenhower, in a Bell 47J, becomes first U.S. president to fly in helicopter while in office.

1957, July 16—Chance Vought F8U-1 Crusader, piloted by Maj. John Glenn, Jr., USMC, sets new coast-to-coast record, flying from Calif. to N. Y. in 3 hr. 23 min.

1957, August 12—F3D makes first fully-automatic landing aboard an aircraft carrier, U.S.S. *Antietam,* using Bell Aircraft all-weather automatic landing system.

1957, August 20—A manned balloon sets new altitude record of 101,516 ft. during Air Force project to determine human reactions in space flight; Maj. David Simons, sealed in a pressurized capsule, stays aloft for 32 hrs.

1957, October 10—Following Russia's launching of first earth satellite (Sputnik) on Oct. 4, President Eisenhower announces that the U.S. will attempt to launch a four-pound "test" satellite in December.

1957, October 22—Air Force reports sending rocket at least 1,000 miles and perhaps 4,000 miles above the earth at Eniwetok Atoll in Operation Far Side.

1957, November 13—Boeing KC-135, piloted by Gen. Curtis LeMay, sets new distance nonstop record, flying 6,350 miles from Westover AFB, Mass., to Buenos Aires; the KC-135's return trip sets new speed record, Buenos Aires-Washington, D.C., over 5,200 miles in 11 hr. 5 min.

1957, November 27—Air Force McDonnell Voodoo jets shatter three transcontinental speed records: Los Angeles to New York and back: 6 hr. 42 min. 6 sec.; east-west, 3 hr. 34 min. 8 sec.; west-east, 3 hr. 5 min. 39.2 sec.

1957, December 12—McDonnell F-101A, piloted by Maj. Adrian Drew, captures world speed record for Air Force by flying 1207.6 mph.

1958, January 31—Army launches first U.S. satellite (Jupiter C Explorer) into space from Cape Canaveral, Fla., at 10:48 p.m.

1958, March 5—Explorer II, measuring 80 inches and weighing 32.4 pounds, is successfully placed into orbit by Army.

1958, March 13—Republic Aviation Corporation's Alouette begins jet helicopter operation in U.S.

1958, March 17—Navy's Vanguard rocket is successfully launched at Cape Canaveral, Fla.

1958, April 8—United States Air Force Boeing KC-135 stratotanker, powered by four Pratt and Whitney J57 turbojet engines, flies nonstop without refueling 10,229.3 miles from Tokyo to Lajes Air Force Base in the Azores, in 18 hours and 48 minutes.

1958, May 7—Major Howard C. Johnson, USAF, sets new world altitude record of 91,243 feet in a Lockheed F-104A Starfighter, powered by a General Electric J79 with afterburner.

1958, May 16—Air Force Lockheed F-104A, flown by Captain Walter W. Irwin, sets new official world's speed record of 1,404.09 miles per hour over a closed course at Edwards Air Force Base, Calif.

1958, July 16—Vertol Model 76 makes what is believed to be world's first successful tilt-wing conversion flight at Philadelphia International Airport.

1958, July 29—President Eisenhower signs bill creating new National Aeronautics and Space Administration.

1958, August 15—Congress passes Federal Aviation Act, creating new Federal Aviation Agency.

1958, October 26—Pan American World Airways, using Boeing 707s, begins regular daily jet transport service between New York and Paris.

1958, December 18—Air Force's 82-foot Convair Atlas intercontinental ballistic missile is launched into orbit at Cape Canaveral, Fla.

1959, January 13—McDonnell Aircraft Corporation wins National Aeronautics and Space Administration's first space capsule competition; work is expected to take about two years and cost about $15 million.

1959, January 25—In launching first jet service across the United States, American Airline's 707 flagship sets two official records: eastbound, Los Angeles to New York, 4 hours, 3 minutes, 53.8 seconds; westbound, 4 hours, 46 minutes, 57.6 seconds.

1959, April 9—National Aeronautics and Space Administration announces names of seven astronauts who will be this country's first pioneers in space.

1959, June 8—Mail is carried by missile for first time as 3,000 letters are delivered in a Regulus I from the submarine Barbero to the Mayport Fla. naval auxiliary air station.

1959, September 14—Russia's Lunik II, 860-pound missile containing instruments and the Soviet coat of arms, hits the moon.

1959, September 17—North American's rocket-powered X-15 makes first powered flight at 1400 miles per hour at Edwards AFB, Calif., with pilot Scott Crossfield at the controls.

1959, September 18—Vanguard III, the nation's eleventh earth satellite, is catapulted into orbit expected to last 30 years.

1959, November 16—Captain Joseph Kittinger, Jr. makes record parachute jump from open Gondola at an altitude of 76,400 feet.

1959, November 20—Discoverer VIII, the nation's 15th satellite, is launched into orbit from Cape Canaveral, Fla.

1959, December 8—Navy announces new altitude record of 98,558 feet set by McDonnell F4H Phantom II powered by two General Electric J79 engines, at Edwards AFB, Calif.

1959, December 9—Kaman H-43B establishes new helicopter altitude record of 30,100 feet.

1959, December 11—Republic F-105 sets 100-kilometer closed circuit speed record, flying at 1216.48 miles per hour.

1959, December 14—Lockheed F-104C climbs to 103,395.5 feet to set new world record. Convair F-106 makes record-breaking flight at 1525.95 miles per hour over straightaway course.

1960, January 3—American Airlines 707 sets new Los Angeles-Baltimore record of 3 hrs. 39 min. and Los Angeles-Boston record of 4 hrs. 24 min.; TWA 707 sets Los Angeles-New York mark of 3 hrs. 57 min.; Eastern Air Lines sets DC-8 Long Beach-Miami record of 3 hrs. 58 min.

United Air Lines inaugurates daily jet service between Washington/Baltimore and Chicago and San Francisco in DC-8s.

1960, February 24—Titan ICBM is launched from Cape Canaveral and fired 5000 miles in its longest flight to date.

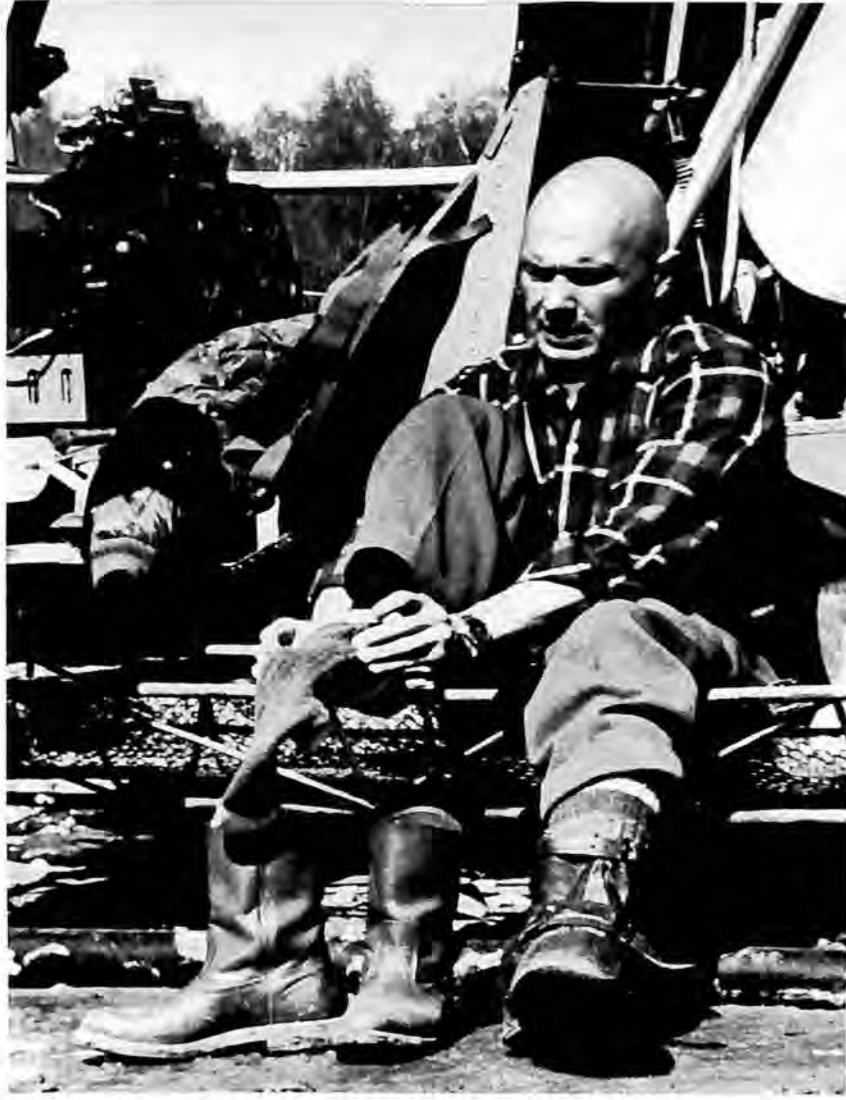
1960, February 29—First North American X-15 is accepted by the Air Force and turned over to NASA Research Center, Edwards AFB, Calif., for research flight test program.

1960, May 20—An Atlas ICBM is successfully fired over 9000 miles, the greatest distance ever covered by a ballistic missile.

1960, May 21—Hiller 12E sets new aviation altitude records in rescue of two mountain climbers from Mount McKinley with six landings and takeoffs being made at 18,000-ft. level, several thousand feet higher than has been attempted previously.

1960, August 16—Air Force Capt. Joseph W. Kittinger makes record parachute jump from a balloon approximately 102,800 feet over the New Mexico desert.

1960, September 7—Sikorsky Aircraft delivers first turbine-powered helicopter, the S-62, to Los Angeles Airways for use in scheduled airline service.



LINK LUCKETT sets new altitude record in Hiller 12E.

1960, September 25—Navy claims new world speed record when McDonnell F4H-1 Phantom II fighter, powered by two General Electric J-79 engines and piloted by Comdr. John F. Davis flies at 1390.21 miles per hour over a 100-kilometer closed circuit course.

1960, November 14—Air Force successfully snares capsule of Discover XVII satellite that had circled the earth 31 times covering nearly one million miles.

1960, November 24—Convair rolls out first 990 jet transport (previously designated the 600) which is powered by GE CJ805-23 engines and cruises at 640 mph.

1960, December 13—Navy claims new world altitude record for jet aircraft carrying a 1000 kilogram payload in North American A3J flight to 91,450.8 feet.

1960, December 20—The Martin Company delivers its last aircraft—a Navy P5M-2 Marlin flying boat—as the company completes transition to production of Missiles, electronics and space exploration.

OFFICIAL RECORDS

The National Aeronautic Association (NAA), being one of the 53 member nations of the Federation (Aeronautique) Internationale (FAI), must sanction, certify and register all record attempts within the United States in order that they be "Officially" recognized world wide.

Any and all competitors must conform to the rules and regulations as set forth by the FAI in its "Sporting Code." This remarkably complete Code is kept up to date by comprehensive studies of the International Sporting Committee who then present their recommendations for changes and/or additions to the Annual General Conference for approval.

The General Conference held in Barcelona, Spain, from the 3rd to the 9th of October 1960, approved the addition to the Sporting Code of the two following new types of world records:

1. ALTITUDE IN HORIZONTAL SUSTAINED FLIGHT WITHOUT PAYLOAD.

The altitude of the record will be the true *constant* altitude measured above sea level as defined in each country by the National Cartographic Authority. By constant altitude is meant the altitude maintained over a distance of 15 to 25 kilometers or during a period of 90 seconds.

2. RECORDS WITH NON AIR BREATHING MANNED ROCKETS.

All flights must have altitude gained of at least 100 kilometers in order to qualify as space flights and the vehicle component reaching the maximum performance must return to the surface at the earth with the pilot alive.

OFFICIAL RECORDS ESTABLISHED (OR CLAIMED) IN U.S.A. DURING 1960

N.A.A. Sanctioned Attempts

CLASS C-1.d (Light Aircraft)

ALTITUDE WITHOUT PAYLOAD (ALSO SEE FOLLOWING RECORD) ....34,862 feet

James D. Webber, Pilot, Beech Queen Air, #65, 2 Lycoming A1A6 Engines, Wichita, Kansas, Feb. 8, 1960.

ALTITUDE WITHOUT PAYLOAD ....36,932 feet*

Miss Jerrie Cobb, Pilot, Aero Commander 6804, 2 IGSO-540B1A Engines, Santa Monica Municipal Airport, Calif., Sept. 20, 1960.

ROTORPLANES—CLASS E

SPEED FOR 500 KILOMETERS IN A CLOSED CIRCUIT WITHOUT PAYLOAD ....148.449 mph

Col. Jack L. Marinelli, USA, Pilot, CWO C. V. Turvey, USA, Co-Pilot, Bell HU-1 "Iroquois" Helicopter, T53-L-1A Engine. Hurst Harrison, Texas course, July 23, 1960.

TIME TO CLIMB TO 3,000 METERS ....3 min., 29.1 sec.*
6,000 METERS ....8 min., 7.1 sec.*

Maj. G. J. Boyle III, USA, Bell HU-1 "Iroquois" Helicopter, T-53-L-1A Engine, Globe Facility Airport, Saginaw, Texas, July 19, 1960.

CLASS E-1.d (Light Rotorplanes)

MAXIMUM SPEED OVED A STRAIGHTAWAY COURSE .... 158.037 mph*
(3 Kilometers restricted altitude)
CWO C. V. Turvey, USA, Pilot, Bell HU-1 "Iroquois" Helicopter, T53-L-1A Engine, Avondale, Texas, 3 Kilometer course, July 22, 1960.

SPEED FOR 100 KILOMETERS IN A CLOSED CIRCUIT .... 142.217 mph
CWO C. V. Turvey, USA, Pilot Bell HU-1 "Iroquois" Helicopter, T53-L-1A Engine, Hurst-Concord, Texas course, July 26, 1960.

SPEED FOR 500 KILOMETERS IN A CLOSED CIRCUIT .... 148.449 mph
Col. Jack L. Marinelli, USA, Pilot, CWO C. V. Turvey, USA, Co-Pilot, Bell HU-1 "Iroquois" Helicopter, T53-L-1A Engine, Hurst Harrison, Texas course, July 23, 1960.

GLIDERS—CLASS D (Single Place)

DISTANCE TO A PREDETERMINED POINT WITH RETURN TO POINT OF DEPARTURE .... 399.86 miles
Richard E. Schreder, Pilot, "Airmate" Model HP-8 Glider, Ector County Airport, Odessa, Texas to Arledge Airport, Stamford, Texas and return, Aug. 4, 1960.

ABSOLUTE WORLD RECORDS (Regardless of Type Aircraft)

MAXIMUM SPEED OVER A CLOSED CIRCUIT 1,390.24 mph*
Cmdr. John F. Davis, USN, McDonnell F4H-1, 2 General Electric J-79-2 Engines, Edwards AFB, Calif., 100 Kilometer Course, Sept. 25, 1960.

DISTANCE IN A CLOSED CIRCUIT .... 10,060 miles*

Pilot—Lt. Col. T. R. Grisson, USAF, Co-Pilot —Capt. J. P. Bosley, USAF, Boeing B52G, 8 Pratt and Whitney J-57 Engines, Course—Edwards-Texas-Washington, D.C. - Newfoundland-Alaska-Montana-Edwards AFB. (19 hrs. 44 min.) Dec. 13, 1960.

WORLD "CLASS" RECORDS—CLASS C—GROUP I (Turbojet Powered Aircraft)

DISTANCE IN A CLOSED CIRCUIT WITHOUT REFUELLING .... 10,060 miles*
Pilot—Lt. Col. T. R. Grisson, USAF, Co-Pilot —Capt. J. P. Bosley, USAF, Boeing B52G, 8 Pratt and Whitney J-57 Engines, Course—Edwards-Texas-Washington, D.C. - Newfoundland-Alaska-Montana-Edwards AFB. (19 hrs. 44 min.) Dec. 13, 1960.

SPEED FOR 100 KILOMETERS IN A CLOSED CIRCUIT WITHOUT PAYLOAD .... 1,390.24 mph*
Cmdr. John F. Davis, USN, McDonnell F4H-1, 2 General Electric J-79-2 Engines, Edwards AFB, Calif. 100 Kilometer Course, Sept. 25, 1960.

SPEED FOR 500 KILOMETERS IN A CLOSED CIRCUIT WITHOUT PAYLOAD .... 1,216.766 mph*
Lt. Col. T. H. Miller, USMC, McDonnell F4H-1, 2 General Electric J-79-2 Engines, Edwards AFB, Calif., Desert Butte Course, Sept. 5, 1960.

ALTITUDE WITH PAYLOAD OF 1,000 KILOGRAMS .... 91,450.8 feet*
Cmdr. Leroy A. Heath, USN, North American A3J-1, 2 General Electric J-79 Engines, Edwards AFB, Calif., Dec. 13, 1960.

CLASS C-1.c (Light Aircraft)

DISTANCE IN A CLOSED CIRCUIT WITHOUT PAYLOAD .... 6,921.28 miles
Max A. Conrad, Pilot, Piper Comanche Pa24-180, 1 Lycoming O-360 Engine, Minneapolis-Chicago-DesMoines-Minneapolis Course, July 4, 1960.

BALLOONS—CLASS A (First Category—250 Cu. Meters or less)

ALTITUDE .... 3,740 feet
Donald Piccard, "D. Piccard S. 10 Holiday" Balloon, from Lake Calhoun, Minneapolis to near Stanchfield, Minn., July 25, 1960.

NATIONAL INTER-CITY RECORDS FOR COMMERCIAL AIRCRAFT

NEW ORLEANS TO BALTIMORE, MARYLAND
Capt. Truman Outland, Pilot; Charles R. Branson, 1st Officer; Delta Airlines, Convair 880, 4 General Electric CJ-805-3 Engines, from Moisant International Airport, New Orleans to Friendship Airport, Baltimore, Oct. 30, 1960.
Elapsed time: 1 hour, 40 minutes, 31 seconds. Distance: 999.25 miles.
Average speed .... 596.47 mph

SAN DIEGO, CALIF. TO ATLANTA, GEORGIA
Captain James H. Longino, Pilot; Captain Jerry Crockett, Co-Pilot; Delta Airlines, Convair 880, 4 General Electric CJ-805-3 Engines from Lindbergh Field, San Diego to Atlanta Airport, May 11, 1960. Elapsed time: 3 hours, 23 minutes, 59 seconds. Distance: 1,889.40 miles.
Average speed .... 555.75 mph

SAN DIEGO, CALIF. TO MIAMI, FLORIDA
Captain Thomas P. Ball, Pilot; 1st Officer, James H. Longino; Delta Airlines, Convair 880, 4 General Electric CJ-805-3 Engines from Lindbergh Field, San Diego to Miami International Airport, Miami, Florida, February 10, 1960. Elapsed time: 3 hours, 31 minutes, 54 seconds. Distance: 2,266.55 miles.
Average speed .... 641.77 mph

*Records documented and reported but not yet "officially" homologated by the Federation Aeronautique Internationale, Paris, France.

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