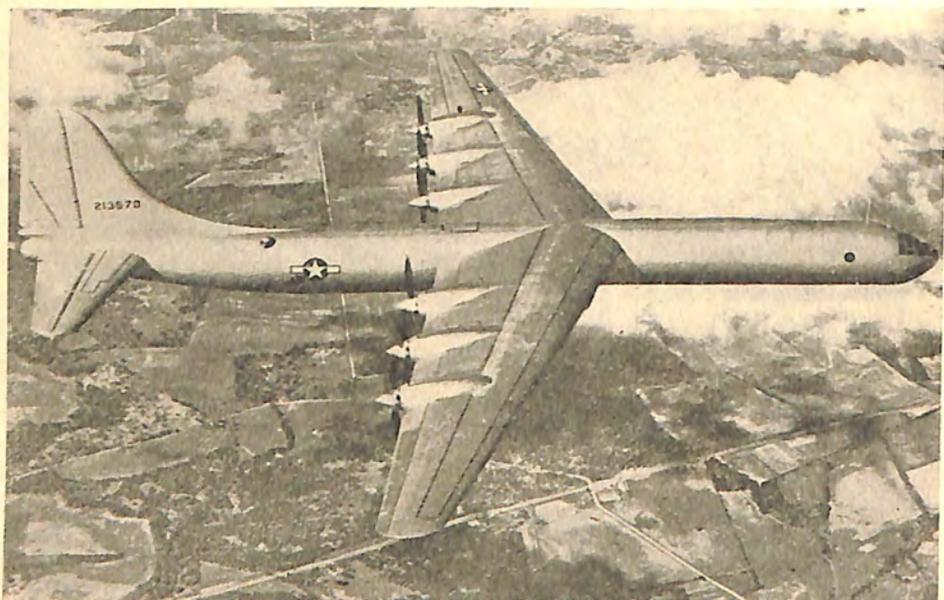


*The*  
AIRCRAFT  
YEAR BOOK

*For 1947*

AIRCRAFT YEAR BOOK FOR 1947



CONSOLIDATED VULTEE B-36 BOMBER

*The*  
AIRCRAFT  
YEAR BOOK

*(Registered U. S. Patent Office)*

*For 1947*

TWENTY-NINTH ANNUAL EDITION

HOWARD MINGOS

Editor

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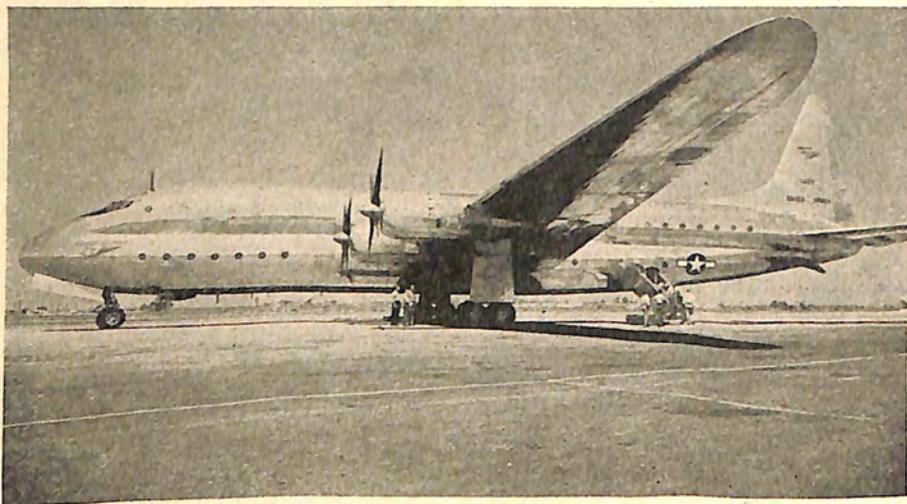
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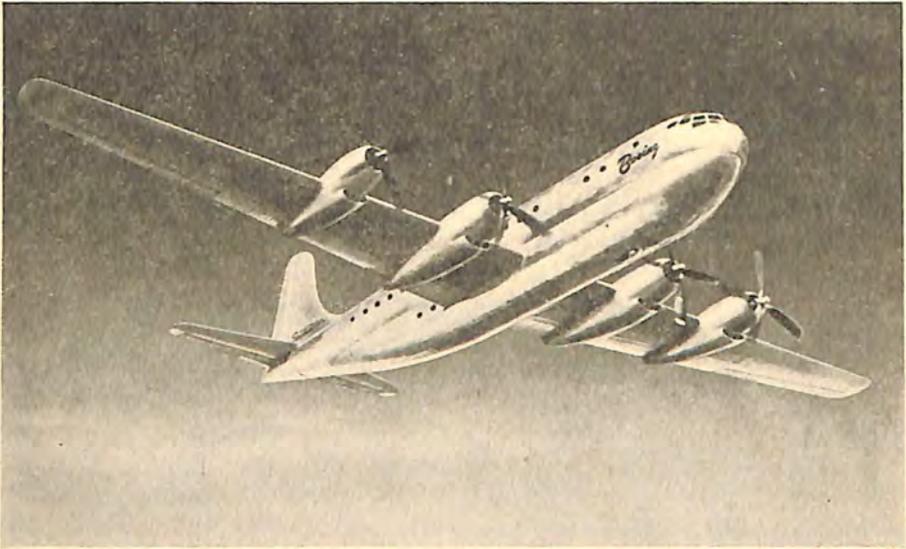
LOCKHEED NAVY CONSTITUTION

## CHAPTER I

### THE RACE FOR AIR SUPREMACY

Three Nations Have Extensive Plans for Peacetime Aviation—Russia a Contender for First Place in Air Power—The United States Leads in Commercial Aviation—Thousands of Transport Aircraft Needed for Emergency Use—Military Production at Low Levels—Need for a National Research and Development Program.

**T**HREE nations are working toward supremacy in the air—the United States, Great Britain and Russia. All three have started extensive programs for the development of peacetime aviation, both for economic reasons and for reserve air power to be immediately available in any emergency. All three want to build up their air transport systems so that they will be capable of carrying whole armies anywhere, halfway around the world if necessary. All three are making fairly rapid progress in the development of jet propulsion for faster aircraft and rocket motors for guided missiles designed to hit any target squarely though it be thousands of miles distant. The United States and Great Britain, which emerged from the war with vast aircraft production capacity, have been carrying on their development programs through processes of evolution, with excellent results. Russia has taken a radically different course. She is basing her post-war aviation on new foundations, trying to establish a new plant for mass production of the variety of planes and missiles that elsewhere are turned out only in experimental numbers. To that end, Russia has taken as much of the German plant and laboratory equipment as she could procure, along with those German scientists and technicians who did not go to England or the United States for similar reasons. This has augmented the already huge scientific facilities which the Russians have been creating for two decades. Their program is to establish the world's most powerful air force, and in Russia the expense of such development is not considered. The principal concern is procuring enough of the right kind of materials. For that purpose Russia has thousands of investigators visiting, and practically established in the United States, Canada and Great Britain, buying every new thing that they can find, machinery, new heat-resistant metals, jet engines, accessories and all the scientific literature obtainable.



BOEING STRATOCRUISER

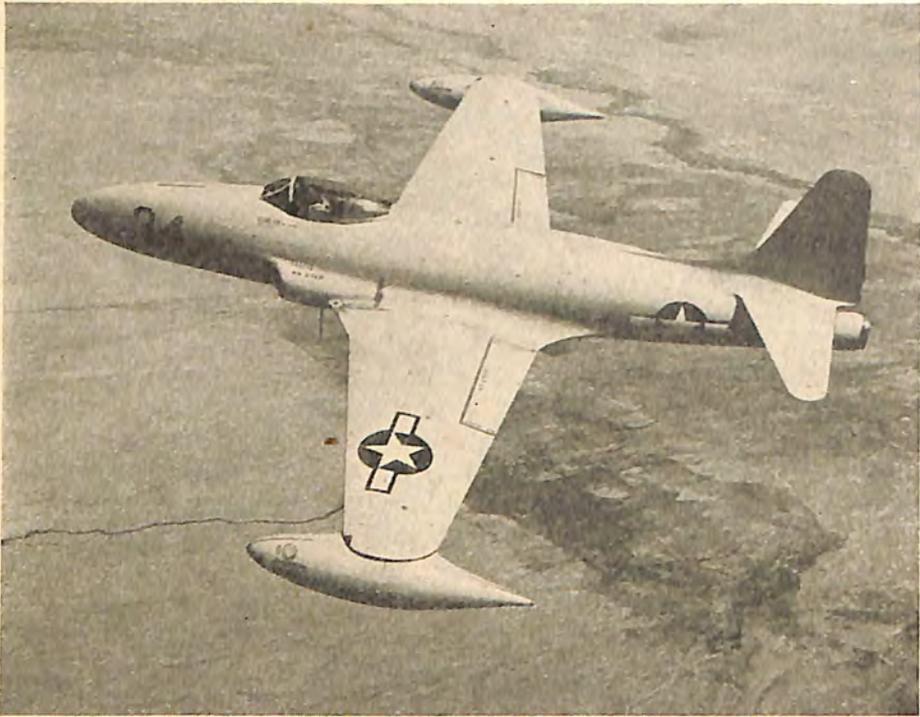
Numerically, Russia has the largest air force in the world, with squadrons in training and other groups doing experimental work from the Arctic to Iran, from Berlin to Korea. Russia has an extensive program for operating bases in the Far North, and is experimenting with transport equipment for air operations over the Polar wastes, besides using those regions as a testing ground for pilotless planes and guided missiles. In her 1948 program, Russia plans to have more personnel at work on guided missiles and long range aircraft than the United States and Great Britain combined. One of the most significant results of the war is the transfer of German technique into the Soviet experimental system. It is making Russia a world leader in aerodynamics, powerplants and metallurgy.

Here in the United States, we still have the world's greatest commercial aviation. Our air transport system has been expanding throughout the country and to practically all countries on earth, except Russia. There are thousands of projects for feeder lines, enough to place every community in the country within easy reach of air transport. Millions of dollars are being put into safety devices and other navigational aids every month. But instead of a few hundred transports to carry commercial traffic, as at present, the consensus is that we should have available at all times between four and five thousand

of the largest and fastest transports, so they can fly an army anywhere in an emergency. The armed forces stress the need for much greater expenditures on research and development projects as the best insurance against national losses that would amount to hundreds of times the money required to keep us abreast of other nations. They also insist that the number of modern military aircraft delivered to the Services each year must be at least thrice that of 1946. The Army Air Forces Materiel Command at Wright Field, Dayton, O., explained the situation in a report made public January 16, 1947. It stated: "A total of 1,010 military aircraft was delivered to the Army Air Forces during 1946. In 1945, the last year of the war, over 30,000 military aircraft were procured by the AAF. This compares with a peak of acceptances by the AAF in 1944, when all-out air warfare required approximately 70,000 military aircraft. Since the war, procurement of military aircraft has fallen off sharply, and AAF officials have cautioned against allowing American air power to shrink to the low levels of prewar years. In 1937, less than 1,000 military aircraft were produced. Production increased to 6,000 in 1940, due to foreign orders and tooling-up in accordance with the President's 50,000 plane program. Under the Air Industrial Preparedness Program, which is one of the peacetime responsibilities assigned to Air Materiel Command, an annual procurement of at least 3,000 military aircraft is believed necessary to maintain the aircraft industry at a healthy level of production and to provide a flow of modern combat aircraft replace-



CONSOLIDATED VULTEE XC-99 TRANSPORT



LOCKHEED AAF P-80 SHOOTING STAR

ments to the Services. By doing this, American air power would be founded on a sounder industrial basis in the event future emergencies necessitate an immediate acceleration to volume production. These 1946 delivery figures reveal the emphasis the AAF places on jet propulsion, because of the 453 fighter planes delivered, over 400 were powered by jet units."

The Senate Committee Investigating the National Defense Program in 1946 issued a report containing these conclusions: "Actual and projected improvements in aircraft and missiles threaten to dissipate our historic natural defenses. We must, as a matter of vital national defense, devote sufficient attention and effort to scientific research and development in aviation and adequate aircraft productive capacity. Since hostilities ended, the wartime aircraft industry has made a remarkable adjustment to the severe reduction in aircraft production, and has demonstrated ingenuity in converting to peacetime aircraft production and in switching to other civilian products.

However, it must be borne in mind that the airplane industry has been deflated to the approximate size it was in December, 1940. It would take two years to rebuild the industry to its productive capacity of September, 1945.

"We have not yet developed a clear and farsighted national policy in aircraft research and development. Furthermore, we have not set a policy for the level of production of military type aircraft and the aviation productive capacity to be maintained in standby condition. In the opinion of the committee, this policy should have been established prior to the drastic cuts and termination of contracts on V-J Day. Then, the problems of the aircraft industry in adjusting itself and in reconversion would have been easier. Moreover, the peacetime character of the industry could have been evolved more rapidly and at less cost. Here again is an instance of too little planning done too late.

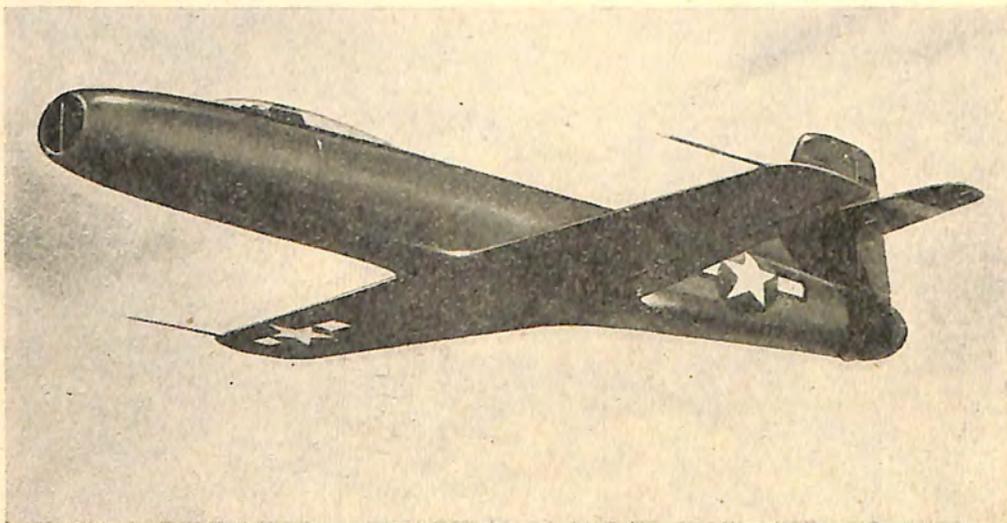
"Military procurement during peacetime should allow for the



REPUBLIC AAF P-84 THUNDERJET

purchase of a sufficient quantity of models to conduct experimental and service tests expeditiously and to afford manufacturers an opportunity to work out problems of production engineering, planning, and tool design."

"Our present facilities for aeronautical research and development are inadequate. The Government should encourage, by financial assistance and otherwise, the establishment of a body of qualified research and technical personnel and the acquisition of adequate scientific research and testing equipment, so as to insure that the United States will maintain a position in the science of aviation second to none."



DOUGLAS NAVY D-558

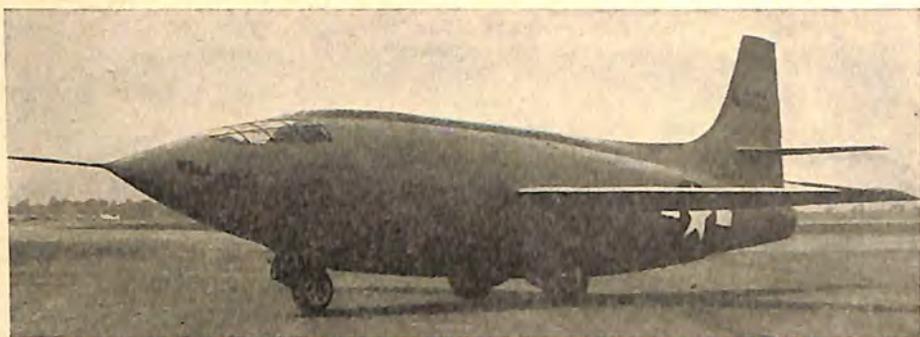
## CHAPTER II

### TECHNICAL PROGRESS AND PROBLEMS

Hundreds of New Developments in Aircraft Safety—Superiority of Transport Airplanes—The Problems to be Solved—Military Planes Fly Faster and Higher—The Guided Missiles Program—New Powerplants—Jet and Rocket Propulsion—The Search for Atomic Power—Awards for Scientific Achievement.

**B**ELIEVING that the security and well-being of the United States lies in developing to the maximum our military air power and every possible phase of peacetime flying, all the scientists and engineers in aeronautics and allied fields were working toward two radically different objectives in 1947. They were trying to make peacetime flying safer, and they were trying to make war aviation more devastating, especially for any enemy of the future who might attack this country. While some of the projects were fantastic, they were no more incredible than many of the developments, already accomplished, which were making flying safer for men of good will and vastly more dangerous for warmongers. Thus while supersonic planes were being tested as forerunners of speeds as high as 1,200 miles an hour or more, and other aircraft were projected as initial developments for machines that ultimately would fly hundreds and even thousands of miles high, rocket-propelled and possibly by atomic power, there were hundreds of new developments which assured more immediate progress in all branches of flying. The Army and Navy air forces had no less than 37 different jet-propelled planes either in operation or on order at the beginning of 1947, besides several rocket projects.

One of the imagination-jolting developments of 1946 was the award to Fairchild Engine and Airplane Corporation by the Army Air Forces of a prime contract for the development of atomic energy powerplants for aircraft. As a result of the contract Fairchild set up a new division, known as the NEPA division, to carry on research work at Oak Ridge, Tenn. Enough had been learned, according to some AAF authorities, to indicate that propulsion of aircraft by nuclear energy is not impractical. While Fairchild had been charged with the basic responsibility for fostering and coordinating the new



BELL AAF XS-1

project, to administer and correlate its various aspects, it was not working alone. Other major aircraft and aircraft engine companies, various universities, and Government agencies were contributing to the tremendous research and development necessary, being brought into the undertaking at various stages of its progress. Unusually close collaboration, not only with the air forces and the Manhattan District Project, but with all the companies and agencies involved, prevailed in an effort to solve the challenge of applying nuclear energy to the propulsion of aircraft. The general knowledge gained in the enterprise was to be spread through the aircraft engine industry. The successful application of the atomic power potential might void all present barriers to aircraft performance.

Major Gen. Laurence C. Craigie, chief of the engineering division of the Army Air Forces Materiel Command, speaking before the Institute of the Aeronautical Sciences in January, 1947, gave an exceptionally clear description of technical objectives and the problems to be solved. He said:

"In the technical field, we are still very much concerned with the problems inherent in subsonic flight, since we have not attained the ultimate in subsonic aircraft. There is still a vital need for such aircraft, particularly in the light of plans now under way to make the entire Army totally air transportable and air borne.

"The possibilities of global warfare make it mandatory that we have transport and cargo aircraft of such size and in such numbers that it will be possible to move complete divisions of fully equipped ground troops over thousands of miles in a minimum of time. The possibility of such aircraft going from one extreme climatic condition to another in a matter of hours requires that all our operational equip-

ment be geared to the whims of the weather over wide geographical areas. It is also indicated that we must devote considerable ingenuity to the design of droppable cargo compartments and containers, to supply troops in inaccessible areas.

"Because of the obvious strategic value of the Arctic regions, we are currently placing great emphasis on so-called winterization of aircraft, aeronautical equipment and personal equipment. We are seeking better solutions to the familiar problems of wing and propeller de-icing, cabin and cockpit heating, cold engine starting, low temperature lubrication and cold weather maintenance.

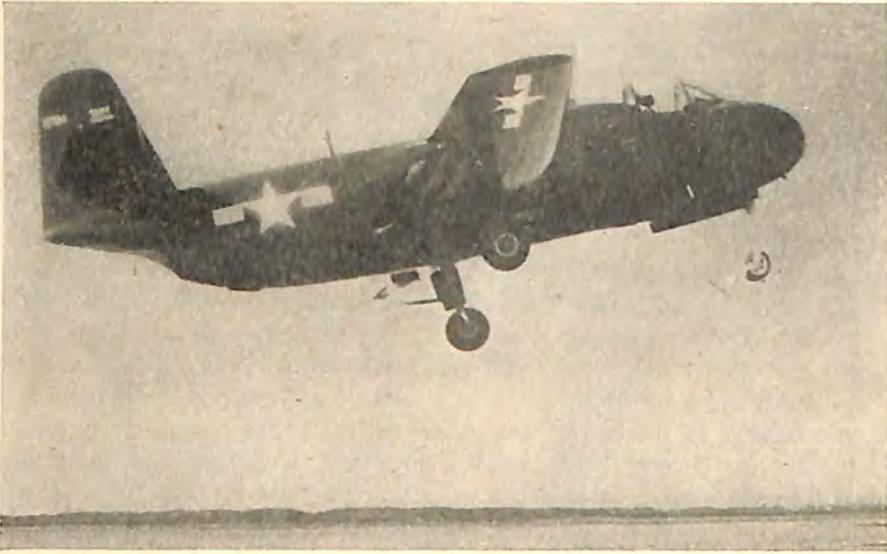
"One of the subsonic aircraft which merits mention is the helicopter. It has many special purpose uses and its further development we deem a military necessity. An interesting design on which we are now working is the flying crane, so called because it is designed to transport and deliver heavy loads over short ranges and into relatively impenetrable places. We are conducting considerable rotor blade research in an effort to arrive at best blade shape and method of construction, choice of suitable material, and how to overcome the hazards of icing and abrasion. Some development work on jet-propelled rotors is being undertaken.

"Our combat aircraft, for an interim period at least, will remain in the subsonic range. So far as powerplants are concerned, the reciprocating engine is still our best bet for long range, sub-stratosphere flight at subsonic speeds. However, the propeller-drive gas turbine gives indication of becoming a strong competitor.

"Today's propeller picture is colored by the necessity of providing



McDONNELL NAVY 2-JET PHANTOM FIGHTER



VOUGHT NAVY XF6U PIRATE

for engines, both reciprocating and turbine, of higher horsepower. The trend is toward much larger propellers, either in diameter or number of blades for subsonic operation. Hub studies are aimed at reversible pitch with high rate of change and safety measures to prevent changes not definitely called for by the controls. Turbine engines with their peculiarity of optimum operation at close to top speed offer a difficult problem of propeller governing, and this study is now receiving very detailed attention.

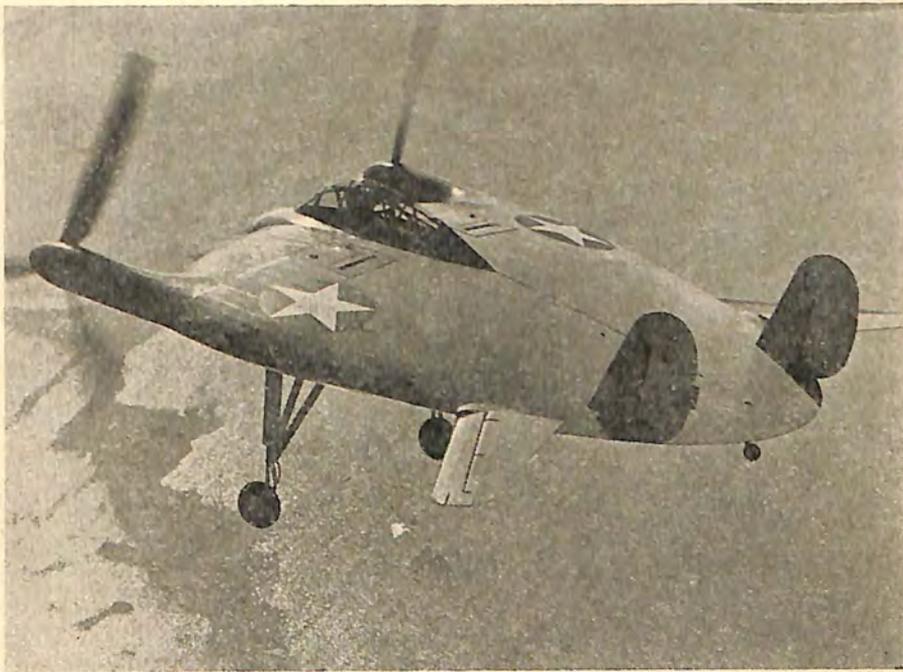
"There is much left to be done in the subsonic sphere, but our major problems today are those posed by the advent of the supersonic guided missile and the necessity for our crashing the wall of transonic speed for accomplishing flight in the supersonic range.

"Incidentally, when we of the Army Air Forces and others speak in terms of supersonic rocket-propelled aircraft traveling at speeds of 1,500 miles per hour at altitudes of 80,000 feet, or radio-controlled planes or missiles going through the upper air at 3,000 miles per hour, I should like to emphasize forcibly that we do not consider these as statements of existing or near-future fact. Nor are they intended as exaggerated claims. They are simply straightforward statements of objectives—objectives which science and industry and we of the armed services are confident lie in the studied, foreseeable future.

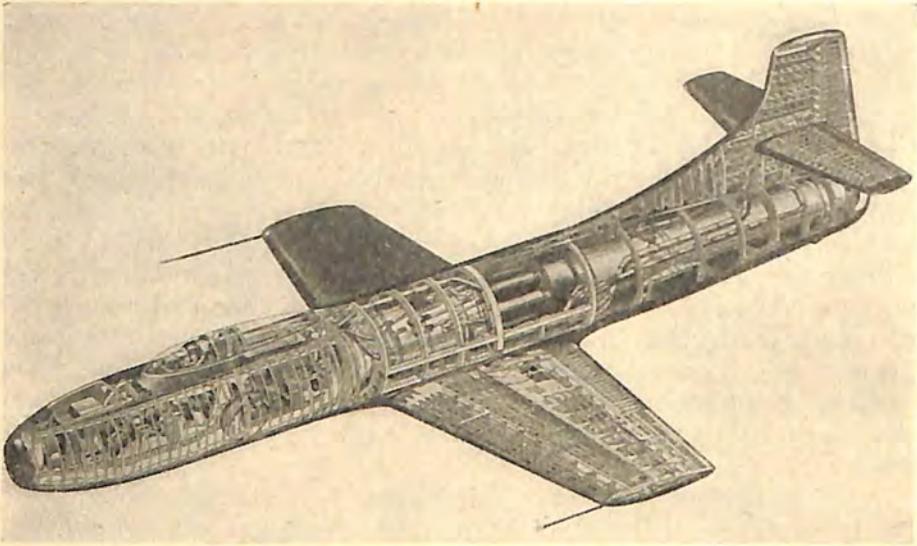
"Not too far back we jointly wrestled with and won the struggle to step up propeller-drive power so as to increase the speed of a plane from 300 to 500 miles an hour. Our later and more powerful jet engines have our aircraft hitting the 600 miles an hour mark.

"There is today a compelling need for a comprehensive and aggressive upper air research program. Our current meteorological data above 60,000 feet are admittedly meager and, for our purposes, we must now extend these to at least 600,000 feet. Gen. Arnold in an address to a group on the west coast covered the situation pretty accurately when he said: 'We have spent a lot of time and money developing the airplane but have spent very little in investigating the medium in which we expect it to operate.' Accordingly, we have initiated an intensive investigation along these lines and this program is being given high priority in relation to other existing research projects.

"In the field of electronics, supersonic flight has interposed some difficult problems. The early warning range of 200 miles now available must be extended to, several thousand miles; ambient tempera-



VOUGHT NAVY XF<sub>5</sub>U-1 FLYING WING



DOUGLAS NAVY D-558 DETAIL

tures of equipment used in pilotless aircraft must be stepped up to several hundred degrees; there is a requirement for added information on wave propagation characteristics if we are to solve problems involved in the guidance of pilotless aircraft at very high altitudes.

"I should like to emphasize the extreme importance of the physiological phase of high speed flight. It is one of our major posers, and it indirectly is reflected in aircraft design. Man is not built to absorb the terrific accelerations and punishing decelerations which we contemplate encountering in supersonic flight. Another thing, he cannot exist in a vacuum. Therefore, we are conducting exhaustive tests to determine man's limitations with the objective of providing means to overcome them. We have already developed a lightweight pressure suit for our flying personnel which has been successfully tested to a simulated 80,000 feet.

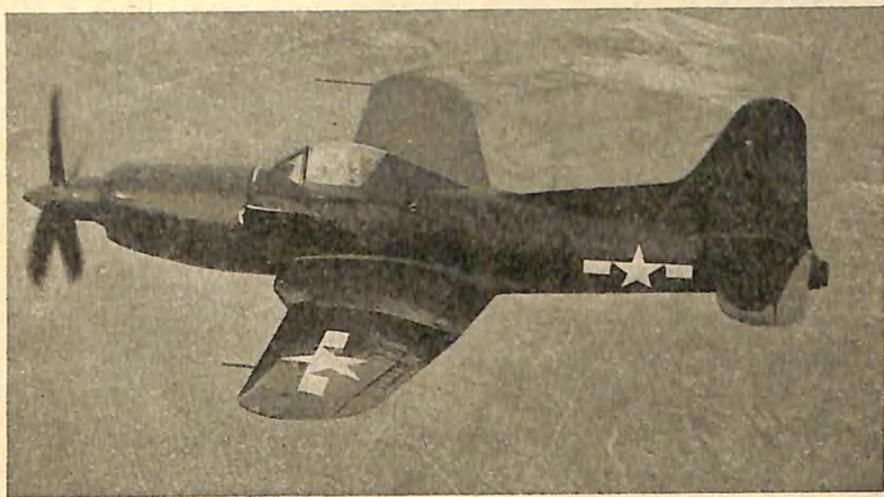
"Powerplants to propel us through the transonic and supersonic ranges are a problem, particularly from the fuel economy standpoint. All the new types—the turbo-jet, the ram jet, the rocket motor and possibly the propeller-drive turbine—meet the power requirements but, as yet, high fuel consumption limits the useful range of flight. Even greater powers will be available from most of these types as soon as materials of higher heat resistance are developed. Metal alloys do

not seem to be able to take it, and exploration of the metal-base compounds such as the carbides and borides may provide the answer. To date these are laboratory curiosities, and will require extensive research before they can be fabricated into usable products.

"The extreme accelerations encountered in supersonic flight have also complicated powerplant development. Whereas conventional engines were called upon to operate at a maximum rate of climb in the neighborhood of 5,000 feet per minute, we have pilotless aircraft contemplated which will have rates of climb in excess of 100,000 feet per minute. For our equipment to stand up under this extreme flight condition, it must be mechanically capable of withstanding very high accelerations. In addition, the rate of response of the engine, the engine controls and the fuel metering system must be greatly increased.

"Our propeller people contend that supersonic flight does not put them out of business. They argue that existing information indicates that application of the same basic principles that make aircraft fly at supersonic velocities will permit propellers to give commendable performance at these same velocities.

"So far as aircraft structures are concerned, the chief problems have to do with wing and control design, nacelle installations, materials, and escape provisions. In the matter of wings and controls, we are, at present, considering and investigating, among other things, sweep-back, sweep-forward and the thin diamond-shaped airfoil.



RYAN NAVY XF<sub>2</sub>R-1



NORTH AMERICAN NAVY XFJ-1

These should at least increase the critical speed and delay the onset of compressibility. For strength purposes, the thin wing will undoubtedly be thick-skinned. We are almost accustomed to the term wing plate, in lieu of wing skin. With respect to nacelles, particularly jet engine nacelles, we must make exhaustive wind tunnel tests with both single and multi-engine types of various shapes to determine the most efficient configuration. Such other protuberances as radome blisters, gun turrets and the like will have to be minimized or eliminated. Work on the pilot ejection seat is being extended to provide protection for other crew members.

"In the field of armament, we are devoting every effort to the development of fire control systems which will automatically locate a target whether in the air or on the ground or on the sea, and insure a hit every time a gun is fired or a bomb released. New types of rocket weapons which can be fired from an aircraft and be detonated by proximity fuse in the vicinity of the target will undoubtedly be part of the armament of future high speed aircraft."

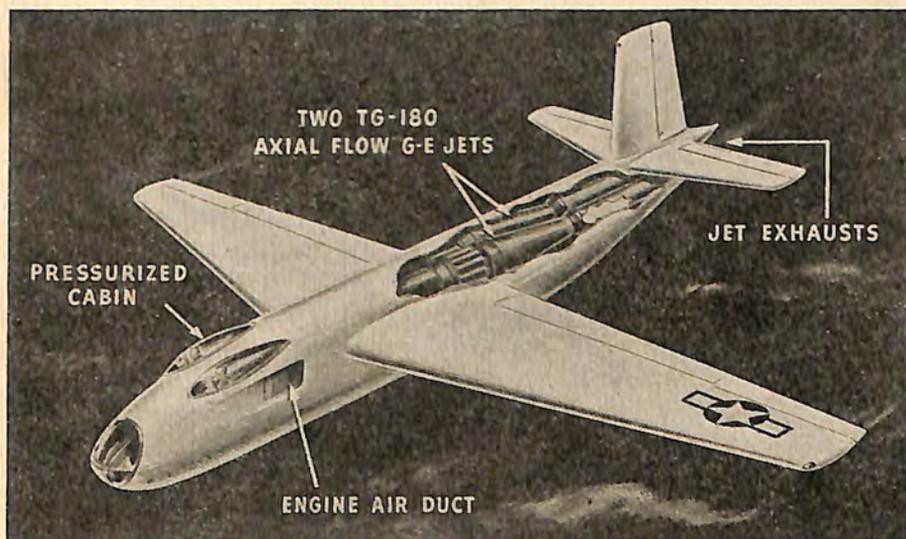
The myriad accomplishments of the engineers in making flying safer were described by Arthur E. Raymond, engineering vice president of the Douglas Aircraft Company, before the aviation subcommittee of the Senate Committee on Interstate and Foreign Commerce, in February, 1947. Mr. Raymond, as a member of the Aircraft Technical Executive Committee of the Aircraft Industries Association, spoke for the entire industry. He said:

"The phenomenal expansion in air transportation in the last six years to global proportions was largely made possible by the research

and development carried on by the armed services in cooperation with all branches of the industry. Certainly, the prompt adoption of what we already have, together with adequate support for research on and perfection of what lies just ahead, should enable this rapid development to continue at a rate matching that of the last six years. The results in employment, travel and communications would be revolutionary.

"To say it another way, Congress has a real opportunity to perpetuate American dominance in the skies by extending forthright support for the necessary research and technical development of our airways.

"The modern transport aircraft perhaps is the most carefully engineered product used by man. The larger aircraft companies each must maintain huge staffs of engineers trained in all the specialities of aeronautical science. Thousands upon thousands of hours of engineering go into each plane before it leaves the hangar for its first test flight. Many more thousands of hours of engineering are expended upon that plane after it flies, to improve and perfect its performance and effect changes shown to be necessary by the exhaustive tests. This engineering is expended before the plane goes into commercial service, and thousands more hours are expended through the entire life of the



DOUGLAS AAF XB-43 DETAIL



DOUGLAS AAF XB-43

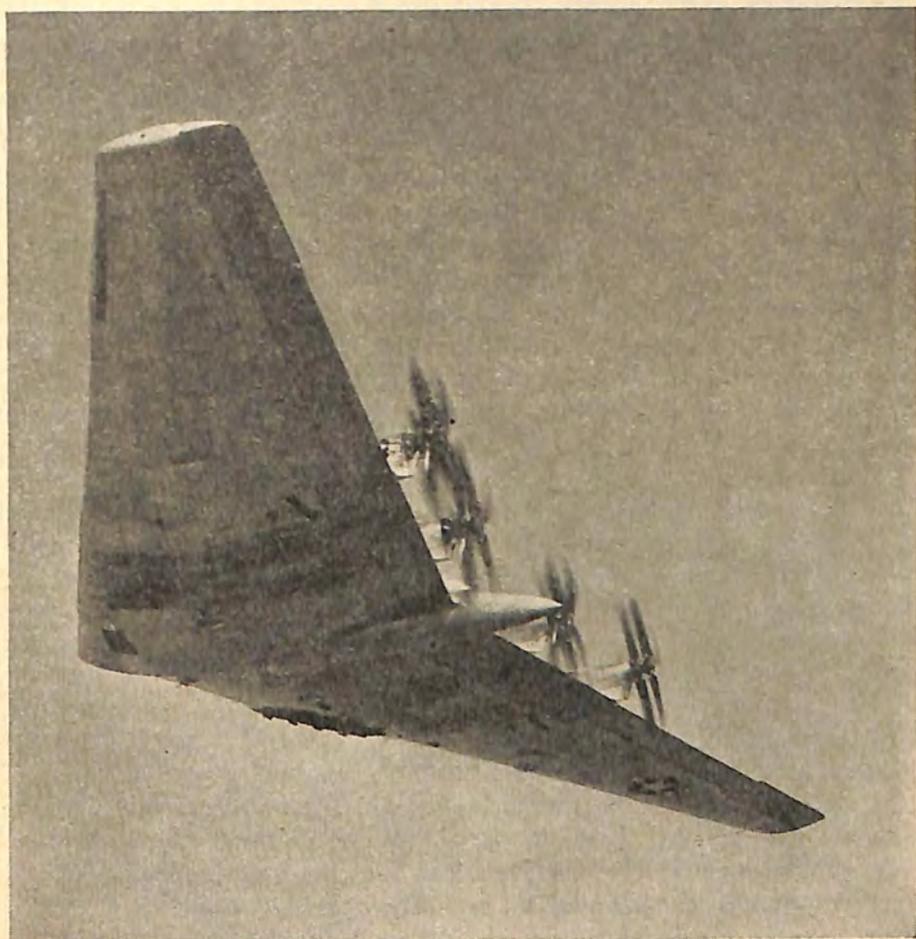
plane. Our industry's total employment has plummeted from around the 2,000,000 mark to about 200,000. Yet, the engineering staffs of many of our companies now stand at record or near record levels. That demonstrates rather conclusively the amount of engineering and research being built into modern airplanes.

"No branch of engineering receives greater attention from aircraft makers than safety. Search for safety has become a science, a most exacting science, and no manufacturer can fail to expend the greatest possible engineering effort to assure that his product is the safest possible. Whole teams of engineers study nothing else but safety. The Aircraft Industries Association maintains a permanent Committee on Airworthiness Requirements for the specific purpose of recommending new aircraft design and performance requirements for increased safety. Continuous industry meetings and joint meetings with the CAA and CAB are held to insure that the level of safety as set forth by the civil air regulations is constantly improved in the light of new developments. This airworthiness activity affords through Government regulatory personnel a full opportunity to keep abreast of all advancements in design which otherwise would not be possible.

"It should be pointed out that all new scheduled transport aircraft

are being built under the new Civil Air Regulations. The new performance requirements, especially those dealing with engine failure in the takeoff, enroute, and landing configuration, as well as many other new and stringent requirements with regard to stalling characteristics, control and stability and rate of climb, insure a standard of safety higher than anything even contemplated a few years ago. The aircraft industry participated in the development and analysis of these new requirements and endorsed their promulgation by the CAB.

"Technological advances in aircraft design during the last decade made possible the revisions that provide greater safety. They would



**NORTHROP AAF B-35 FLYING WING BOMBER**



CONSOLIDATED VULTEE XB-46 BOMBER

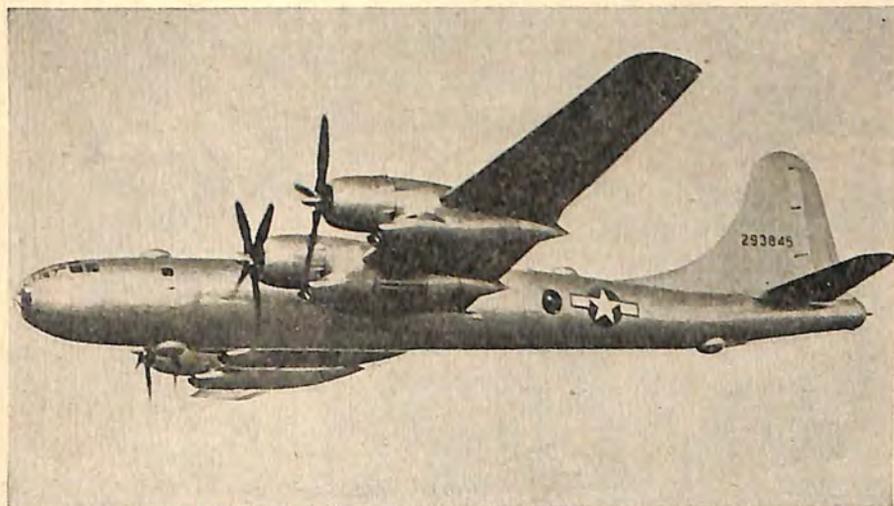
not have been possible of attainment a few years ago, and their adoption now is indicative of the great advances made by the aircraft industry during the war years. Following are some of the developments which are contributing to the greater safety of our transport aircraft. Each is the result of definite research and development programs on the part of the manufacturers.

“Tricycle landing gear—This development increases safety by reducing the piloting skill required in landing the airplane, reducing the possibility of veering off the runway (ground looping) because of its inherent directional stability on the ground, reduces the possibility of nosing over in a hard landing, allowing safer landings in strong cross winds, its inherent tendency to stay on the ground and quit flying once contact is made with the ground, improved pilot vision on ground because of nose-down attitude of airplane, dual wheels and tires on tricycle landing gear decreasing the hazard in case of a tire failure and increasing load distribution on airport runways and taxiways.

“Structural integrity—Advancements in structural design also are noteworthy. Airplane structures are becoming more efficient and more safe (1) because of the development of structural materials having greater strength per unit of weight or, what is commonly called, a higher strength-weight ratio, (2) because of more efficient design of structural materials such as use of tapered sheet and stringers which

permits the load-carrying material to vary uniformly with the stresses imposed by the air loads, and (3) because of advancements in analytical methods of design so that the strength of a wing or fuselage is known within a very few per cent. To insure that the design loading conditions—that is the assumed air loads—are realistic, the manufacturers, the NACA, Army, Navy and CAA are conducting studies and research requiring elaborate flight instrumentation to obtain aerodynamic data, airplane accelerations, time histories of maneuvers, and data on rough weather or gust loads. The almost unblemished record free from structural failures can be attributed to the years and years of painstaking engineering design and testing which every manufacturer puts into a new transport airplane.

“Pressurized cabins—Parallel with other rapid engineering advances, the manufacturers have developed pressurized cabins for maintaining air-crew efficiency and safety as well as passenger comfort. Pressure control, in the way of rate of climb and descent adjustment, is particularly important to the comfort of passengers in flight who may have respiratory infections and sinusitis. With such controls it will be possible to maintain in the cabin a rate of descent lower than that of the plane itself, and thus an actual rapid descent to an airport is minimized. Cabin pressurization enables the crew members to maintain an alertness and quick response which they lose to some extent when flying even at 8,000 feet altitude for a number of hours. An additional safety feature in aircraft pressurization is the ability of the



BOEING AAF XB-44 SUPERFORT



DOUGLAS DC-6 TRANSPORT

pilot, if he so desires, to fly above storms and normal atmospheric disturbances.

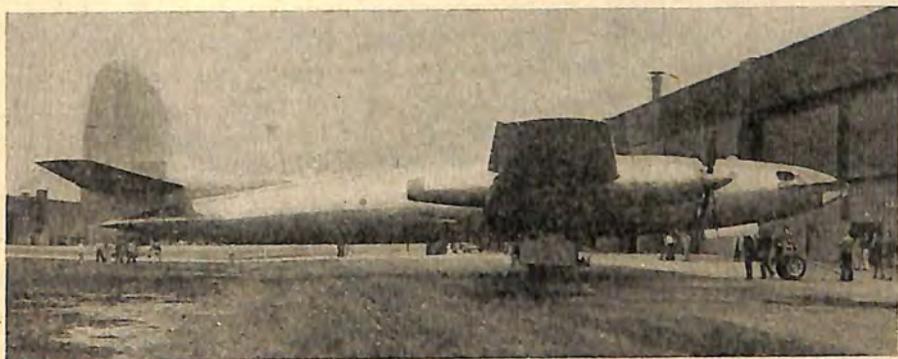
“Reducing pilot fatigue—The manufacturers have bent every effort toward arriving at a solution to the problems creating pilot crew fatigue. Aircraft design improvements that have been achieved which will reduce pilot fatigue materially are the following: (1) pressurized cabin, allowing advantages of altitude flying; i.e., smoother air, out of icing conditions, less instrument flying and greater terrain clearance; (2) decreased vibration and noise, reduction due to position of pilots with respect to propellers, improved soundproofing and better communication between crew members; improved heating and ventilation, air conditioning and humidity regulation, draft-free ventilation and uniform cockpit and cabin heating; roomier cockpit and flight deck, ease of crew interchange—getting in and out of seats, stretching and moving about, improved communication between pilots, more comfortable, more adjustable seats, installation of bunks for rest periods; improved visibility (window arrangement—window defrosting), less strain for pilots during restricted visibility conditions on final approach; improved stability, stalling and control characteristics, makes manual flying less tiring; division of responsibility, addition of flight engineer and navigator; greater safety due to four engines; increased wing loading, reduces rough air effect; more reliable wing and propeller de-icing, reduces mental strain; improved cockpit and instrument lighting; better instrument arrangement, and the improved auto-pilot which permits less manual flying.

“Fire prevention—The steps that have been taken to prevent the occurrence of aircraft fires are (1) In a continuous series of meetings with the CAA, CAB Safety Bureau and airline operators, the aircraft manufacturers participated in the development of more stringent fire

prevention regulations which will provide the basis for installation of extensive fire protection equipment and design features so that all probable sources of fire hazard are being eliminated; (2) The aircraft manufacturers established, approximately two years ago, an active fire protection subcommittee of their airworthiness requirements committee which undertook to study, on a continuous basis, ways and means of eliminating all factors which contribute or which may contribute to fires in aircraft. Fire reports from every possible source are being compiled and analyzed with respect to apparent cause, operating condition, hours on ship at time of fire, combustible medium, original location of fire, source of ignition and end result. From these, design recommendations have been developed and put into use by all manufacturers; (3) The industry's airworthiness requirements committee is participating in the CAA fire protection test program being conducted at its laboratory in Indianapolis; (4) The committee also is following the Army Air Forces' project in investigating the suitability of new types of fire extinguishing agents that were found in use by the Germans.

"Safer hydraulic fluid—A problem yet to be solved is the development of a non-inflammable hydraulic fluid. Upon the basis of what has been determined to date there is no acceptable non-inflammable hydraulic fluid available for use at the present time. However, the manufacturers have established a nationwide industry project which will coordinate for the industry the activities of the Army, Navy, CAA, NACA and other private research institutions to assist in and expedite the development of a suitable non-inflammable fluid.

"Cockpit and cockpit control arrangement—The simplification of



REPUBLIC ARMY F-12

cockpit arrangement with respect to instruments and controls required, as well as arrangement, is being continuously investigated to determine how the pilot's job can be made easier and under emergency conditions less subject to hazards from either mental or manual complex operations. The accumulation of instruments and control equipment in the four or more engine airplanes often has brought up the question of how much more complication a flight crew can handle and still perform its functions efficiently. There is strong hope that future development may provide simplification of multi-engine cockpits which will provide simpler operation than that now required for simple two-engine airplanes. This would be achieved by making certain controls automatic and by combining and integrating others. Developments have been proceeding for the last four years on a number of these simplifications, and there is reason to believe that they will be realized eventually. They are (a) Automatic cowl flap mechanism and also exhaust pumps which would eliminate conventional cowl flap operation look promising; (b) Automatic fire extinguishing systems; (c) Use of an automatic flight control which would correlate and integrate manifold pressure, propeller r.p.m., mixture and throttle setting in one control for each engine to give proper performance; (d) Development of a control means which would automatically feather an engine in the event improper r.p.m., manifold pressure or temperatures occur; (e) Development of an instrument which would correlate true indicated airspeed with fuel flow consumption and which, with adjustment of the various engine controls, would give the most efficient fuel consumption without following complicated procedures.

"Thermal anti-icing—A thermal anti-icing system, rather than the conventional rubber boot de-icer, soon will appear in our newer high performance transports as protection against icing of the wings, tail surfaces and propeller. This, we expect, will ultimately allow these ships to fly safely into extremely severe icing conditions while providing, at the same time, additional safety from improved airplane stalling and controllability characteristics and from increased rates of climb as compared to conditions with boot de-icers. There not yet has been sufficient experience with heat anti-icing systems to permit the establishment of definite design criteria for a completely satisfactory system, but there is every assurance that it is being adopted as rapidly as research data can be obtained and analyzed.

"Additional design safety features—Among other design safety features are the provisions for 1—Non-icing carburetor air induction systems to minimize danger of engine failure in cold weather flying;

2—Structural reinforcement and other design features which allow high degree of safety in emergency belly landings; 3—More than adequate emergency exits; 4—Dual wheels and tires on tricycle landing gear, decreasing the hazard in case of tire failure and increasing load distribution on airport runways and taxiways; 5—Windshields are being designed to withstand probable damage from bird strikes.

“Engines—The above are factors in the safe construction of aircraft. The same attention to paramount safety is true in the design, development, and manufacture of aircraft engines, propellers, instruments and accessories. The greatly increased power available in modern engines, with the aerodynamic advances in the construction of aircraft themselves, make possible the high speeds and the consequent greater safety of today's transports. An example of the complexity of modern engine design is provided by one company. This company is providing two types of engines for new transports. Both engines will be used in commercial operations for the first time this year. The cost of development of the two engines under discussion has been \$55,000,000. The time of running on the test bed totals approximately 95,000 hours on one and 25,000 on the other. To accumulate that much time, 23 experimental engines of each type have been employed over periods of 10 years for one and six years for the other.

“At one stage in the development of aircraft engines, bearing failures plagued operators. Now they rarely give trouble. Cylinder heads once gave considerable trouble. Development of better techniques by the manufacturer, among which has been forging instead of casting, has virtually eliminated this as a source of difficulty. Water injection was devised as a means of suppressing detonation and protecting cylinders from excessively high temperatures. In recent years methods of suppressing engine vibration have been developed which contribute greatly to the reliability of the propeller, accessories and the airplane supporting structure, as well as the engine itself. Tremendous strides have been made in improving the strength and durability characteristics of such vulnerable parts as valves, cylinders, pistons and rings which are subjected to high thermal stresses, as well as to other parts less likely to give trouble.

“Propellers—The industry in the last few years has developed the reversible pitch propeller, which, when it comes into full commercial service, will add greatly to the safety factor. It will permit reduction in the distance required to bring an aircraft to a stop. On icy runways, the use of conventional wheel brakes alone might cause skidding. Certainly they cannot be applied with impunity on ice. Reverse thrust will provide swift, sure air-braking. Vibration stresses in propeller

blades at one time were a source of considerable difficulty. Today, a blade must operate within clearly defined stress limits. Tuned ball dampers in the blade bore, shot-blasting processes and cold-working of applicable sections of the blade are among the developments utilized to provide this extra margin of safety.

"To achieve the full potentialities of commercial aviation, it is obviously necessary to improve safety to the utmost. I have already mentioned some of the efforts being made by the aircraft designers towards this end. I should like in conclusion to make some suggestions as to what might be done to achieve a really substantial improvement in safety in fields in which the Congress may have considerable influence.

"1—The development of airborne equipment for avoiding obstacles or collisions. Contrary to some popular thinking, there is no existing equipment, radar or otherwise, which really is suitable for this purpose. Reliability is not as good as it should be, constant attention is necessary, and the indications are difficult to read or interpret, or they are not sufficiently definite. Also, cost and weight are prohibitively high, except possibly for the largest airplanes. Much is being done by the airlines and the manufacturers, in close coordination with the efforts of the military services, toward the improvement of such devices but a good solution will take time, and will require the design, construction and trial of entirely new equipment. We recommend that the Congress give careful attention to the appropriation of sufficient funds to enable the military services and the CAA to underwrite a proper proportion of this development. The airlines cannot do it all, nor should they, for the Government's interest is substantial, even in the military field alone.

"2—The improvement of weather reporting. Here the problem at least is twofold, first the development of meteorological techniques and second the improvement and consolidation of weather reporting systems. The Government has a distinct part to play in both these elements of the problem and we would recommend that this Committee take testimony from those competent to discuss this matter, before concluding its hearings.

"3—Air navigation and traffic control aids. This subject has been so thoroughly covered in previous testimony that little of value can be added except to say that whatever the differences of opinion of the past may have been there now is substantial agreement as to what equipment should be adopted. There is a program, and it is now a good one. It needs to be supported and carried out as promptly as possible. Further study will resolve the remaining technical questions,

and it is intensively being carried on, but the all-important thing is to begin to get substantial experience with these various devices in actual commercial operation. This can be done without introducing any hazard even in the introductory stage and it must be done before ultimate proof can be obtained as to relative utility and as an essential part of planning for the future.

"Provision of the requisite funds for this work is necessary if we as a nation are to realize upon our vast opportunity in the air. The other nations of the world are eager to take leadership in the air from our hands if we show any signs of relinquishing it. Failure to provide for a consistent program of development of these navigation aids or the adoption of hasty and ill-advised regulatory reforms is a good way to stultify our growth and turn the leadership over to our competitors."

The United States came into the jet propulsion picture in June, 1940, with a special report to the Navy on the aircraft gas turbine prepared by the National Academy of Science, although this had been preceded by some informal, preliminary work at the Air Corps Power Plant Laboratory, Wright Field. About the time of Gen. H. H. Arnold's visit to England in April, 1941, which resulted in the American program for the development and production of the Whittle-type turbojets featuring a centrifugal compressor, the National Advisory Committee for Aeronautics recalled Dr. William C. Durand from his retirement in California to head up a Gas Turbine Committee, which was formed in the early summer of 1941. At its first meeting the Committee assigned to General Electric Company the development of an axial-flow gas turbine for propeller drive (turboprop), which was designated TG-100. It also assigned to Westinghouse Electric Company an axial-flow gas turbine for jet propulsion (turbojet), which later became the 19B Yankee, with 8-stage axial compressor. Both projects were begun before the end of 1941. Earlier in 1941, Northrop Aircraft Company had begun work on a turboprop with a 17-stage axial compressor, the Turbodyne. Lockheed Aircraft Corporation was given a contract by the AAF to develop the L-100 turbojet, and this was completed by Menasco, with a larger unit, the L-4000, ready for bench tests early in 1947. Although designed for military fighter and bomber installations, it was suitable for large commercial transports. Lockheed had an option on the first 250 commercial models. Menasco's jet powerplant prime contracts totaled over \$2,400,000. Wright Aeronautical Corporation, United Aircraft's Pratt & Whitney Division, and the Allison Division of General Motors also were given development contracts for turboprops, and later for turbojets. Early in 1947, Wright had a model of each type ready for testing. Those projects

were independent of British developments. However, after Gen. Arnold's return from England, where he had seen the Whittle turbojet-powered Gloster E/28 fly, and was taken behind the scenes in other developments, a special, high-priority jet program in collaboration with the British was begun. Wright Field, General Electric, Bell and Lockheed cooperated. The Whittle-type I-16 (1,600 lbs. of thrust) and the I-40 (4,000 lbs., initially 3,750) were developed, and those units became the power plants of various AAF and Navy fighters. The Bell P-59A took two I-16's, and the Ryan FR-1 Fireball and the XF2R-1 had the I-16 as tail booster units. The I-40 powered the Lockheed P-80A Shooting Star. Two were in the Bell XP-83, and it also was used as the tail unit of the Consolidated Vultee XP-81. Allis-Chalmers was given a contract to produce de Havilland turbojets, turning out seven of the H2-B (similar to the British Goblin), and the company in 1947 had a turbojet of its own design.

From August, 1941, to the end of 1945, the British made all their knowledge of aircraft gas turbine developments available to the U. S. Government. From October, 1941, they actively assisted General Electric to get into early production a jet unit of the Whittle type. Close collaboration continued as GE designed the I-16 and I-40, and as Rolls-Royce (picking up the ball from Rover) went on to the Welland, Derwent and Nene turbojet engines (named for English rivers), and de Havilland developed the Goblin and Ghost. All five were Whittle types. Information flowed freely in both directions, and some of the General Electric details were adopted by the British. The technical data on the Whittle-type engines supplied during the war was on the understanding that the information would be used by American firms for war purposes only. This agreement was meticulously carried out, and negotiations for the peacetime use of the patents involved were completed by the end of 1946.

In 1945 General Electric's gas turbine design team at Schenectady, N. Y., began the development of their own through-flow turbojet with 11-stage axial compressor, the TG-180 (4,000 lbs. of thrust) and Westinghouse began work on a larger model than the 19B, the 24C (3,000 lbs. of thrust). The 19B had been tested meanwhile as a tail unit of a modified Vought Corsair fighter, and in a JBM, Navy version of the Martin B-26 Marauder. As the 19XB-2B, the Yankee early in 1947 was in production at Pratt & Whitney as power plant for the twin-jet McDonnell FD-1 Phantom carrier fighter. The 24C powered the Chance Vought XF6U-1 Pirate, the Grumman XTB3F-1 torpedo bomber and other Navy fighters and bombers. It also was specified as the power plant of the McDonnell XP-85 and XP-88.

The General Electric TG-180 (J-35) was test-flown in the Republic XP-84 Thunderjet in February, 1946, and in the Douglas XB-43 twin-jet bomber in May, 1946. It was the power plant of the North American XFJ-1, test-flown in October, 1946. That was the Navy's counterpart of the AAF XP-86. The J-35 also powered the Curtiss XP-87, advanced Northrop, Lockheed and Republic experimental jet fighters. It also powered the Curtiss XA-43 attack bomber, the XB-45, XB-46, XB-47, XB-48 and XB-49—multi-jet heavy bombers developed by North American, Consolidated Vultee, Boeing, Martin and Northrop; also some of the new high-speed medium bombers, and the Douglas Navy D-558 Skystreak transonic plane.

Since mid-1945 all I-40 production had been at the Allison plant as the J-33, under a new nomenclature used by the AAF, with J- for turbojets, and T- for turboprops. The J-33-4 was rated at 3,850 lbs. of thrust. All engineering and future development, as well as production, of the J-33 was to be done by Allison, and that company had made a number of substantial improvements in both production and design by early 1947. The J-33-17 model had passed the 100-hrs. type-test, and the improved J-33-21 version underwent the A-N 150 hrs. test early in 1947, a test which had the same endurance standards required for reciprocating engines. A greatly improved turbojet, the J-33-19-AL, was lighter in weight and was expected to produce over 4,500 lbs. of thrust, with more economical fuel consumption. Allison also was busy with its own designs, including a series of turboprops in the 5,000 to 8,000 s.h.p. class.

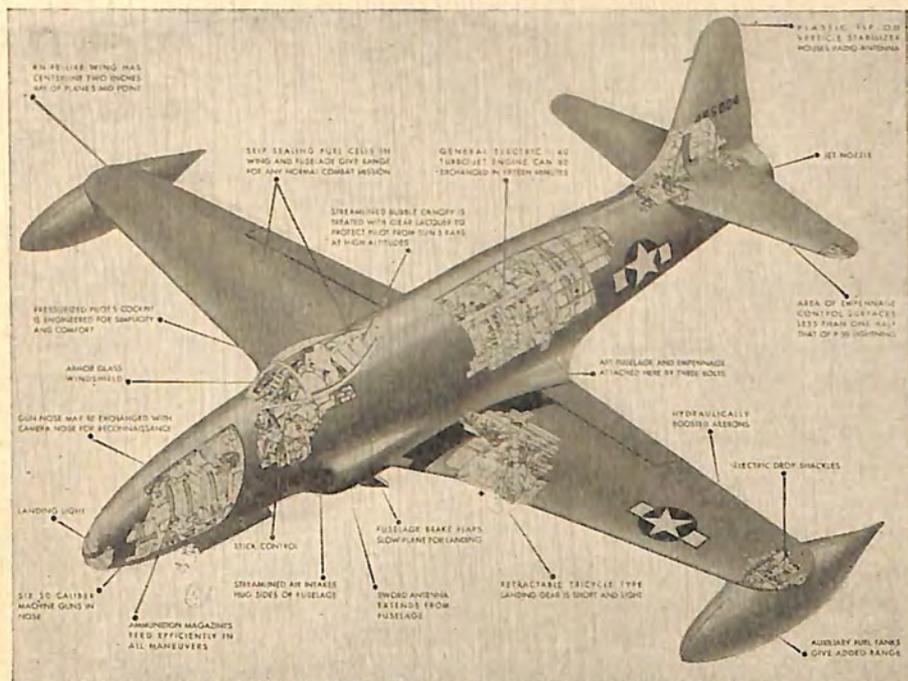
During the early part of 1947, production of the General Electric TG-180 was transferred to Allison as the J-35, including plant equipment and machinery from the Chevrolet Tonawanda, N. Y., factory, set up for TG-180 production during the last months of the war. General Electric continued development of the TG-180 and also development and production of the TG-100 turboprop (now T-31), power plant of the Consolidated Vultee XP-81 (J-33 in the tail), the Ryan XF2R-1 (I-16 or J-31 in the tail), and projected for the Martin 304 transport for United Air Lines. A more powerful version of the TG-180 axial flow turbojet was under development at General Electric. Thus, at the end of 1946, production of American aircraft gas turbines was confined to Allison, General Electric and Westinghouse. On the development front, besides those three, many others were in the picture. They included Wright Aeronautical, Pratt & Whitney, Menasco and Northrop-Hendy. General Electric had begun a 2-year expansion program for its Aircraft Gas Turbine Division at Lynn, Mass., including a new laboratory for testing components and in-

creased production facilities for jet engines of advanced design. Production capacity was a total of 75 aircraft gas turbines a month on two or more models. Packard Motor Car Co. had an extensive aircraft gas turbine division with development facilities at Toledo, O., including a new laboratory scheduled for completion by June 1947, and a flight testing center at Willow Run. A new turbojet engine, reported to be based on the de Havilland Goblin, for aircraft and guided missiles had passed factory tests. Another element in the American jet propulsion picture was the Taylor Turbine Corporation, New York, who had a sales agreement with Rolls-Royce for production of their aircraft gas turbines in the United States. Under Taylor auspices, a Rolls-Royce Nene I had passed the 150-hrs. type test at the Navy Air Materiel Center, Philadelphia. Navy engineers were planning installation of a Nene in a new Grumman carrier-based jet fighter. Taylor Turbine also sent a Derwent V to Wright Field for similar tests by the AAF. That was the turbojet which powered the British Star Meteor in a speed record. A key unit in gas turbine research was the National Advisory Committee for Aeronautics Aircraft Propulsion Laboratory in Cleveland, which had concentrated increasing effort on jet power.

In 1944 the Aeronautical Chamber of Commerce of America (now Aircraft Industries Association) organized a Jet and Propeller Turbine Committee, which functioned as a Subcommittee of the main Engine Technical Committee. It was formed for the purpose of developing recommended Army-Navy design, procurement and test specifications for turbojet engines, with preliminary proposals discussed for similar turboprop requirements. It comprised representation from General Electric, Westinghouse, Allison, Wright Aeronautical and Pratt & Whitney. First results of the Committee's work appeared late in 1945, when it was called upon to review proposed drafts of a joint Army-Navy turbojet specification which was prepared as a result of the Services' review of the original industry proposals.

As interest in this activity grew, the membership of the committee, which had been renamed the Gas Turbine Requirements Committee, was expanded to include additional members from Packard Motor Car Company, Chrysler Corporation, deLaval Steam Turbine Company and Menasco Manufacturing Company. For certain special discussions technical men from Frederick Flader, Inc., Northrop-Hendy Aircraft Company and Allis-Chalmers Manufacturing Company participated. DeLaval was engaged on a design study of an advanced turbojet. Flader had a turboprop under development. Besides those companies which had development or production contracts for com-

plete aircraft gas turbines, several others were taking an important part in the program. Thompson Products, for example, built no complete jet engines, but it made three basic, high precision components—the air compressor, the turbine wheel and the diaphragm, which accounted for over half the cost of a jet engine—and supplied one or more of them for over 90 per cent of this country's jet projects. For example, the 11-stage axial compressor of the TG-180 contained 1,800 small blades, made from a special heat-resistant alloy, each of which must be perfectly forged, polished, curved and capable of withstanding a centrifugal pull of 30,000 lbs. per sq. in. at red-hot 1500° temperatures. Thompson Products backlog of aircraft gas turbine components was over fifty million dollars. Ryan Aeronautical Company had a Navy contract for metallurgical research on new high heat-resistant alloys for jet power plants. It also made components for current production units. The Steel and Tube Division of the Timken Roller Bearing Company developed the stainless steel, 16-25-6, used in the turbine wheels of aircraft gas turbines. Haynes Stellite Company, a



LOCKHEED ARMY P-80 SHOOTING STAR

unit of Union Carbide and Carbon, developed Hastelloy, a high-strength, nickel-base alloy for resistance to extreme heat, and also made parts for jet engines. It was the development of those metals which made possible the use of the aircraft gas turbine, impracticable only a few years previously. The aircraft gas turbine industry in the United States was developing at a rapid and accelerated pace. The great effort early in 1947 was concentrated on building prototype engines for endurance and acceptance testing, analysis of new and higher performance units, and review of the performance, maintenance and overhaul aspects of turbojets and turboprops in actual operation. The industry was confident that the next few years would produce very tangible results in higher power, fuel economy and endurance.

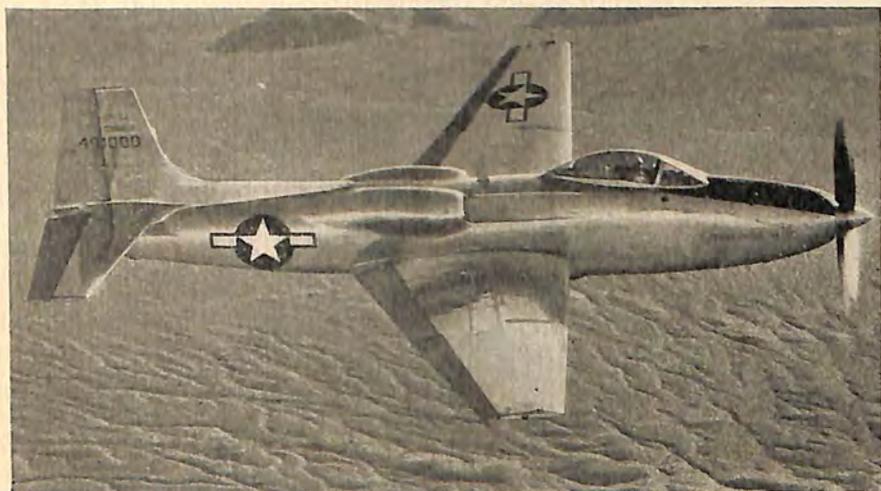
The National Advisory Committee for Aeronautics, in response to the editor's request for comment in this edition of *The Aircraft Year Book*, had the following to say about current NACA research in aerodynamics: "The tremendous power made available for aircraft propulsion by the development of the various forms of jet engines has brought aerodynamics to the threshold of sonic speed and its attendant difficulties. As the speed of sound is reached by the air flowing over an airplane wing, a shock wave is formed which creates tremendous drag increases and loss of lift. This speed may be reached over the thickest part of an airfoil long before the airplane itself attains sonic speed, and compressibility difficulties may begin at speeds as low as 400 miles an hour. There has been accumulated a large body of knowledge on supersonic speed, largely through the study of artillery missiles and exterior ballistics. Since the airflow is normally stable in the supersonic regime, good fundamental theory and accompanying mathematical tools are available for the solution of problems. The major aerodynamic problem of current concern in 1947 was the transonic zone, in which both subsonic incompressible flow and supersonic compressible flow exist. There was no fully developed mathematical theory for this mixed flow condition and it, therefore, occupied the major attention of the NACA aerodynamics research program.

"Several solutions show promise in the reduction of drag in the transonic zone: extremely thin wings with a thickness of only 8-10 per cent of the chord, swept wings extending either forward or rearward from the fuselage and low aspect ratio wings with short, stubby planforms. Although all these delay the onset of shock waves and minimize their effect after their appearance, recent tests show these wings possess very poor stability at slow speeds, such as during takeoff and landing. Stability and control problems of transonic airfoils, therefore, comprise a major portion of NACA aerodynamic research.

"The next problem, in importance, is maintenance of adequate lift by transonic and supersonic airfoils, which must be designed primarily for their low drag characteristics. Various methods for increasing the lift of these radical double wedge and circular arc profiles are being investigated. The use of nose and trailing edge flaps, various forms of boundary layer control, wing heating devices and smooth skin construction are undergoing intensive research.

"Many problems of jet power plants are fundamentally problems of air flow. Research into internal flows, air intakes, compressor and turbine blade design, nozzles and combustion chamber configurations has become purely aerodynamic research.

"Because of the formation of shock waves which choke the tunnel in the region of the model and cause shock waves to bounce between the walls and model, it has proved impractical to obtain dependable data from wind tunnel tests in the immediate vicinity of the speed of sound. The NACA, therefore, has developed a number of alternative test methods for obtaining lift, drag and pitching moment data at sonic speed: the free fall method, the rocket missile method and the wing flow method. By dropping heavily weighted and carefully streamlined bombs from a Boeing B-29 at altitudes up to 40,000 feet, the missiles quickly attain the speed of sound. Through the use of telemetering equipment installed in the bombs in addition to radar and optical tracking devices on the ground, the drag of the streamlined



CONSOLIDATED VULTEE AAF P-81

body may be accurately measured through the speed of sound. In the rocket method, standard military rockets are equipped with tiny airfoils extending laterally from their body and carefully instrumented on the interior of the rocket to telemetering equipment. The rocket is then fired out to sea from the carefully guarded Pilotless Aircraft Research Station of the NACA off the Virginia Capes, and data is obtained on the characteristics of the attached airfoil. By careful design as many as six or eight airfoils may be tested simultaneously in a single flight. A third method of procuring sonic data makes use of the fact that air is accelerated as it moves over the upper curve of an airfoil. Thus, sonic speed may be obtained over the thickest part of an airplane wing while the airplane itself is traveling at a speed as low as 500-550 miles per hour. NACA scientists mount tiny airfoils vertically on the upper surface of a North American P-51 Mustang wing and, by diving the plane at high altitudes, sonic speed is obtained across the model airfoil. Instrumentation leading from the airfoil to fuselage recording equipment permits an accurate record of the characteristics of the airfoil at sonic speed. In addition, tiny control surfaces are mounted on the trailing edge of the model airfoil and data on the effect of moving the control surface of an airfoil at sonic speed is obtained.

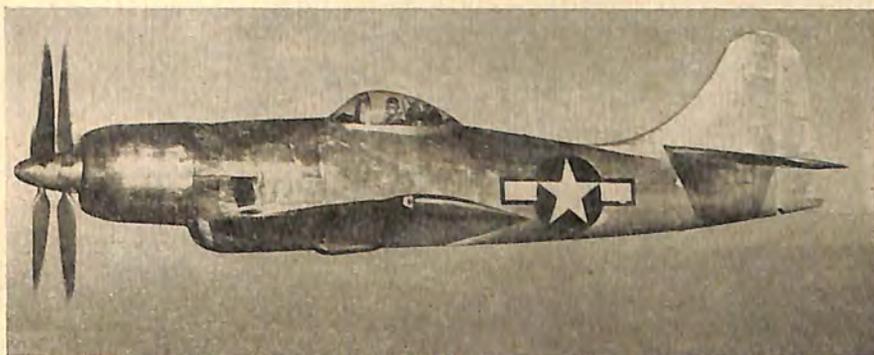
"The NACA currently has being built for it, through the cooperation of the Army and Navy, research airplanes capable of flying in the transonic speed range. It appears reasonably certain that before very long the NACA will be making systematic flight investigations in the supersonic speed range. However, the comparatively simple achievement of supersonic speed is not a consideration in the NACA program. The purpose of these special research airplanes is to provide scientific investigation, under carefully controlled conditions, of the effect of piloted flight at sonic and supersonic speed on stability and control, structural strength, power requirements and operating conditions of aircraft. The aircraft now under construction are designed to provide accurate quantitative data on the effectiveness of thin wings, swept wings, airfoil profile, dihedral (both positive and negative), various forms of propulsion, control stick force, vibration and flutter, pilot escape, skin friction heating and flying qualities of aircraft at extremely high speeds.

"Following completion and acceptance flight tests for the procuring service, each of the airplanes will be turned over to the NACA for an extensive flight research program. These programs are not decided in elaborate and final form in advance. As each phase of the flight test of a particular configuration is completed, the data obtained are carefully

analyzed before the next phase is initiated. The entire program, in its present form, centers about a careful feeling out of the airplane at small increments of speed. As difficulty is experienced, changes will be made in the airplane as indicated until a thorough record of piloted flight at sonic speed and through the difficult transonic zone is obtained. These findings will then be made available to industry and the military services for incorporation into the design of service types suitable for safe and effective flying, combat and transportation at supersonic speed. That this program is of critical importance is seen in the fact that until such fundamental data are obtained, the industry and the services cannot proceed on a sound basis with the design and evaluation testing of aircraft intended for flight at these speeds.

"The successful introduction of jet propulsion of aircraft has ushered in an entirely new era in aeronautical science. At the moment there appears to be no foreseeable limit to the amount of power that can be made available for the propulsion of aircraft. The miracle of jet propulsion lies in its inherent characteristic of increasing power with increasing flight speed together with increased efficiency and reduced fuel consumption.

"Most promising new form in this field is the ramjet engine, which has not a single moving part. There is now under investigation at the Aircraft Engine Research Laboratory of the NACA a ramjet engine 20 inches in diameter and weighing only 400 pounds that is capable of producing the equivalent of 20,000 horsepower at a flight speed of twice that of sound about 1,500 miles per hour. The tremendous power and efficiency of this simple engine is made possible by the ram effect of air entering the nose intake at tremendous speed, resulting in its compression in a ratio of about 8 to 1 with no expenditure of power



BOEING XF8B-1 FIGHTER

as in the reciprocating engine. Higher speeds will provide even greater compression of the air resulting in increased power output. Thus, when supersonic speed aircraft are available, the power plant is available for propelling them at any practicable speed.

"Improvement is being made constantly in the familiar turbojet engine, and a recent development of NACA research is the application of water injection and after-burning as methods of thrust augmentation. By introducing a mixture of water and alcohol into the compressor, thrust increases of the order of 25 per cent have been obtained. The water acts as a coolant, thereby permitting higher combustion temperatures resulting in the increased thrust. The alcohol is used merely as an antifreeze for high altitude operations. The tail pipe after-burning method involves the injection of fuel into the tail pipe of the turbojet engine and its combustion aft of the compressor stage. This method provides increases of about 40 per cent in sea level static thrust and as high as 90 per cent additional thrust at high speed. Major problem, however, is the tremendous fuel consumption created by this after-burning, and its use is expected to be reserved for emergency use such as during takeoff, when the run may be reduced 40 per cent, and for high speed acceleration at high altitudes under combat conditions. Further research is under way on these two methods as well as other forms of thrust augmentation.

"Due to the fundamental nature of its research program and the applicability of its research findings to all aircraft, regardless of type or size, NACA data obtained through its wartime research on military aircraft has broad application to lightplane design. To simplify the application of these data to lightplane problems, an NACA-industry conference on personal aircraft research was held at the Langley Memorial Aeronautical Laboratory in 1946, and 21 papers were presented by NACA engineers. These dealt broadly with such problems as flying qualities, stability and control, safety and spinning, wing design, propellers (including noise reduction), drag clean-up, aircraft loads, seaplanes, power plants and new research problems.

"As a practical example of what might be accomplished toward increasing the safety of the lightplane, a program was conducted by the NACA during 1940 and 1941 towards this end within the basic requirements that modifications be held to a minimum and suitable for incorporation on production airplanes with a minimum change in production tooling required. As a result, a standard lightplane was rendered incapable of spinning through very minor modifications to the wing, tail and propeller thrust line. These recommendations were provided the lightplane industry for their guidance.

"Another important contribution of the NACA to the lightplane field is development of a fundamental theory of propeller noise propagation and the suggestion of methods through which this source of noise, which constitutes about 90 per cent of total airplane noise, might be substantially reduced. Through the use of a fan-type, multi-blade propeller, an engine-propeller combination can be produced that is virtually inaudible from a distance of 300 feet.

"The NACA is continuing its investigation of gust loading and accompanying structural problems of aircraft. The combination of increasing weight and mounting speed of aircraft has placed gust loading in the structural picture as the determining factor in the design of aircraft. The NACA gust loading research program has extended over the past decade and comprises an attack on the problem from several avenues of approach. First step was the development of the NACA V-G recorder, a small instrument which provides a continuous record of the vertical acceleration of an airplane in flight. These recorders were installed in numerous transport planes operating across the nation, both oceans and through South America, with the result that a complete record of gust intensity encountered in normal scheduled airline operation was obtained. Second step was the instrumentation of a special research airplane, the Lockheed XC-35 stratosphere plane, and an extensive flight program involving flights directly into thunderheads and turbulent air conditions. This instrumentation provided extensive records of the structure of gusts, including their intensity, direction and acceleration, methods of formation and frequency of occurrence in specific weather formations. This study is being continued currently in collaboration with the U. S. Weather Bureau, the Army Air Forces and numerous others. Operational headquarters is in Florida.

"Parallel to these flight investigations are the studies in the unique NACA gust tunnel at the Langley Laboratory, which provides vertical currents of air under carefully controlled conditions of intensity, direction of application and model speeds. Models are fired from a catapult across the face of this vertical air current while a motion picture record is made of the change of flight path, and instrumentation within the model records the application and stress about the model structure. In this manner, the effect of gusts on aircraft structures may be carefully examined.

"Aircraft icing is another serious operating problem which the NACA is investigating through several different methods. A specially equipped airplane is currently flying throughout the northwest area continually seeking icing conditions which, oddly enough, have proved

difficult to find with consistent regularity and intensity. The airplane is equipped with such special equipment, developed by the NACA, as exhaust heat de-icing utilizing the hollow leading edge of the wing, electric de-icing equipment, special ice-free carburetor air intake ducts and numerous other such items of equipment, including complete instrumentation for obtaining accurate quantitative data on the effectiveness of these various devices. These flight tests supplement wind tunnel investigations in the icing research tunnel at the Aircraft Engine Research Laboratory in which combinations of altitude, temperature and humidity conditions may be carefully controlled."

Probably the most powerful experimental reciprocating aircraft engine in the world was the AAF Lycoming XR-7755, developing 5,000 horsepower at 2,600 r.p.m. for takeoff and 4,000 horsepower at 2,300 r.p.m. for continuous operation. It was a 36-cylinder, single crankshaft, liquid cooled, radial type with cylinders in four rows of nine each, a total piston displacement of 7,755 cubic inches. It was the result of experimental work started by Lycoming engineers in cooperation with the AAF Materiel Command at Wright Field in 1932. Progressively larger models were developed, along with essential expansion of laboratory and test stand facilities. The XR-7755 was started late in 1943, and it was completed in July, 1946. It was 10 feet long and five feet in diameter. It weighed 6,050 pounds. Its power was greater than the average railway steam locomotive 90 feet long, 15 feet high and weighing 670,000 pounds. The AAF described the XR-7755 in further detail, as follows: "Being liquid cooled, it is necessary that this engine have a pump to circulate the coolant through the labyrinth of passages to carry away the vast amount of heat dissipated through cylinder heads and walls. While operating at take off speed and power, this heat dissipation amounts to approximately 95,600 BTU's per minute (2,250 h.p.), requiring that the pump be capable of circulating the coolant at a rate of 750 gallons per minute. This is equivalent to the output of the average fire engine, or would fill an 8,000 gallon tank car in approximately 10½ minutes. In order that oil may be supplied to the many parts needing lubrication, and in sufficient quantities, the oil pressure pump has a capacity of 500 pounds per minute which is equal to 71 gallons per minute at an outlet pressure of over 100 pounds per square inch. Heat generated by friction and part of the heat rejected from the combustion process is absorbed by this oil and carried away from the engine to the oil cooler. At the maximum power of the engine, this heat rejection is at the rate of 25,500 BTU's per minute (600 h.p.) or enough to heat a large hotel or apartment building. Another pump located in the re-

duction gear unit increases the pressure from 100 pounds per square inch to 300 pounds per square inch for the operation of the hydraulic shifting mechanism. When operating at maximum speed and power, this AAF engine will consume gasoline at a rate of approximately 580 gallons per hour. If this rate of consumption were maintained for an hour, the same amount of gasoline would operate the average automobile for a period of one year, or over 10,000 miles. Since economy of operation was one of the primary objectives, the design of this engine incorporates several unique features. The propeller drive is through a two speed dual rotation reduction gear, either ratio of which can be used at the pilot's discretion to obtain maximum propeller efficiency." The AAF reported that facilities existed in 1946 for testing reciprocating engines in excess of 7,000 horsepower.

As part of its comprehensive research program to exploit former enemy aeronautical developments, the Air Materiel Command's Technical Intelligence agency was using the services of some 86 top-flight German aviation scientists of World War II. Working side by side with American military and civilian aeronautical engineers in the laboratories of Wright Field, these German experts were being used, as were tons of captured enemy materiel, documents, blueprints and microfilm, to save American engineers the time they would devote to problems already investigated by the Germans. Their knowledge also helped the Americans to catch up and improve upon Germany's wartime advancement in such phases of aeronautical developments as rocket and jet power. Similar groups of former enemy technicians were employed in other parts of the country by various branches of the armed forces. At Fort Bliss, Texas, one group was working in connection with research on German V-2 rockets and other guided missiles. Others were working with the Army ordnance and engineer experts, and still others were working for the Navy in several fields of applied war research and development.

Among those in the German group at Wright Field were Rudolph Hermann, Alexander Lippisch, Heinz Schmitt, Helmut Heinrich, and Fritz Doblhoff and Ernst Kugel. Hermann was attached to the Peenemunde Research Station for Aerodynamics, where Germany's V-2 rockets were hatched and launched against England. A specialist in supersonics, he was in charge of the supersonic wind tunnel at Kochel in the Bavarian Alps. He also was a member of the group entrusted with Hitler's futuristic plans to establish a space-station rocket-refueling base revolving as a satellite about the earth at a distance of 4,000 miles—a scheme which he and certain high-ranking AAF officers in 1947 still believed to be feasible. At Wright Field, Hermann was

working in the field of supersonics. Doblhoff was the inventor of the German jet-propelled helicopter, known as the V-4. Technical Intelligence engineers believed that the V-4 might contribute substantially to the development of rotor-blade aircraft. The V-4 was the fourth and last in a series of experimental helicopters built by Doblhoff at Weiner Neustadt, Austria. The first two models never were flown and the third, a one-place V-3, crashed. Figured on the basis of five reichsmarks per dollar, the cost of research and development of the V-4 was nearly \$100,000 and construction cost about \$3,200. Study of the V-4 showed that the aircraft had such features as freedom from torque, elimination of a transmission system, and excellent hovering performance. The exhaust from a jet engine, piped to the blade terminals, revolved the rotor blades in the V-4. Thus it could hover, ascend or descend. Tipping the tail elevators gave the helicopter forward speed. It could cruise at speeds up to 25 m.p.h., and with the addition of another propeller for forward thrust, engineers believed increased speed would be attained.

Lippisch, a noted glider designer before the war, for such companies as the Research Institute of the Rheon-Rositten organization and the German Experimental Glider Institute, was head of the Research Institute for Aviation in Vienna when Germany capitulated, specializing in flying wings, swept-back wing models and high speed planes. His work with the Messerschmitt Company, Augsburg, from 1939 to 1945, led to the development of the Me-163A and 163B, known as the Comet, first fighters ever powered solely by rocket motors. At Wright Field he was helping technicians in preparations for scheduled flight tests of the captured rocket fighter. Postwar American craft of this type also were scheduled for testing in 1947. An interceptor, the Me-163, was used by the Luftwaffe in the latter days of the war. It was reported that the plane could attain a speed of 620 m.p.h. with ability to climb 30,000 feet in three minutes. Associated with Lippisch in the Me-163 tests at Wright Field was Rudolph Opitz, first German airman to fly the plane in combat and a veteran of 150 flights in it.

Other German equipment being investigated at Wright Field was the Walther rocket motor which powered the Me-163 and the BP-20 Viper, another type of rocket-propelled craft intended by the Germans for use as a ram against invading bombers. That motor contributed much to the wartime efforts of the Germans to attain transonic speeds. Although the weight of the motor was only 365 pounds, it developed a maximum thrust of 3,300 pounds at sea level. Unlike reciprocating and turbo-jet engines, the liquid rocket motor gave increased effective thrusts at high altitudes. This was possible because it carried the re-

quired oxygen, while conventional engines had to take their oxygen from the air which afforded a diminishing supply with higher altitudes. The two fuels employed in the Walther motor, named T-Stoff and C-Stoff, gave an impulse of 180 to 190 pounds at a consumption rate of one pound a second. To express the consumption rate in pounds per hour for each pound of thrust, the figure for the Walther motor was 19 to 20 pounds as compared with 1.3 to 1.5 pounds for current German turbo-jet units. This endurance was sacrificed for speed. T-Stoff was concentrated hydrogen peroxide and C-Stoff a mixture of hydrazine hydrate and alcohol. At full thrust the rate of consumption was about 17.75 pounds a second, or more than 1,000 pounds a minute. The BP-20, although not known to have been used operationally in the West European theater, could have been a formidable interceptor. Conceived by a Dr. Bachem, formerly with Messerschmitt, the Viper was almost wholly an expendable craft, being made of wood and other cheap materials. Practically a suicide plane, it nevertheless gave the pilot a chance for his life, being equipped with an ejection system with parachutes for pilot and motor. Shot from a rocket platform, the pilot was to guide his craft toward an invading bomber formation, maneuver within range, fire his 24 rockets, press the ejection control, jettisoning the plane's nose, then descend, while the engine dropped some distance away. Critical altitude was around 37,000 feet.

Dr. Heinz Schmitt, a jet engine expert, was largely responsible for the success of the Jumo 004 turbo-jet engine, probably the most widely known of all the various types of jet and rocket-propulsion units currently being examined at Wright Field. The Jumo 004, manufactured by Junkers, was used in the Me-262 jet fighter, one of Germany's fastest operational planes. The Me-262 still was undergoing standard evaluation tests, and any valuable findings were to be distributed to accredited manufacturers and institutions. The Me-262 was qualified for fighter, fighter-bomber, ground attack or reconnaissance duties. However, the Germans used it mainly to draw off Allied escort fighters in order to expose bomber formations to attack by the slower Me-109 and the FW-190 interceptors. The merits of the Me-262 could be summed up in its speed, climbing ability and heavy armament. In level flight, the plane attained a speed of 515 to 550 m.p.h. It cruised at 465 m.p.h. and could dive from 620 to 650 m.p.h. It had a climb rate, at 25 to 30 degrees, of 5,000 feet a minute. It had a service ceiling of 38,000 feet and its critical altitude was 45,000 feet. Its formidable armament consisted of four fixed 30 mm. MK 108 automatic guns grouped in the nose with a group firing rate of 375 to 600 rounds a minute.

Ernst Kugel, who was technical director of the Alfred Schloemann Co. in Germany, a firm specializing in heavy machinery for rolling mills and hydro-electric presses, was at work at Wright Field helping American technicians in the sorting and rearrangement of detail drawings of a 30,000-ton hydraulic die press which he had designed for I. G. Farben and with which the Germans pressed out propeller blades and other vital aircraft components during the war. Five times more powerful than the largest similar American press, the big German press could turn out 1,940 32-foot wing-spar flanges or propeller blades in 24 hours. Wing-spar flanges were the strongest lengthwise supports of the wing frame. Thousands of detail drawings of the 30,000-ton and other large presses were seized in Germany, but because of their state of disorder none was available early in 1947. Working with Kugel on the press drawings were Alberts, Bottenhorn, Krause and Nehlsen, all engineers recruited from Germany. The largest American die presses in general use were listed as of 6,000-ton capacity. Larger ones were under experiment, and one concern anticipated success with an 18,000-ton press. It was not considered feasible to move the heavy German presses to this country. Data on the big German presses being analyzed at Wright Field were to aid in determining whether claims of faster, cheaper and more efficient production were justified. Such presses cost heavily in money, time and precious materials. The estimated total cost of the 30,000-ton press was \$2,000,000, the foundation alone costing \$200,000. The big press weighed 4,800 tons. A similar German press, which could exert a pressure of 15,000 tons, weighed 1,800 tons. Fortunately, adequate drawings and operating techniques of the 15,000-ton press were available, and those details, similar in many respects to those of the larger press, were being used by Kugel and his colleagues in their reassembly of the 30,000-ton press drawings.

A ribbon parachute, which German aviation technicians claimed could take a plane out of a spin, or withstand the sudden jerk of a 2,500-pound mine dropping at 600 m.p.h., was another enemy development under study at Wright Field. Considered to be a major improvement in the development of equipment used for flight at near sonic and transonic speeds and extreme altitudes, this "parachute with holes" was developed by a large staff of German scientists and engineers under the supervision of Helmut Heinrich, formerly of the Graf Zeppelin Research Institute, Stuttgart. In 1945, Heinrich, as a research engineer for the AAF, began developing and testing special high speed ribbon parachutes. The ribbon parachute was used by the Germans for several purposes, as a brake for jet and rocket aircraft

and gliders; a load chute for dropping mines, bombs, and supplies; an auxiliary lift device for heavily loaded conventional planes; and as a salvage chute for pilot ejector seats and other valuable equipment. The chute enabled fighter pilots to employ extraordinary diving maneuvers. One chute attached to each wing tip would stop a spin or slow a crash-bent plane sufficiently to eliminate danger to the pilot as he bailed out of the disabled plane.

In order to break down the language difficulties in deciphering captured German documents, prominent educators were working with the AAF in compiling a new 75,000-word German-English dictionary intended to clarify German aeronautical terms and phrases. Supervising the project was Dr. Kurt L. Leidecker, on leave from the Behr-Manning Corporation and Rensselaer Polytechnic Institute, where he was assistant professor of modern languages and instructor of scientific German. Nearly half the contents of the new dictionary were to be new words. The Germans had nazified aeronautical terms formerly having classic roots, and had coined many new terms not found in any existing dictionary. Material for the dictionary was being extracted from broken enemy codes and from 250 tons of captured German air documents. Considerable value was attached to the widely heralded German ZWB (Central Organization for Scientific Reports) Index which contained important scientific documents. Included were many of the newer aeronautical terms and some applications of older words, which served as an aid to the project translators. Also helpful were German translations of American and British aeronautical terms found in captured documents, and the arbitrary words and phrases applied to German prototypes and equivalents of Allied equipment and accessories.

The German scientists worked voluntarily at Wright Field under special contracts as alien civilian employees of the War Department. Their salaries ranged from \$2.20 to \$11 a day, and were paid to their banks or families in Germany. The Germans were paid an additional \$6 a day to cover their living expenses while on temporary duty in the United States, the same allowance granted U. S. civil service personnel away from their permanent stations. Salaries generally were below those paid American Government workers with comparable qualifications. Living quarters were similar to those of American junior officers. In the way of security measures, mail from the German scientists to their families in Germany was reviewed for project security, and was forwarded through Army channels. Spot checks were made on the scientists' activities outside the post.

The following awards of the Institute of the Aeronautical Sciences



NORTHROP ARMY F-15 REPORTER

were presented in 1947: The Sylvanus Albert Reed Award was presented to Robert T. Jones, Ames Aeronautical Laboratory, National Advisory Committee for Aeronautics, "For his contributions to the understanding of flow phenomena around wings and bodies at speeds below and above the speed of sound." The Thurman H. Bane Award was presented to Col. Leighton I. Davis, Chief, Armament Laboratory, Engineering Division, Air Materiel Command, "For Gyro Computing Sight for aiming guns, bombs, and rockets from fighter aircraft." The Robert M. Losey Award was presented to Dr. Carl G. Rossby, Head, Department of Meteorology, University of Chicago, "In recognition of outstanding contributions to the science of meteorology as applied to aeronautics." The John Jeffries Award was presented to Brig. Gen. Malcolm C. Grow, Air Surgeon, Army Air Forces, "For outstanding contributions to the advancement of aeronautics through medical research." The Octave Chanute Award was presented to Ernest A. Cutrell, Captain, American Airlines, Inc., "For outstanding achievement in flight testing and developing instrument landing equipment and techniques contributing to improved performance of instrument flying." The Lawrence Sperry Award was presented to Peter R. Murray, "For radio controlled systems for guided missiles and pilotless aircraft."

Dr. Luis W. Alvarez, professor of physics at the University of California, was awarded the Robert J. Collier trophy for 1946 "for his conspicuous and outstanding initiative in the concept of, and his contribution to the construction, adaptation and effective use of, the Ground Controlled Approach system for safe landing of aircraft under all weather and traffic conditions." Selection of Dr. Alvarez was made by a committee appointed by National Aeronautic Association to

determine the person who had contributed the most to aviation in the preceding 12 months. Use of GCA enables any type of airplane equipped with radio transmitter and receiver and flown by a pilot with blind flying experience to approach a fog-locked airport and land. The plane is talked onto the field through cooperation between the pilot and the controller on the ground, the latter using radar to see the plane through soupy weather and guiding the pilot to a landing by giving directions, speed and rate of descent to be flown and other information. First employed by the Army and Navy during the war to speed up landings in combat zones, GCA got its civilian application early in 1947 at airline terminals in New York, Chicago and Washington in tests to determine its value in bringing airliners to safe landings at rapid intervals despite low ceilings. It was the standard peacetime blind landing system at AAF and Naval air station installations. In November, 1940, Dr. Alvarez joined other scientists working under the National Defense Research Committee at Massachusetts Institute of Technology in experiments with radar. He suddenly hit upon the idea that if radar could spot and track a plane closely enough to shoot it down, it should be able to track a plane lost above a weather-bound airport so someone could aid the pilot in making a landing under even zero-zero conditions. In January, 1942, he had perfected the equipment to do the job, and it was unveiled at Washington before the high command of the Army and Navy. Through use of the equipment, an airport control tower operator could see all planes within a 30-mile radius of the airport and under 4,000 feet in height.



DOUGLAS C-74 GLOBEMASTER ARMY TRANSPORT

Igor I. Sikorsky, pioneer aeronautical engineer and engineering manager of Sikorsky Aircraft division of United Aircraft Corporation, was awarded the gold medal of the Federation Aeronautique Internationale for 1946 for his development work on helicopters. Myron Tribus, of the College of Engineering, University of California, was awarded the 1946 Wright Brothers medal for his paper "Report on the Development and Application of Heated Wings."



BOEING B-29 SUPERFORTRESS

### CHAPTER III

#### THE ARMY AIR FORCES

Strength of the AAF at Home and Abroad—The Peacetime Organization—AAF Installations—The Long Range Bomber Program—New Jet Fighters and Bombers—Training for Supersonic Speeds at High Altitudes—Experiments with Guided Missiles and Pilotless Aircraft—The Air Transport Command.

**T**HE Army Air Forces at the beginning of 1947 had a total of 49,529 officers and 291,892 enlisted personnel. There were 31,497 officers and 196,551 enlisted personnel on duty in the United States and 18,032 officers and 95,341 enlisted men, a total of 113,373, stationed outside this country. Of the 49,529 officers, 24,234 were pilots and 6,660 were bombardiers, navigators and other flight specialists. During 1946, they put in 3,643,000 hours of flying, 2,483,000 in the United States and 1,160,000 overseas.

The Army Air Forces had a wartime high of approximately 800 AAF installations. With the cessation of hostilities, necessity for maintaining a large physical plant for Army Air Forces operations and activities correspondingly decreased. Early in 1947, there were approximately 90 interim installations in continental United States, plus installations in overseas theaters, departments and territories where the Army Air Forces were operating. The activation of the Air Reserve and Air National Guard programs meant an increase in installation usage. As units of these organizations were activated, they were located at either municipal airports or at AAF installations. Installations or airports occupied by units of the Air Reserve and the Air National Guard had three types of occupancy; installations or airports occupied by a unit of either organization exclusively; those occupied jointly by units of both; and those occupied by units of either or both, singly or jointly with the AAF. With all units of the Air Reserve and Air National Guard activated, it was estimated that there would be approximately 225 installations occupied by units of those organizations and the AAF.

For its peacetime mission as a first line of defense, the Army Air Forces plan at the beginning of 1947 was to have a personnel of 419,355 officers and enlisted men, organized into 70 groups. They would

be supplemented by an Air Reserve and Air National Guard, which, in time of emergency, would serve to help bring the regular AAF up to wartime strength, and also to provide a pool of trained replacements. Reserve and Guard components would be approximately 6,000 planes of all types for training purposes. The regular AAF had been assigned 8,000 aircraft for tactical, training and troop carrier purposes. The 70 groups were to include 25 for very heavy bombardment, 25 fighter, 5 light bombardment, 10 troop carrier and 5 for tactical reconnaissance. As part of the 25 VHB groups, two would have as their primary mission weather reconnaissance. Two would be trained for VLR photo and RCM reconnaissance; one for VLR mapping reconnaissance; and four groups would serve for tactical reconnaissance. There also would be separate squadrons consisting of transport, liaison, mapping, night fighter, emergency rescue and geodetic control units. Under a system of rotation, most combat groups would see both continental and overseas service.

Directly responsible to headquarters of the AAF, would be three major combat commands and five supporting commands: 1—Strategic Air Command, for long-range striking; 2—Tactical Air Command, to support surface forces; and 3—Air Defense Command, for defending the homeland. Supporting commands would include: a—Air Materiel Command, for supply, logistics and specific research functions; b—Air Training Command, for all phases of individual training except higher technical education; c—Air Transport Command, for providing global air transport service plus such functions as air communications, weather, rescue and aeronautical charts; d—Air University, for higher training; e—Air Proving Ground Command, for tactical experimentation.

The headquarters of the Strategic Air Command was Andrews Field, Md. As America's long-range striking force, SAC would be capable of striking at the heart of any future enemy via polar routes or from perimeter bases. With emphasis on mobility and striking power, SAC's very heavy bombardment, very long range fighters and very long range reconnaissance planes would be equipped to operate independently or in cooperation with ground and sea forces anywhere in the world. The principal air weapon of SAC for the immediate future would be the XB-36, closely supported by B-29s and long range fighters. The SAC also would be equipped with VLR mapping and charting planes, radio counter-measure aircraft, and with facilities for establishing geodetic control networks by means of Shoran for mapping and charting purposes. Subordinate commands of SAC were the 8th and 15th Air Forces.

The Tactical Air Command, with headquarters at Langley Field, Va., controlled the 9th Air Force, based at Greenville, S. C., and the 12th Air Force, at March Field, Calif. The 9th had troop-carrier, fighter, attack bomber and photo reconnaissance groups. The 12th Air Force was a jet plane group using the Lockheed P-80 Shooting Star and FP-80, photo-equipped version of the P-80. The mission of TAC was to cooperate with ground and naval forces, or operate independently, anywhere in the world. In this respect TAC normally would give closer support to ground forces than would SAC. TAC training functions involved gunnery, rocket-firing, tactical bombing and air occupation duties overseas.

The mission of the Air Defense Command was to organize and train units of the Air National Guard and Air Reserve to support, in time of emergency, the regular AAF. The continental air forces coming under the jurisdiction of ADC were the 1st Air Force, Fort Slocum, New Rochelle, N. Y.; 2nd Air Force, Fort Crook, Omaha, Nebr.; 4th Air Force, Hamilton Field, San Francisco, Calif.; 10th Air Force, Brooks Field, San Antonio, Texas; 11th Air Force, Harrisburg, Pa.; and the 14th Air Force, Orlando, Fla. Those six air forces were to supply regular AAF personnel to train the national guard and reserve units.

The Air National Guard program, which required the cooperation of individual States, was started in April, 1946. It was to consist of 12 wings composed of 24 fighter and three light bombardment groups, forming 84 squadrons to be based at 79 airfields throughout the country. Guard personnel would comprise about 3,000 pilots, 3,800 non-rated officers and 50,000 enlisted men. Units would be equipped with North American P-51 Mustangs, Republic P-47 Thunderbolts and Douglas A-26 Invader bombers. Jet planes would be used when available.

The Air Reserve, serving as a minute man force, would have 17,500 pilots, 5,000 additional staff pilots, 27,000 non-pilot officers and 120,000 enlisted men.

Wright Field, Dayton, O., was headquarters for the Air Materiel Command. AMC was committed to carry out a research program which would assure AAF leadership in logistical and technological developments. To this end, AMC utilized the research facilities of the three military arms in addition to those of civilian agencies. AMC also was responsible for procuring supplies and equipment for the AAF. The development of AAF industrial mobilizations plans came within AMC activity. AMC handled all production involving control, resources, scheduling and allocation by plants. Other functions were

preparing budget estimates for all AAF materiel, and maintaining a storage and distribution system for supplies, including such operations as stock control, salvage, disposal and identification functions. AMC also was responsible for modifying new equipment for aircraft and training air depot units for maintenance and repair of aircraft and equipment beyond the facilities of air bases.

The Air Institute of Technology at Wright Field was administered by the Air Materiel Command. A military school, it was staffed by civilian experts in engineering and logistics. It awarded the degree of Bachelor of Science or Bachelor of Business Management to graduates of a two-year engineering or business management course, pending its accreditation by the Society for the Promotion of Engineering Education.

The Air Training Command, with headquarters at Barksdale Field, La., had three subordinate headquarters—Flying Training Division, Randolph Field, Texas, Technical Training Division, Scott Field, Ill., and Indoctrination Division, Military Training Center, San Antonio, Texas. The Training Command controlled pilot and ground crew training. Following basic training, students were assigned to either the Flying or the Technical Training Division. There were more than 170 different courses extending from 4 to 40 weeks. The latest flying instruction included a course offered at Mather Field, Calif., for aircraft observer-bombardier which combined the functions of navigator, bombardier and radar observer into one flying position. Student pilots also were given a P-80 transition course designed for jet piloting. Technical training was given at Chanute Field, Ill., Lowry Field, Col., and several other technical schools throughout the country. The Training Command also supervised military correspondence courses in which approximately 100,000 men were enrolled.

The Air Transport Command had its headquarters at Washington, D. C. In addition to providing world-wide troop and cargo transportation, ATC recently had incorporated the functions of other AAF branches, including weather, air communications, flight, air transport, aeronautical charts and air rescue. Flying safety, formerly an ATC function, went under the supervision of the Commanding General, AAF. In addition, ATC had command of all United States troops (ground, service and air), communications and bases from Iceland to the South Atlantic area, including Bermuda, Newfoundland, Greenland, the Azores and Brazil.

To furnish adequate air transportation for occupation forces in Europe and the Pacific, the consolidation of the Atlantic and the Con-

tinental Divisions was effected, cutting down the Command's domestic activities 25 to 50 per cent. Also, because of large personnel reduction following demobilization, ATC had to curb its global air transport service, eliminating its Globester runs, the first scheduled round-the-world air service.

The Air University, located at Maxwell Field, Montgomery, Ala., operated an Air War College and four other AAF schools which taught regular AAF officers (and in some instances Air Reserve and National Guard officers) the latest scientific advancements affecting aerial warfare. The Air University also coordinated educational work in all AAF schools, supervising the Air Command and Staff School, Maxwell Field, which as the Air University's basic school, trained selected officers with four to 12 years service for senior staff positions with command groups and wings. Emphasis was placed on the application of air power at the level of the group, wing, and Air Force, and the particular responsibilities of commanders. Other schools supervised by the Air University included the Air Tactical School, Tyndall Field, Panama City, Fla., instructing junior officers having one to four years of service for staff duty as squadron commanders. Instruction included tactics and techniques, intelligence, communications, administration, supply, personnel management, public relations and civilian affairs; the Air Special Staff School, Gunther Field, Montgomery, Ala., giving specialized instruction to prepare officers for administrative and technical assignments on the staff of groups and higher units, teaching senior intelligence, command and management, public relations, staff communications and air inspection; the Air War College, Maxwell Field, the highest echelon of the Air University. It was the research and planning agency similar to the Army War College in the Army. Officers attending had 16 years or more service with major Air Force units. Study was concentrated on the broad aspects of air power in relation to offense and defense, the coordination of air power with surface operations, and strategic and tactical evaluation of aerial warfare in World War II; also the School of Aviation Medicine, Randolph Field, Texas, which was under the technical supervision of the Air Surgeon. It offered courses for aviation medical examiners and aviation nurses, and gave basic and advanced work for Air Force Medical Officers.

Headquarters for the Proving Ground Command was Eglin Field, Fla. As the AAF's testing laboratory, it conducted experiments on all types of aircraft, AAF ordnance equipment, radar, radio, photography, navigation, personnel equipment, air-sea rescue equipment and techniques, and practically every technical development intended

for Air Force use. It also had charge of the Guided Missiles Group.

The era of flying by remote control came a step closer when, early in 1946, at Roswell Field, New Mexico, the AAF successfully demonstrated the robot principle of aircraft operation. Basically, the principle involved a drone, or babe plane, and a mother control ship, both operating on fixed radio frequencies. A television camera installed in the drone plane projected onto a scope in the control plane a picture of either the drone's control panel or an area of approximately 50 miles in front of the drone. On the basis of this picture, the control operator, through radio, would then transmit the necessary control functions to keep the babe in sustained flight. Takeoff and landing were accomplished by control jeeps stationed near the runway. At Bikini, in July 1946, within minutes after the atomic test bomb was dropped, four pilotless B-17s, specially-equipped for gathering the all-important atomic data, flew through the radioactive cloud remotely-directed by mother aircraft. On August 5-6, 1946, two crewless B-17s, accompanied by two mother control ships, landed in California after a 2,600-mile crossing from Hawaii. The trip took only 14 hours and 55 minutes, a new endurance record for remote-controlled aircraft operation.

On Feb. 15, 1946, a Douglas C-54 Skymaster four-engine transport plane, completed aviation's first push-button flight. Present on the flight were a safety pilot and a number of passengers. The event took place at Wright Field, Ohio, under the guidance of the AAF's Air Technical Service Command. Following an instrumental adjustment to a pre-set flight pattern, an automatic flight controller, used in conjunction with the Sperry A-12 automatic pilot, assumed the coordination of a mechanical system of controls which got the plane into the air, brought it up to and maintained cruising altitude, directed it toward its destination, picked the selected range and homing beacon, lowered it for a landing, and finally braking it to a full stop. The nerve center of the automatic flight controller, known as the master sequence selector, was fed impulses which motivated in sequence all the mechanical functions necessary for flight, such as controlling the throttle, brakes, flaps and landing gear. Originally designed to maintain safe flight during severe weather conditions, automatic flight equipment was considered to be an important step in achieving accident-proof flying.

The B-36, a pusher-type bomber weighing 278,000 pounds completed by Consolidated Vultee in the summer of 1946, was the AAF's first plane capable of carrying a bomb load to any part of the world and return without refueling, according to the official reports. The

wing, which was mounted slightly forward of the midpoint of the fuselage, could hold 21,116 gallons of gasoline and 1,200 gallons of oil. Powered by six 3,000-horsepower engines, with two superchargers for each engine, the B-36 could make more than 300 miles an hour, a normal range of 10,000 miles without extra fuel tanks and a 40,000-foot ceiling. At a reduced range, the bomber could carry 36,000 pounds of bombs—three times the capacity of the wartime B-29. The plane carried a regular crew of 12 plus a four-man relief crew.

Loran, a radar system developed and used for long-range flight during the war, was an invaluable navigational aid to cargo aircraft supplying the American and Canadian Army units during their joint Arctic expedition, Operation Musk Ox, in March, 1946. Principally important over vast uninhabited distances where radio communication was impractical, Loran helped navigators to determine the exact location of their aircraft while in flight. On the basis of radio signals received from Loran stations in Manitoba, Saskatchewan and British Columbia, aircraft navigators were able to plot intersecting lines on Loran time charts, the point of intersection disclosing the plane's exact position. The information gathered by 10 Loran monitoring stations during the expedition was expected to be of great assistance to future AAF operations in Arctic areas.

A forward step was taken in meteorology when technicians successfully applied radar to determine the speed and direction of winds aloft. The value of radar was evident during periods of darkness or poor visibility, both conditions being limiting factors in theodolite-tracking of a balloon, the time-honored visual method of obtaining upper air data. Radar also determined wind data in the stratosphere, impossible with a theodolite or a sighting tube. In a radio wind observation, the speed and direction of upper air winds were computed on the basis of the distance, direction and height of a balloon-borne target. Distance was determined by the position of pulse echoes, transmitted by the target, on the radar's oscilloscope. The elevation and azimuth readings, determined by the radar's antenna, ascertained direction. From this data, the height of the target could be computed either trigonometrically, or from the radar set.

Light aircraft could use APS-10, a radar device which traced through fog and darkness accurate fluorescent pictures of cities, rivers, terrain, storm centers and other aircraft. Announced by the Air Materiel Command as an improvement over the heavier 500-pound, 34-control radar used by the AAF during the war, the new development incorporated five range delineations: a four-mile setting reflecting large-scale details for close traffic flying, a 90-mile setting suitable for

cross-country navigation, and intermediate 10-, 20- and 50-mile ranges which provided a variety of scale miniatures, affording immediate detection of nearby obstructions. Airport radar beacons were revealed in coded pips of light, their direction and range by relative position on the scope.

As part of its research and development program, the AAF was assigned by the War Department responsibility for development of guided missiles. In carrying out this function, the Commanding General, AAF, could call upon agencies both within and outside the War Department to perform cooperative research tasks for which they were best qualified.

A radar-controlled, rocket-propelled missile, 10 feet long and almost pencil-slim, was developed by the AAF. It was expected, upon launching, to intercept and destroy any enemy planes or missiles before they reached their target. The missile was called GAPA (Ground to Air Pilotless Aircraft) and obtained high speed acceleration by means of a booster unit attached to the tail. Boeing Aircraft Company was handling that development.

Converted from the Lockheed P-80 Shooting Star to make it one of the fastest photo reconnaissance planes in the world, the AAF's new FP-80 utilized a variety of camera arrangements to provide shots ranging from wide angle, general mapping photography to highly detailed pinpoint pictures. The plane could shoot pictures at a speed of 600 an hour from heights of 300 to approximately 35,000 feet. Shutter speeds clicked from  $1/350$ th to  $1/800$ th of a second, depending on the speed of the plane. Because of the speed achieved by the jet, the plane was less inclined to tilt, tip or crab. This eliminated causes of distorted photography. The three standard AAF cameras installed in the plane were the K-17, K-18 and K-22.

The Air Materiel Command developed an automatic chain system of three safety devices which would eject a pilot from a disabled plane and automatically parachute him safely to earth. Consisting of an ejector seat, an aneroid automatic parachute opener and a ribbon parachute, the system was expected to be of great value to pilots of high speed and supersonic aircraft of the future. The squeeze of a trigger fired a 37mm. cartridge in a gun barrel hooked to the back of the seat. From this point on, the pilot's descent to earth was entirely automatic, even though he might be unconscious. The small explosion following the trigger action shot the pilot and seat straight up and out of the fuselage at approximately 60 feet a second. As soon as the pilot and seat were in mid-air (three seconds after the initial explosion), another small cartridge was exploded by a pre-set time mechanism,

causing the seat belt to fall clear. Simultaneously, a small parachute attached to the seat opened and pulled the seat away from the pilot. The pilot then fell freely until the aneroid parachute release, automatically set to open at a pre-determined barometric pressure, went into operation. A third small explosion was set off, automatically releasing the ripcord and allowing the parachute to open. The ribbon parachute was so constructed as to eliminate the terrific shock which airmen experienced with standard chutes following a long free fall. The canopy of the parachute was made up of a vast latticework affair of strips of ribbon each  $2\frac{1}{8}$  inches wide by 32 feet long. Circular bands of tape supported the intersecting ribbons. The opening shock was alleviated by the escape of air through the spaces between the ribbons. After the parachute had opened, the ribbons came closer together, and the result was a slow, steady deceleration to earth. The ribbon parachute also eliminated oscillation, a major cause of injuries sustained in jumps with standard parachutes.

The Air Transport Command in 1946 flew a total of 69,561,060 plane miles, carried 396,534 passengers, 31,408 tons of cargo and mail, flew 203,092,637 ton miles and about 90,727,000 cargo and mail ton miles. The ATC was operating in the peak month, January, 119,071 route miles.

The AAF Air Transport Command had developed from an organization on paper to the largest air transportation agency in existence. At its peak strength, shortly before V-J Day, its fleet numbered over 3,500 aircraft; its 10 divisions, with over 300,000 military and civilian personnel, operated 184,000 route miles around the world to every fighting front. Victory over Japan climaxed the spectacular wartime operations. On September 2, 1945, the ATC started the bloodless invasion of Japan with a fleet of 200 C-54 Skymasters. Within 17 days it had ferried 23,500 troops, 1,191 motor vehicles, 2,400 barrels of gasoline and 5,000,000 pounds of rations and equipment into Atsugi Airdrome, near Tokyo, thus completing the final link in its wartime chain of bases, many of which later were being utilized by American civil air carriers in international operations.

Late in the Fall of 1945, the Hump route, which had supplied American forces in China throughout the war, was terminated except for special missions. Other bases and routes no longer needed to meet our military obligations were closed. The bases and facilities in most cases were eventually turned over to the native governments. Despite this demobilization, however, several special post-war assignments were undertaken. Over 1,300 B-29's and other combat type aircraft were returned from the Pacific to the United States by ATC.

Concurrently, the overwhelming burden placed on the railroads in transporting troops arriving in coastal ports to separation centers was somewhat relieved by an ATC transcontinental shuttle between Newark in the east and Sacramento, Calif., Seattle, Wash., and March Field, Calif. in the west. In that project, ATC was assisted by United, TWA, American and Northwest airlines. A total of 167,468 troops were moved from coast to coast, cutting by four days the time required for them to reach home. From V-J Day through November 1946, ATC recorded 23,597 domestic ferry flights.

The mobility and versatility of ATC was again demonstrated in May, 1946, when it was called upon to assist in relieving the national emergency resulting from the short, but serious, rail strike. With only four days advance preparation, ATC mobilized 1,000 transport planes, quadrupled all domestic schedules and plotted additional routes to 60 key cities where liaison officers were placed. Operations lasted only 48 hours and the full potentiality of the ATC was never reached, but in that short time thousands of pounds of mail, passengers and cargo were air-delivered.

For the Bikini atomic bomb tests, ATC flew 1,800 passengers and 397 tons of supplies to Kwajalein Island, operations base for the experiment. From V-J Day to December 31, 1946, the Air Transport Command had flown 927,681 passengers 2,681,437,527 passenger-miles; had moved cargo over 537,443,822 ton-miles and had operated its transport fleet over 197,032,563 transport-miles. Daily operations in October, 1946, averaged 161,319 transport-miles. In November, 1946, they averaged 548 passengers and 393,399 ton-miles. Air evacuation operations accounted for movement of approximately 1,000 patients a month.

Although reduced in strength to 638 transports and 60,000 personnel, as of February, 1947, the Air Transport Command had expanded its activities by assuming greatly increased national policy and military command responsibilities. In March, 1946, the Command was assigned jurisdiction over all Air Forces and Ground Force troops and operations in Bermuda, Iceland, Azores, Newfoundland and Greenland. In May the Command responsibilities were further increased by the inclusion of Airways and Air Communications Service, the Air Weather Service, the Air Rescue Service, the Aeronautical Chart Service and Flight Service. Those services were functional requisites of global military air operations, and they were complements of the air transportation mission. Being closely interdependent, and also global in scope, they were consolidated to achieve greater efficiency of control under a single central authority at the highest

level. ATC's transport functions were carried out by its three divisions, the Atlantic, Pacific and European. Because of the severe shortage of technically skilled military personnel, some of ATC's overseas routes were contracted to civilian airlines under jurisdiction of the divisions, in order to give U. S. occupation forces the military air transport service demanded by their complex requirements.

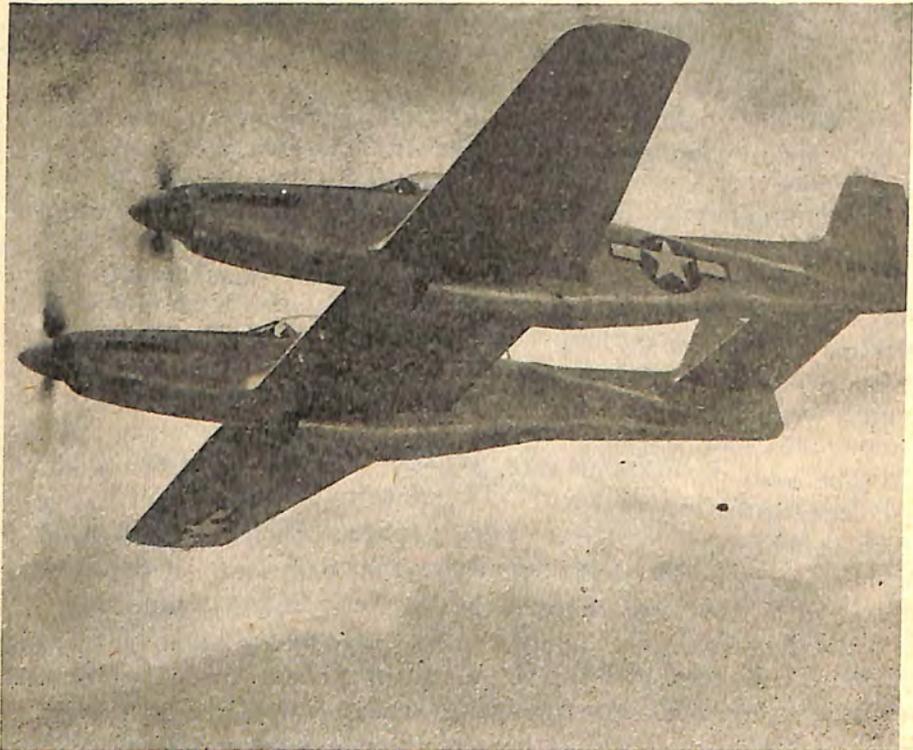
American forces in Japan were supplied by three flights a day to Tokyo, flown by Pacific Division. The Division headquarters at Hickam Field, Honolulu, controlled additional supporting flights from the ATC port of aerial embarkation at Fairfield-Suisun, Calif., to Guam, Johnston Island, Kwajalein, Manila, Shanghai and Peiping. Flights to Air Force bases in Alaska from the United States and a thrice weekly round trip from Fairfield-Suisun to Washington, D. C. also were maintained by Pacific Division. From Atlantic Division headquarters at Fort Totten, N. Y., six flights weekly were routed from Westover Field, Mass., and one daily from Washington to Wiesbaden, Germany, with additional missions to Newfoundland, Labrador, Greenland and the Azores. Air transport requirements for American troops in Panama and Puerto Rico also were met by Atlantic Division. Within the continental United States the Atlantic Division operated schedules connecting the aerial ports of embarkation with the major Army air fields and air depots. In that way, vitally needed personnel or supplies could be rushed overseas in a matter of hours.

Additional functions of the ATC included air evacuation of military hospital patients, supervision of the ferrying of all Army aircraft to and from points outside the United States and special mission flights for high-ranking Government officials and operations incidental to the major functions. The allied services conducted other flights in support of their functions, i.e., Air Weather Service maintained long range weather reconnaissance flights, Air Rescue Service operated amphibious and helicopter aircraft.

The assignments had as a primary purpose maintenance of the efficiency and effectiveness of ATC's fleet and personnel for its M-Day responsibilities, which were strategic concentration and deployment of armed forces by air, and logistical support of the overseas theaters by air from the zone of the interior. Realizing that time would be the deciding factor in any future war emergency, the ATC was in training with the objective of providing a force constantly prepared in its entirety to operate at once in a war emergency at the highest level of efficiency. It was anticipated that, as in the last war, assistance from the civil air carrier industry would be required. However, due

to the inevitable time lag required to convert civil carrier transports designed to carry light cargo and personnel, to aircraft able to transport heavy war cargo, it was vital that such a heavy-cargo fleet be in existence and ready to operate at a moment's notice. That was the primary mission of the Air Transport Command in 1947. In order to be prepared, the Command was training or planning to train, with the latest equipment, new types of long-range, 4-engine cargo aircraft such as the Douglas C-74, the Boeing C-97 and the Consolidated C-99.

Among the very good books published late in 1946 or early 1947 about the Army Air Forces were "One Damned Island After Another," the war story of the Seventh Air Force, by Clive Howard and Joe Whitley (University of North Carolina press), "Air Transport at War," the story of our Army and Navy air transport services during the war, by Reginald M. Cleveland (Harper) and "The Official Pictorial History of the AAF" by the Historical Office of the Army Air Forces (Duell, Sloan and Pearce).



NORTH AMERICAN P-82 TWIN MUSTANG FIGHTER

## CHAPTER IV

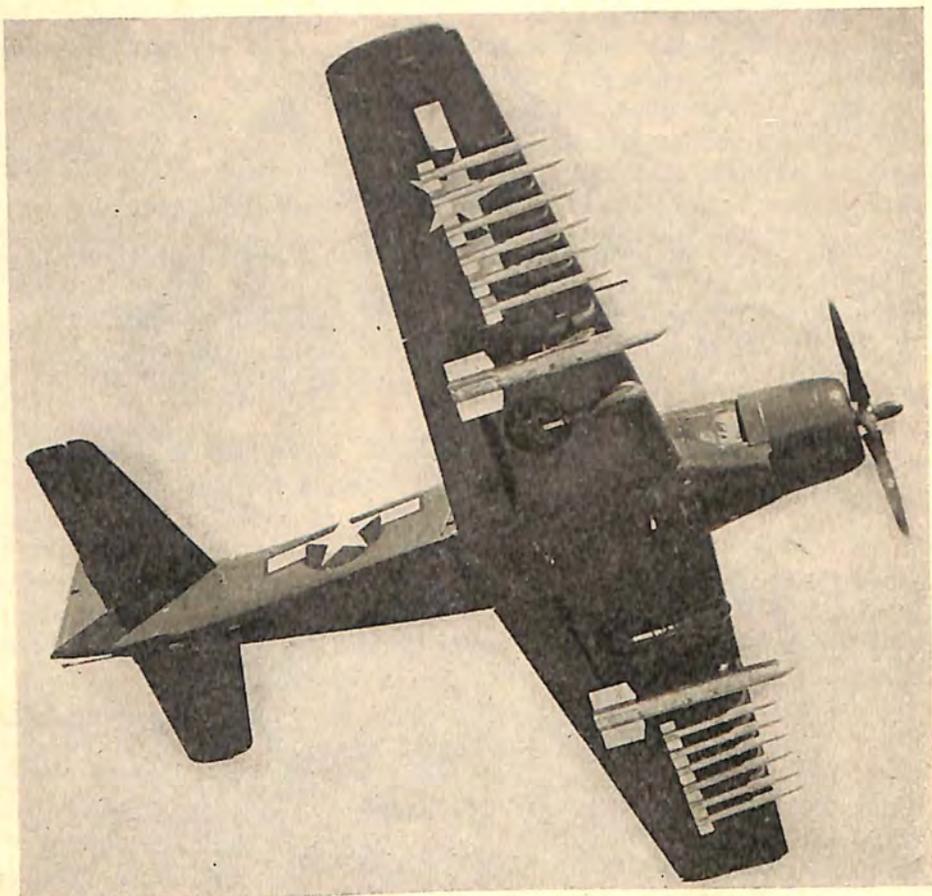
### NAVAL AVIATION

Strength of Naval Aviation in Personnel, Planes and Carriers—  
Navy's Aviation Program—Naval Airmen Make World Record  
Distance Flight—New Aircraft—Supersonic Aircraft—The  
Guided Missiles Program—The Naval Air Transport Service  
—The Search and Rescue Agency.

**A**T THE beginning of 1947, the U. S. Navy had on active duty, including reserves and Marine Corps, a total of 637,585 personnel, of whom 90,753 were in Naval Aviation. Of the total on active duty, 104,275 were officers—96,192 Navy and 8,083 Marine Corps—and 27,176 of those officers were in aviation, including 24,269 Navy and 2,907 Marine Corps. Of the 533,310 enlisted personnel on active duty—433,560 Navy and 99,750 Marine Corps—63,577 were in aviation, including 42,592 Navy and 20,985 Marine Corps.

At the same time Naval Aviation had 8,010 aircraft in operation. They included 4,950 combat planes—3,129 used by Navy, 665 by the Marine Corps and 1,156 flown by reservists. Of the total, the Navy Department rated 1,461 as first line combat planes. The figures, of course, did not include the new combat planes on order, numbers of which were scheduled for delivery in 1947. The total combat planes on hand included 2,088 fighters, 1,392 attack, 110 observation, 245 heavy land patrol, 176 medium land patrol, 189 medium patrol flying boats and 146 patrol amphibians. Utility planes included 109 heavy land transports, 275 medium land transports, four heavy transport flying boats, 363 two-engine utility planes, 134 single-engine utility, 515 two-engine trainers, 1,643 single-engine trainers and 17 rotary wing aircraft.

In a report which Secretary of the Navy James V. Forrestal submitted to a Congressional Committee early in 1947, the statement was made that the Navy "planned for retention 7,973 aircraft in overhaul, in replacement pools and in storage (to supplement new production) in order to support the 8,010 operating aircraft." The 7,973 aircraft were divided as follows: Navy and Marine Corps, 2,190 fighters, 1,527 attack, 129 observation, 221 heavy land patrol, 38 medium land patrol, 162 medium patrol flying boats, 43 amphibians, 37 heavy land



DOUGLAS NAVY AD-1 SKYRAIDER

transports, 133 medium land transports, 240 two-engine utility, 89 single-engine utility, 292 two-engine trainers, 1,090 single-engine trainers and one rotary wing. The Navy and Marine Corps reserves were allotted 734 fighters, 502 attack, 58 medium land patrol, 45 patrol amphibians, 24 medium land transports, 28 two-engine utility, 27 single-engine utility, 93 two-engine trainers and 270 single-engine trainers. They provided the entire Naval Aviation program with a total of 15,983 aircraft, besides the new production.

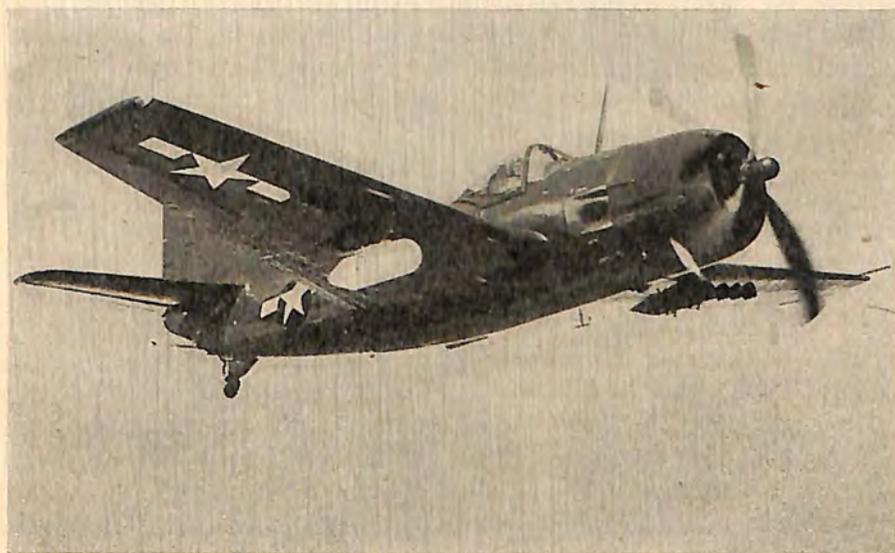
The Navy had 938 major combatant ships at the beginning of 1947, and 101 were carriers. They included three large carriers, combined gross tonnage 135,000 and combined plane capacity 360, 24

carriers with 551,000 gross tonnage and 2,160 plane capacity, eight light carriers with 88,000 gross tonnage and 320 plane capacity and 66 escort carriers with 467,500 gross tonnage and 1,650 plane capacity. Thus the Navy had a total carrier capacity of 4,490 planes, not including new construction. Of the totals, 25 carriers were in active service with the fleets, including three large, 11 carriers, one light carrier and 10 escort carriers. The others were maintained in reserve.

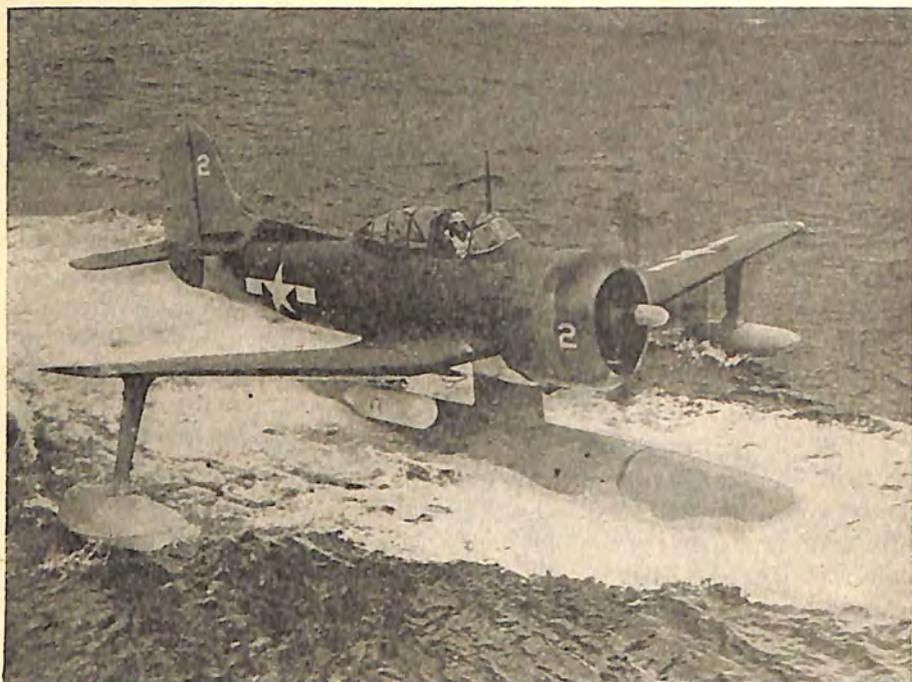
Naval Aviation in 1946 trained 2,834 pilots and 16,819 enlisted personnel in aviation ratings.

The Naval Air Transport Service in 1946 flew a total of 36,036,402 plane miles, loaded 429,302 passengers, and 25,707 tons of cargo and mail, covered 52,236 miles of NATS routes during the peak month of the year, and flew a total of 51,886,784 cargo and mail ton miles.

Among the many Naval Aviation records in 1946 was the longest non-stop flight in history, made by four Navy airmen in a Lockheed Navy P2V Neptune patrol land plane. Leaving Perth, Australia, late in September, 1946, Cmdrs. Thomas C. Davies, Eugene P. Rankin and Walter S. Reid and Lt. Cmdr. Roy H. Tabeling flew non-stop across the Pacific and the United States to Columbus, O.—a distance of 11,236 miles. They were in the air 55 hours and 15 minutes. Cmdr. Davies found only 25 gallons of gasoline left in the tanks when the plane



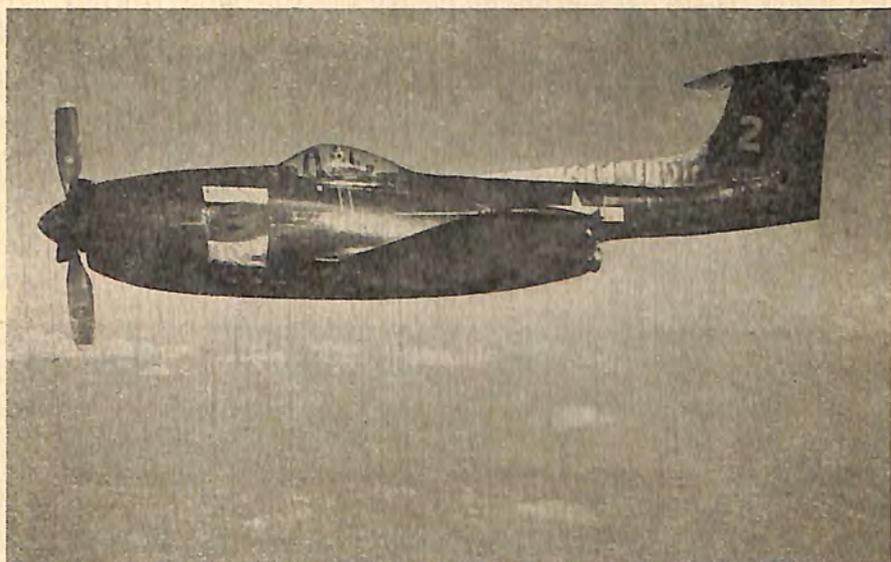
CURTISS-WRIGHT NAVY XBT<sub>2</sub>C



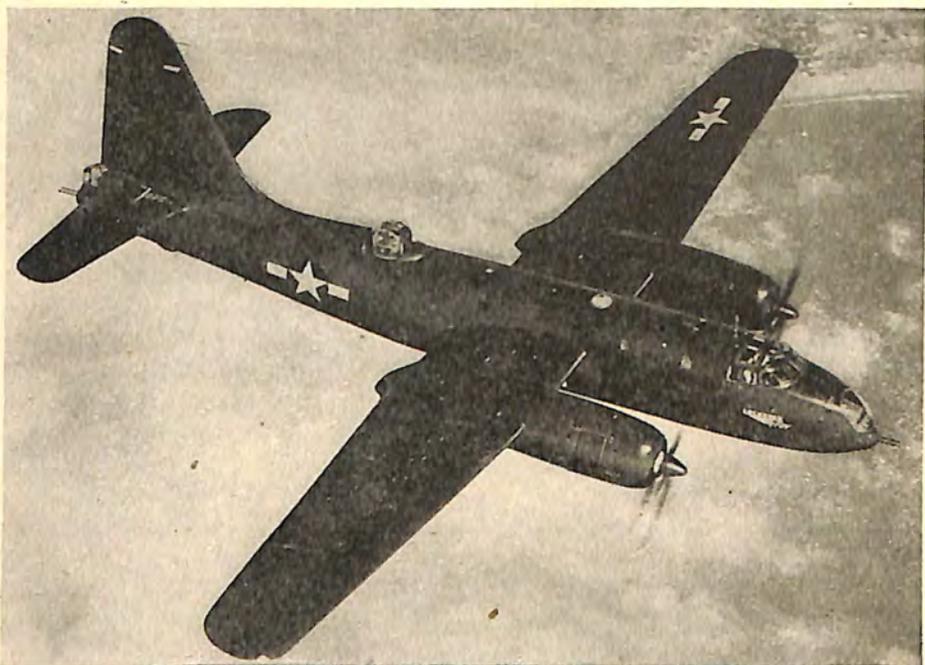
CURTISS NAVY SEAHAWK

landed. But for headwinds which they bucked clear across the Pacific and freezing weather which once put an estimated 1,000 pounds of ice on the wings, the Neptune, which the crew had named Truculent Turtle, could have gone on to Bermuda, Davies believed. "The plane averaged about 200 miles an hour," he said. "At the start we had 8,600 gallons of gas and a gross load of 85,500 pounds, which we believe is a record for twin-engine airplanes. We used four Jato jet units for an assisted takeoff and dropped them in the ocean once they were burned up." The four Jato units, he explained, added about 4,000 pounds thrust to the 16,000 pounds thrust of the two 2,300-horsepower Wright Duplex Cyclone engines. With 85,500 pounds aboard a plane designed for a gross load of 58,000 pounds, the Turtle climbed about 450 feet a minute. A headwind hit the nose of the plane. Davies and his crew said they had as much trouble over Bougainville and New Guinea in the southwest Pacific as our troops did during the war. The weather at that point became even worse than it had been, they said, but the worst was still ahead. When the plane hit the Equatorial front, which the flyers described as "250 miles of bottled-up disturb-

ance," they had some apprehension about the ability of the plane to take such a pounding with so great a load. They feared for a while that the added fuel tanks might leak, but nothing of the sort happened. Flying at about 8,000 feet, the Turtle ran into heavy rain and dense clouds over the Marshall Islands. From there to Midway the weather was bad. The flyers checked by radio with Honolulu for weather data and learned that the West Coast of the United States, particularly Seattle, where they had planned to make a landfall, was "socked in tight" and that there were icing conditions. This prompted them to fly south of Seattle. They finally altered their course to take them over the Coast at Red Bluff, Calif., about 100 miles north of San Francisco. They still faced a headwind, and it was about this time that the tachometer that records the functioning of the engines went out on the left engine. "Just as I was about to feather the left propeller," Davies recounted, "I realized that the engine was running all right and that it was only the tachometer that was out. Shortly thereafter the right engine quit, for about 30 seconds, from ice, but it cut back in when we opened an alternate heating system." They finally got out of the headwinds a few miles short of the Coast but ran into instrument weather, and when they made a landfall, the crew could not see the ground. They headed for Ogden, Utah, where the weather was re-



CURTISS-WRIGHT NAVY XF15C-1

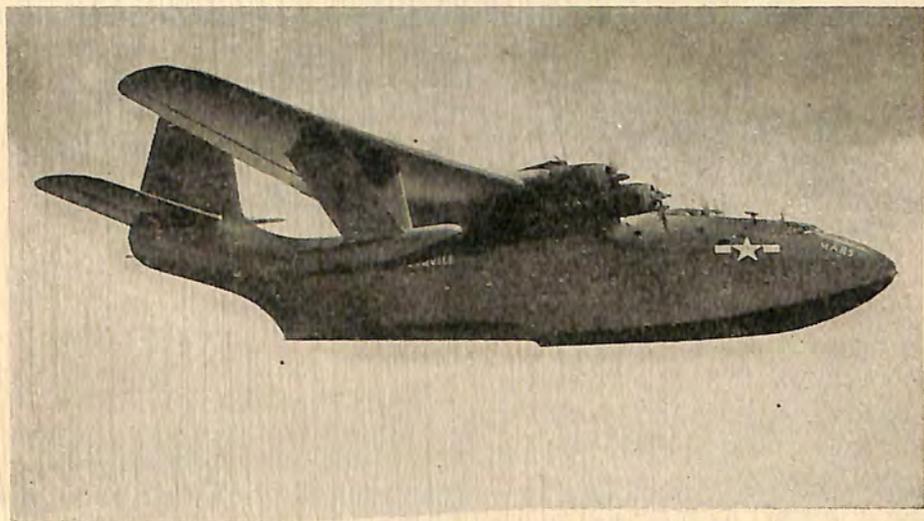
LOCKHEED NAVY P<sub>2</sub>V PATROL BOMBER

ported good. Shortly after crossing the Rocky Mountains the plane picked up a tailwind and the crew decided to try for Washington. They landed at Columbus finally rather than risk a forced landing because of empty fuel tanks. They said they had flown and slept on the basis of two men on and two men off every four hours. They said each had averaged about 20 hours sleep, little of it the first night, when the plane was heavily loaded and the weather bad. They had hot meals, steaks and soup. These they prepared on an electric stove. They said the rubber mattresses in the bunks were comfortable and the plane was soundproofed as are commercial airliners. They also had an oxygen supply and benzedrine tablets, but did not use either. It was, they agreed, "just like a good hard patrol," which most of them had flown for the Navy during the war. Davies said the Sperry automatic pilot was used about "99 per cent of the trip."

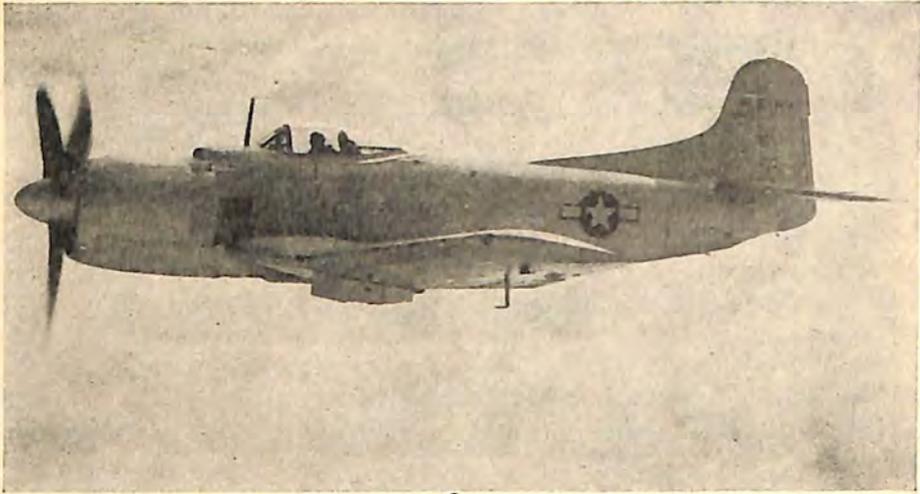
The Navy had to its credit many other achievements in 1946. One was the Lockheed Constitution, one of the world's largest transports. Others included the development of the Martin Mars flying boat and

several other types of Martin patrol and transport aircraft, latest being the XP4 M-1 land patrol plane powered by two Pratt & Whitney R-4360-4 reciprocating engines and two Allison jet engines mounted aft the conventional engines and in the same nacelles. Maximum range was over 3,000 miles and top speed over 350 miles an hour. The Navy had a galaxy of new aircraft, some secret, others in the experimental stages and several in production. There were conventional designs, pilotless planes, guided missiles and still more radical types of new things for air defense. One of the Navy's main projects lay in the realm of supersonic flight, and Douglas built the XD-558 for the Navy and National Advisory Committee for Aeronautics as a supersonic test ship. It is described in the Douglas section of Chapter X. Among others working on advanced design were Boeing, Consolidated Vultee, Curtiss-Wright, Grumman, McDonnell, North American, Ryan and Vought.

In announcing the Vought XF5U-1, the Navy termed it "the only known plane which offers practically both extremely high speed and extremely low speed in one machine. The XF5U-1 will have a speed range from 40 to 425 miles per hour with its present two-speed engines. With the addition of water injection, the range of speeds could be extended to 20 to 460 miles per hour; and by the possible future use of gas turbines, from 0 to 550 miles per hour. Preliminary tests be-



MARTIN NAVY JRM MARS



NAVY MARTIN AM-1 MAULER

gan in 1942 with a full-scale, low-powered, flying model of wood and fabric construction, designated the V-173. Tests proved that the original design was usable and practical. Since the structure of the plane can be made much stronger than conventional-type aircraft, use of the prone position for the pilot has been studied. The XF5U-1 is powered by two R-2000-2 engines which, through a transmission system, turn its two propellers at approximately one-fifth the revolutions per minute of the engines. A further refinement enables either engine, in case of failure of the second, to drive both propellers. One of the peculiarities of the new design is that, although the geometric aspect ratio is less than one, the effective aerodynamic aspect ratio is approximately four when the plane is in flight with the propellers turning over under power."

The Navy divulged a small part of its program in August, 1946, with a statement by Capt. Steadman Teller, head of the guided missile section. He said: "One year ago this week the Navy dominated Japan's homeland with air and sea power which had swept the enemy from the Pacific. The Naval air and sea power which won this victory employed weapons that had been developed through years of peacetime effort and improved by experience gained in battle. As demobilization reduced the air squadrons and laid up many of the fighting ships, the Navy turned its main effort from improving these weapons to developing new ones. It was realized that the types of naval forces which

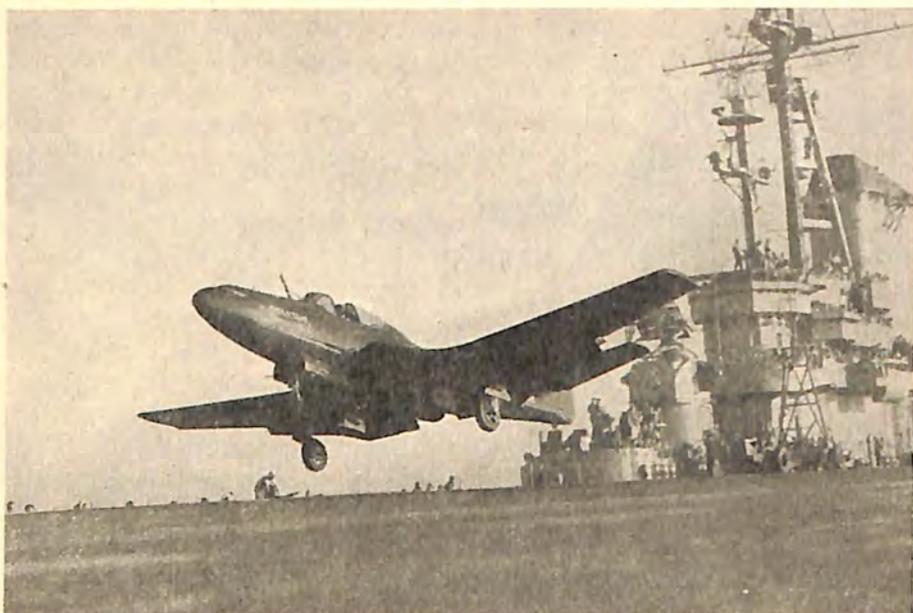
filled Tokyo Bay for the surrender ceremonies would not be adequate to defend our country if war should come again a few years later.

"Immediately after the war the Navy's development programs were reviewed, and emphasis was placed upon weapons which would give us many times the effectiveness of those we then had. The urgent requirement for volume of proven weapons was replaced by just as urgent a need to develop more powerful weapons. One of the first steps was the establishment of a Deputy Chief of Naval Operations for Special Weapons. Vice Adm. W. H. P. Blandy was assigned this post and the responsibility for the development of guided missiles, atomic power and those atomic weapons which the national policy determined should be produced. The guided missile section has laid out a program for progressive development which will give the Navy those weapons which are necessary to perform its mission in future warfare of long range bombardment by guided missiles, supersonic aircraft and super-destructive explosives.

"Anti-aircraft missiles launched from both ships and planes, guided or homed to the target by electronic beams or target-generated intelligence are an important segment of the program. Anti-submarine and anti-ship missiles which will dive deep and speed unerringly to a fast maneuvering target are under development. Heavy missiles to be launched at shore objectives from ships or submerged submarines will extend the striking range of our mobile task forces and make our submarines the scourge of enemy shore installations as well as his ship-



MARTIN NAVY XPBM-5A AMPHIBIAN



McDONNELL NAVY PHANTOM

ping. Before these weapons roll off the line in their final deadly form, there are many problems to be solved to provide propulsion for the desired supersonic speeds and accurate guidance through media of the upper air as well as at normal altitudes and under the sea.

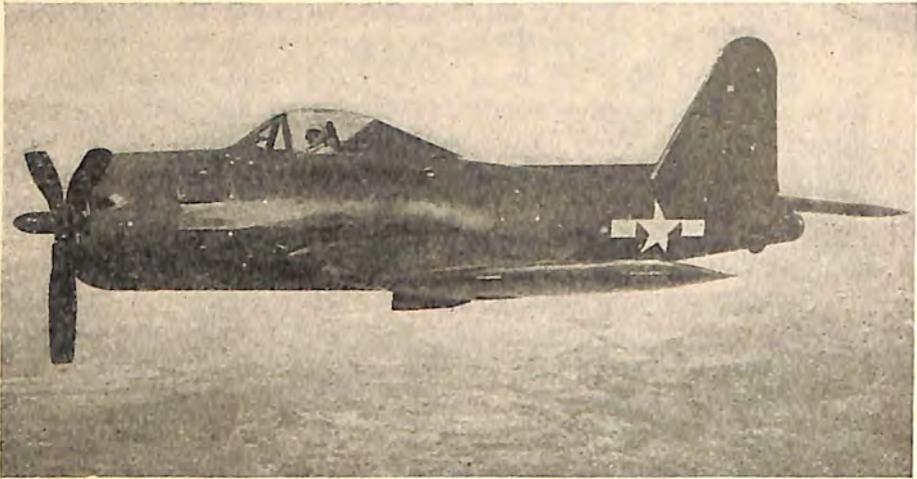
“The Navy is attacking these problems as first things first, maintaining a realistic discrimination between current scientific advancements and future possibilities in order that practical development may not be rushed ahead of sound knowledge. For example, considerable progress has been made in ram jet propulsion which, until a recent successful test flight at supersonic speeds, was just a theoretical probability. Investigating the upper atmosphere by instrument carrying rockets and eventually an earth satellite test vehicle are parts of a logical and progressive program from today’s accomplishments through the predicted possibilities in technical achievement to the advanced weapons of tomorrow. The Navy knows what new weapons it will need to perform its mission in wars of the future, and is taking full advantage of developments of other services and the creative ability of American science and industry in providing these essential requirements for the national security.”

Rear Adm. H. B. Sallada, Chief of the Bureau of Aeronautics, issued a supplementary statement, saying that work by the Bureau "on radio controlled aircraft has been almost continuous since 1922, although it was slowed almost to a standstill during the economy years. The first fleet application of radio controlled aircraft was in the field of target drones. They were either retired service aircraft, or specially constructed small airplanes, fitted with radio control equipment, and are used for realistic fleet gunnery training. The value of the target drones in developing the enviable record of the Navy in anti-aircraft gunnery is immeasurable. The fleet is now being provided with target drones of performance equal to modern aircraft, and plans are well underway with jet-propelled drones approaching the speed of sound. Soon, missile-like drones will provide realistic training in bringing down missiles and ultra-fast pilotless aircraft.

"A logical step from the target drone development was the installation of a bomb, and radio controlling the drone into a target. In 1940, projects were initiated for the development of assault drones, and soon television was added to permit the control plane to remain out of sight and still direct the drone into the target. These assault drones paid their way in World War II, by inflicting severe damage on enemy installations at Rabaul. The gratifying demonstration of the drones



MCDONNELL NAVY XHJD-1 HELICOPTER



U. S. Navy photo

**RYAN FR-1 NAVY FIREBALL FIGHTER**

opened the way for more ambitious weapons—types that would have seemed fantastic even to a highly imaginative comic-strip artist a few years ago. In immediate prospect from Bureau of Aeronautics projects with the U. S. aircraft industry are supersonic (speeds up to several thousand miles per hour), jet propelled (rocket ram-jet, pulse-jet, and turbo-jet) pilotless aircraft carrying payloads from a small charge capable of knocking down an airplane, to an atomic bomb, and capable of sniffing out the prescribed target with no help from human hands or brains. A little farther in the future are satellite vehicles, circling the earth hundreds of miles up, like moons. Interplanetary travel, in case someone feels the urge to visit far places, is only a short step from the satellite vehicle.

“But to get down to earth, or near it, again, the pilotless aircraft now being developed require long and arduous testing to determine necessary modifications in order to bring them to perfection. For this purpose, the Army and Navy have agreed on a plan of joint use of the several test ranges recently placed in operation or being established. To supplement the desert ranges (White Sands, N. M., under primary jurisdiction of the Army Ordnance Department; Wendover, Utah, the Army Air Forces range; and the Navy Bureau of Ordnance Test Station at Inyokern, Calif.) the Bureau of Aeronautics is establishing necessary launching and instrumentation facilities at Point Mugu, Calif., and on the outlying islands, to provide an overwater range. Since the

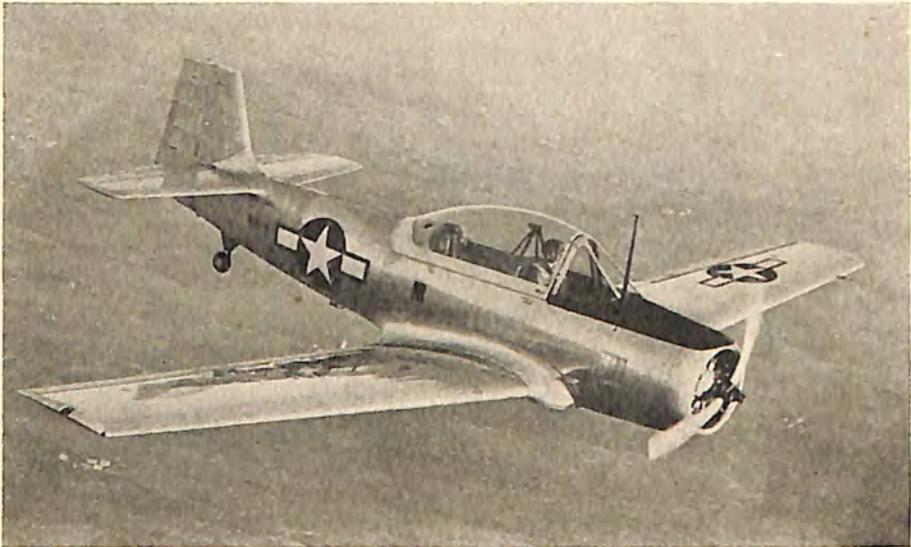
Mugu range will necessarily be confined to the testing of fairly short range missiles (150 miles or thereabouts) due to proximity of shipping lanes, consideration is already being given to the establishment of a long sea range in a more remote area."

The Navy Bureau of Ordnance made this statement: "Development of the Bat, a radar-guided glider bomb, during the war has provided the Bureau with a firm foundation of experience in organization and skill upon which to base development of ultra modern weapons of even more advanced type. The Bat was the only fully homing missile used in the war. It was virtually a pilotless Kamikaze which was even more efficient than the Japanese suicide pilots, and had the war continued and provided sufficient Japanese ships as targets, would have been a major weapon. Advanced forms of the Bat are now under development, and the future will see even greater precision, reliability and striking power. The new glider bombs are being developed in co-



U. S. Navy photo

RYAN FIREBALL FIGHTERS ON THE RANGER



FAIRCHILD NAVY XNQ-1 TRAINER

operation with the National Bureau of Standards which did much of the wartime work.

"In the Fall of 1944 the Bureau of Ordnance initiated project 'Bumblebee' for the development of a supersonic guided missile which would be effective against fast-flying Japanese aircraft, and assigned responsibility for this scientific direction to the Applied Physics Laboratory of Johns Hopkins University Outstanding development to date under this project is the supersonic ram jet engine, with a speed of 1,500 miles per hour, twice that of sound. Theoretical studies show possibilities of weapons using this engine with a range of several thousand miles. Another major guided missile project of this Bureau is being carried out by Massachusetts Institute of Technology and several large industrial firms.

"In the technical fields there are still many difficult problems. Guidance of missiles in particular is a major one. Wartime missiles such as the German V-2 had rather poor accuracy, and the difficulty of increasing precision where ranges of hundreds of thousands of miles are involved is still serious. However, continuous application of the principle of organized group research should lead to the solution as fast as could be attained by any possible enemies. Ships will undoubtedly have to be radically modified in order to utilize the advanced

forms of missiles which are under development. Experience has shown us that no matter how deceptively quiet the international situation may appear at any time, there is still the need for the United States to be prepared for combat operations on a moment's notice. The Navy is laying the foundation for that preparedness in its guided missile research program."

The Office of Research and Inventions stated: "This office has 81 contracts with educational institutions and private laboratories throughout the country covering all fields of science which will contribute in some aspect to the development of new weapons and in particular to guided missiles. Basic research in combustion phenomena and in the chemistry of new fuels has been underway for some time and has already made major contributions to the efficiency of jet propulsive devices. Many of the basic problems of remote guidance of missiles are now being studied with a view toward their early solution. The vast amount of information available today in the field of subsonic (below the speed of sound) flight is slowly being duplicated for supersonic (above the speed of sound) flight through the efforts of many competent aerodynamicists working for the Navy. One of the most comprehensive research programs sponsored by the Office of Research and Inventions is that of investigation of the physical phenomena to be met in the regions of the upper atmosphere. Work on providing instruments to obtain the data necessary to the design of missiles to traverse the upper atmosphere is being carried on by the Naval Research Laboratory. The platform in use at the present time for carrying the



U. S. Navy photo  
VOUGHT F4U-4 CORSAIR FIGHTER

instruments to the necessary altitudes is provided by the German V-2 rockets being fired at the White Sands Proving Ground. Much data will be necessary before the characteristics of the atmosphere at these extreme altitudes can be definitely established. Further experiments will be conducted through the use of the V-2. The Office of Research and Inventions has taken steps to provide other vehicles necessary for making these observations after the German V-2's are no longer available for experimentation. One of the large aircraft companies will develop a high altitude research rocket for the express purpose of taking scientific instruments into the upper atmosphere. It is expected that this rocket will be approximately 40 feet long and weigh about five tons. It will carry 500 pounds of instruments 120 miles above the earth. This rocket will be the first large rocket produced in this country from strictly American engineering and design."

Four thousand officers and men participated in the Navy Antarctic Expedition which Rear Adm. Richard E. Byrd took to the South Polar regions early in 1947.

During 1946, the Search and Rescue Agency in one way or another devoted its facilities to helping a total of 863 aircraft in distress, besides helping in 239 aircraft accidents, where planes were crashed, ditched or missing, involving a total of 573 persons, of whom 245 were saved by SAR facilities. Also during the year, the SAR assisted a total of 7,105 surface vessels and saved 5,192 persons in that activity.



MARTIN 202 TRANSPORT

## CHAPTER V

### AIR TRANSPORTATION

Airlines of the United States Set World Standard—Postwar Programs Improve World-Wide Service—Remarkable Safety Record—New Routes and New Equipment—New Services Projected—American Planes to Circle the Earth on Regular Schedules—International Cooperation—Steamship Companies Plan to Operate Airlines—Status of Feeder Lines—Growth of Air Express and Cargo.

THE air transportation system of the United States was the world's model of high speed, regularity of service, passenger comfort and safety. No vehicle or system in the long history of transportation had a better record for efficiency and safety than that of our airline network which embraced the important centers of this country and gradually was linking together all the cities of the earth in one vast system at speeds of four miles a minute or more. It was not perfect, of course. Airline operations still were subject to dangerous handicaps cast up by bad weather which delayed traffic and caused accidents, but the performance record was good, nevertheless, the safety record for 1946 was exceptionally good, and the problem of safe flying and landing in bad weather was being solved with incredible rapidity by new things in the air and on the ground. The hundreds of millions of dollars worth of new navigational aids developed during our war effort, radar for example, were destined to make flying ever more reliable. The new transports and other auxiliaries scheduled to appear on the airlines soon, some of them in 1947, were to provide further safety, reliability and comfort. There was very little about our air transport system in the form of inefficient operations that could not be corrected quickly, and such measures were well under way at the beginning of 1947. Such was the fine record of our pioneering airlines and the superiority demonstrated by American equipment that the whole world was copying our system and using our aircraft, and our railroads, ship companies and bus lines were going into airline operations at every opportunity.

The number of aircraft in scheduled service on U. S. airlines



REPUBLIC RAINBOW INTERIOR

reached a total of 826 at the beginning of 1947, of which 664 were operated domestically and 162 to points outside the United States. They compared with 495 at the close of 1945, of which 397 were in domestic use and 98 to points outside the United States. The corresponding seating capacity jumped even more sharply, or about 125 per cent from 10,889 in 1945 to 23,513 in 1946. Early in 1947, about 30 all-cargo planes were in operation, approximately one-third of which were four-engine aircraft. Planes on order or option at the beginning of 1947 totalled 714 with an estimated seating capacity of about 34,000 and a value of \$347,330,000. Changing production conditions made difficult any forecast as to how many would be delivered in 1947. Possibly half might be in service before the end of the year.

For the first time in the history of the domestic scheduled airlines, air freight ton-miles exceeded air express during October 1946. Air freight for that month totalled 3,128,846 ton miles, as compared with 2,653,491 ton miles of express, an excess of 17 per cent or more than 475,000 ton miles. One airline transported more than three times as much freight as express.

As to the safety record, it could be explained in simple terms. For every fatal accident in 1946, our scheduled airlines flew the equivalent of 3,200 times around the world. Compared with the amount of flying done, the great number of passengers flown, and the increased number of hours which the airliners spent actually in the air, the safety record was better than ever before.

There were only 12 fatal accidents on the scheduled airlines in the United States during 1946. They killed a total of 107 persons, including 32 members of the crews. Only half of those accidents involved deaths of passengers. Our scheduled lines had only two fatal accidents outside this country, killing a total of 52, including 12 crew members. Other accidents in 1946, officially considered as potentially fatal totaled 10 in this country and two outside, with only one person, a crew member, severely injured. The causes of accidents, insofar as they could be determined, were bad weather, error in judgment and mechanical failures, in that order, and possibly all three causes combined in some cases.

Considering the hundreds of new operating companies which entered the non-scheduled airline business in 1946, flying anywhere and everywhere, with all kinds of loads from charter passengers to emergency freight—throughout this country and abroad—their accident record was amazingly good. They had only seven fatal accidents in this country, and one in Alaska, killing 77 persons of whom 19 were crew members. They had only three potentially fatal accidents, and nobody was injured.

Admitting that air transport operations by the Army Air Forces and Naval Air Transport Service were conducted under different circumstances than those surrounding scheduled airline operations, Asst. Secretary of Commerce William A. M. Burden told the House Committee on Interstate and Foreign Commerce, on January 28, 1947, "It is difficult to compare military and civil transport operations fairly because during the war military necessity forced the Services to accept an element of risk in their transport operations which civil aviation could not tolerate. A very large proportion of Army and Navy transport operations were outside the United States, and thus were not comparable to domestic operations. Also, in 1946, the Naval Air Transport Service did not operate at all across the North Atlantic which is one of the more hazardous world routes.

"With those qualifications, the Committee may be interested in the following table showing the safety record of the Army Air Transport Command and the Naval Air Transport Service as compared with that of the certificated air carriers in recent years. In general the mili-

tary and naval record shows, as does the civilian record, a continuing improvement but even when one takes the peacetime year 1946, which was a year when special military hazards did not exist, one finds that the domestic operations of both ATC and NATS were 6 to 9 times as dangerous as those of the domestic airlines. In 1946, the ATC domestic operations had 8.2 passenger fatalities per 100 million passenger miles as compared to 1.2 on the domestic airlines. In international operations, the ATC in 1946 was twice as dangerous as our certificated airlines—7.8 passenger fatalities per 100 million passenger miles as compared to 3.5 for the U. S. certificated airlines.

“The NATS record in international operations has been exceedingly good in the last two years. In 1945, it was 2.5 passenger fatalities per 100 million passenger miles as compared with 3.6 for our commercial international airlines. In 1946, NATS had no fatalities in international operations in 537 million passenger miles of traffic, which was about one-half of the volume flown by the U. S. certificated international carriers in the same year. The largest United States international airline also flew throughout 1946 without accident, doing over 700 million passenger miles of flying.”

#### COMPARATIVE SAFETY RECORD

AIR TRANSPORT COMMAND, NAVAL AIR TRANSPORT SERVICE, AND U. S. SCHEDULED AIRLINES  
Passenger Fatalities per 100,000,000 Passenger Miles

Year	Domestic			International			Total		
	ATC	NATS	U. S. Airlines	ATC	NATS	U. S. Airlines	ATC	NATS	U. S. Airlines
1946	8.2	10.8	1.24	7.8	0	3.52	8.0	1.8	1.60
1945	6.0	19.7	2.14	4.7	2.5	3.64	4.9	3.9	2.31
1944	5.5	18.1	2.09	11.3	4.6	5.33	10.7	8.0	2.48

The insurance companies' appreciation of air travel safety was significant. Early in 1947, the Life Insurance Institute announced that the downward trend of passenger fatalities on scheduled airlines during 1946 had resulted in a further increase in the number of life insurance companies accepting confirmed air travelers without restriction as policy holders. About 98 per cent of the companies surveyed, doing 80 per cent of all life insurance business in the United States, accepted air travelers on the standard basis, as compared with 87 per cent in 1945. Also, an improved trip insurance policy was agreed upon by the insurance underwriters and was to be available to the public as quickly as approved by insurance commissions in the 48

States. Thirty-four already had approved. The new policy permitted an individual to buy up to \$25,000 of insurance at 25 cents for \$5,000 covering the trip specified in the policy, with 30 days allowed for the coverage.

The number of route miles in the domestic network increased to an all-time high of 95,921, a gain of 28,772 miles. The gain was approximately the equivalent of the entire airway system as late as 1936. The overseas routes granted to United States carriers totalled 175,488 miles at the beginning of 1947, an increase of 67,910 miles in 12 months. The new domestic mileage included 12 new so-called feeder lines, bringing the total to 13. Some had started operations. Airline stops in the United States had reached a total of 573 in January, 1947, of which 81 were on a non-operating status because of temporary local conditions. They did not include feeder line stops. Applications for new service franchises poured into the Civil Aeronautics Board. There were 749 applications for scheduled routes pending at the beginning of 1947, of which 542 were domestic (including 472 conven-



BOEING STRATOCRUISER

tional, 28 pick-up or combination and 42 helicopter) 114 overseas route applications (110 conventional, three helicopter and one lighter-than-air) and 93 in Alaska. There were 141 route applications for non-scheduled domestic service and 46 more for overseas. Twenty-eight foreign airlines had applications pending for service into this country. The total of 964 applications compared with 882 a year previously.

Air express service continued its upward trend in number of shipments handled, weight and gross revenue. As American business and industry shifted its production facilities to manufacture and distribution of peacetime necessities, air express transportation was called upon to fly machinery, raw materials, semi-finished and finished merchandise to every part of the country during 1946. The addition of bigger and faster plane equipment, exclusive cargo flights and extension of domestic airline route mileage, all contributed to record-breaking totals. Air express shipments topped the three-million mark for the first time. The year's total was 3,182,053 shipments, handled by the Air Express Division of Railway Express Agency for the certificated airlines of the United States. This record volume was a gain of 48.2 per cent over the previous yearly mark of 2,146,650 shipments established in 1945. Weight of shipments was 46,694,966 pounds, an increase of 16.3 per cent, while gross revenue for 1946 was estimated at \$14,100,200, up 4.4 per cent over 1945. (Air express rates were reduced 13 per cent at the beginning of 1946.) Average weight per shipment was 16 pounds, while average haul per shipment was about 900 miles.

As air express service entered its 20th year of operation in September, 1946, five additional certificated airlines, with routes totaling 4,743 miles, were added to the nationwide system. Serving 90 cities in Western states and in Florida, the new lines were Empire Air Lines of Lewiston, Ida., 695 route miles; Monarch Air Lines of Denver, Colo., 1,550 route miles; Southwest Airways Company of Los Angeles, 1,152 route miles; West Coast Airways of Seattle, Wash., 870 route miles; Orlando Airlines (formerly Florida Airways) of Orlando, Fla., 476 route miles.

More than 1,000 cities in the United States and Canada received direct air express service; and by means of coordinated air and rail schedules, the 23,000 Railway Express offices located at off-airline points were linked to the nationwide air express system of 67,000 route miles. More than 20 per cent of all air express traffic was handled part way in rail service, it was estimated. One of the most dramatic examples of how the transportation facilities of Railway Express

Agency, combining both air and rail service, were called upon to act in an emergency, occurred in May, 1946, during the railroad labor crisis. Under O.D.T. General Order No. 65, the Air Express Division of R.E.A. was directed "to receive, bill and forward by any available air service, all cargo that qualified for air transportation." As a result, 1,111 air shipments of emergency commodities weighing 80,000 pounds were handled by R.E.A. and participating airlines within a 12-hour period. Included in the shipments were two carloads of tomato plants, 8,730 pounds of DDT needed to combat polio in Florida, and one corpse.

International air express traffic also broke all records in 1946. Shipments flown between the United States and foreign cities built up a 47.3 per cent gain over 1945, with a total of 480,780 shipments being interchanged through the international airports during the year, compared with 326,214 shipments in 1945. Commodities shipped regularly by international air express included advertising materials, blueprints, cotton and tobacco samples, films and pharmaceuticals. Air exports to Mexico, Central and South America, Europe, Asia and many other points, continued to maintain a three-to-one ratio over air imports. December ranked highest in number of international air shipments handled, with a total of 50,085 shipments, an increase of 36.3 per cent over the similar 1945 month. The international airports of Miami, New York and Brownsville, Texas, ranked in that order, in number of shipments interchanged.

During 1946, additional air shipping routes to foreign countries were opened to supplement established service. The additional points included Berlin and Frankfurt, Germany; Copenhagen, Oslo and Stockholm, also Anchorage, Alaska and Havana, Cuba. At the beginning of 1947, international air express service was being operated by Pan American World Airways, American Overseas Airlines, Chicago & Southern Airlines and Northwest Airlines. A number of poundage rate reductions to certain Latin American points were instituted effective January 1, 1946, while the express rate between New York and Hamilton, Bermuda, was cut one-third in October.

New York City's LaGuardia Field continued to lead the nation's airports in volume of air express handled, and it topped the million mark in shipments for the first time in its seven-year history. More than 1,157,600 shipments, an all-time high, were dispatched in and out of the airport during 1946 for a gain of 46.7 per cent over 1945. New records were set in October, November and December, with the latter month reaching a new record of 165,687 shipments, 62.8 per cent higher than in December, 1945. To attract specific types of traffic

from various sections of the country, a number of air express commodity rates were established. These reduced rates covered such commodities as fresh seafood, cooked shrimp, fresh fish and fresh fruits, fresh mushrooms and vegetables, cut flowers, magazines and newspapers. Generally, those rates ranged from 50 to 70 per cent of regular air express rates.

In its first full peacetime year since 1940, it was interesting to note that Air Express service was called upon to transport substantially the same class of traffic that it handled before the war. Air express traffic in 1946 consisted principally of the following types of traffic, clothing, furs, department store merchandise and style goods of all descriptions, advertising electros, mats and printed matter, machinery and spare parts, automobile parts, drugs and pharmaceuticals, and flowers. Increasing competition in manufacturing, wholesale and retail lines, spurred by need for re-establishing prewar markets as quickly as possible, was reflected in continued use of air express to reach consumer markets quickly and frequently.

Typical of the volume and variety of air express that was flying air routes in the United States and was picked up and delivered by the R.E.A. fleet of 18,000 motor trucks, was a sample of one month's traffic at an average office, Peoria, Ill. During October, Peoria's air express employees handled everything from live animals to holiday costume jewelry, with weight of shipments varying from a few ounces to over 600 pounds per piece. Dispatched through Peoria were such things as cut flowers from the West Coast, feature films, insurance papers and radio transcriptions. In addition, there were the regular day-in and day-out shipments—machines and machine parts, gift shipments, clothing, meat and dairy products. That office, too, had status as an international airport office, and was equipped to issue waybills and receipts for international air express to South America, Europe and many other foreign points.

Air Cargo, Inc., was a permanent ground-service organization set up by the scheduled domestic airlines to promote air cargo operations between all points in the United States. The corporation had been created originally as a research unit. A new program of the organization embraced a series of projects. The initial functions of Air Cargo would be to provide for pick-up and delivery service within terminal areas at all domestic airline points, and employ joint facilities and personnel for the cargo operation of city and airport terminals, similar to the plan of Airline Terminal Corporation to consolidate passenger and servicing facilities. The reorganized cargo division also would offer miscellaneous services such as preparation of shipping

documents, operation of local clearing houses for the collection of shipping charges and central purchasing of air cargo forms, supplies and other material. In addition, it would serve as attorney-in-fact for the scheduled airlines in negotiating through-service arrangements with surface carriers. The agency ultimately would assume responsibility for carrying out many improvements to expedite the interline transport of airborne goods. As part of their program to develop the air cargo field, the scheduled airlines early in 1947 filed with the Civil Aeronautics Board an agreement designed to streamline and expedite air freight. It placed the handling of air cargo on the same nationwide level as the simplified passenger ticketing and baggage systems employed between nearly 500 points over more than 90,000 miles of domestic airline routes. The proposed regulations, which called for a single uniform airbill, provided for one airline to receive shipments from another if the necessary papers were in order and the transfer was in accordance with the specified routing. The shipments also had to be acceptable for transportation under the applicable tariffs of the airline to which they were tendered. Participating airlines would adopt and comply with uniform forms, methods, and procedures to be prescribed by the standard practices Committee of the Cargo Traffic Association of America. An Interline Air Cargo Claims Manual covering the handling and disposition of claims arising from damage or delay of shipments would be published by the insurance committee of ATA. Accounts and balances from the transportation of interline cargo would be cleared through Airlines Clearing House, a corporation owned and operated by the airlines. The regulations also established a maximum valuation limit of \$25,000 for each shipment without advance arrangements. Carriers signing the agreement were All American Aviation, American Airlines, Braniff, Capital Airlines-PCA, Chicago and Southern, Colonial, Continental, Delta, Eastern, Florida, Inland, Mid-Continent, National, Pioneer, United, and Western. Additional scheduled airlines offering air freight service on a common carrier basis were expected to participate in the agreement, making it industry-wide for the benefit of shippers throughout the country.

Four-engine planes first went into regular service on the domestic routes in 1946. The Post Office Department conducted successful experiments with suburban delivery of mail by helicopter. Progress was made toward the start of air parcel post.

The situation regarding feeder lines in the United States was explained by Chairman James M. Landis of the Civil Aeronautics Board, as follows: "The Board must measure the requested route in terms of

connecting trunkline operations and build an intelligent network that, at one and the same time, provides service to as many areas as possible, but does not unbalance the economy of the air transportation picture. The Board also must have some regard to the economics of operation in the feeder services. The certification of 30,000 miles of route mileage to feeder applicants, which I assure you is a very small fraction of what is being requested, would at a very conservative estimate add about \$20,000,000 a year exclusive of the cost of navigation aids and airports to the taxpayers' bill for aviation. And costs such as these are likely to continue for several years until the time comes, which we believe will come, when a new form of transportation shall have become accepted as part of the fabric of our national life. We have consolidated, as you know, a great many of the feeder applications into so-called area proceedings and are doing our very best to expedite decision in all of them. But the job is bigger than just an area job, and eventually we will have to tie them all together."

Impressive as was the 1946 scheduled airline record for traffic volume and safety, the carriers individually and jointly were spending vast amounts of time, effort and money to continue improvement. While larger and faster planes were due to enter service in 1947, the emphasis in airline development was upon improving navigation, landing approaches and traffic control. When the war ended in August, 1945, it was clear that much had been accomplished by the military services during the war which should be used by commercial aviation in order to improve safety and efficiency of operations. During the war it had been impossible to take advantage of those developments, because many of them were secret, and technical personnel were busy on war projects. With the close of the war the scheduled airline industry undertook a realistic program designed to make the greatest possible use of wartime developments. The Air Transport Association had Brig. Gen. Milton W. Arnold in charge of engineering, with 15 years of aviation experience as a pilot and operations official in military and commercial operations. He had created an organization of 17 specialists. In addition, the airlines acquired the Airborne Instruments Laboratory at Mineola, N. Y., to collaborate with Aeronautical Radio, the communications corporation owned by the scheduled airlines, in research in the field of electronic air navigation aids. In the first postwar year, over \$800,000 was spent, and the ATA was planning to spend about \$1,000,000 during 1947 for improvements in safety and efficiency of operations.

Realizing the necessity for improved lighting to aid night landings in bad weather, the airlines chose what they regarded as the best ap-

proach light developed, and provided for its installation at Newark Airport to give that type of light a test in actual operations. The lights were available for use by the military services and the general aviation public, and for tests to achieve still further improvement. The cost of installing the lights was about \$120,000. It was the type of approach control by which operators on the ground using radar equipment talked the pilot in the approaching aircraft down to a safe landing. Based upon favorable experience with this type of equipment during the war in handling thousands of aircraft landings, the ATA wrote an official letter to the CAA and the CAB in March of 1946, advocating the use of this equipment, in addition to other navigational aids required. After considerable work with the electronic manufacturers, a GCA suitable for commercial use was developed in June, 1946. An active program by the ATA, with the Army, Navy and CAA, resulted in the Army's loaning three GCA sets to the CAA. The AAF spent approximately \$200,000 modifying the equipment and purchasing the remote scopes required for the improved model. The Navy



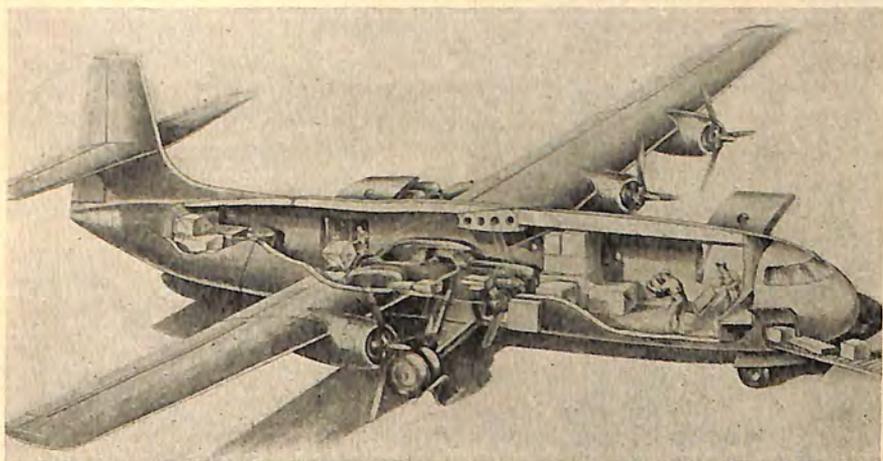
BOEING STRATOCRUISER INTERIOR

Bureau of Aeronautics assisted materially with specialized pieces of equipment. CAA agreed to train required personnel and to operate the sets at the three locations selected for installation—New York, Chicago and Washington. The airlines bore the entire expense for the installation of those three sets, \$86,000. In addition, Pan American Airways obtained the loan of a GCA set for installation at Gander, Newfoundland, where they and the other lines serving that point assumed the entire financial burden for operation of the unit. Aeronautical Radio, representing the scheduled airlines, also worked out an agreement either to lease or purchase a GCA from the AAF to be installed at Shannon, Ireland, the cost borne by the scheduled airlines operating there. The airlines, through the Airborne Instruments Laboratory, erected and operated a huge radar set at Mineola, N. Y., during the latter part of 1946 for the sole purpose of determining how ground radar could improve safety and efficiency of traffic control in congested areas. This set, known as MEW (Micro-Wave Early Warning), scanned an area for a radius of 100 to 140 miles, and to an altitude of 20,000 feet. During 1946, the airlines' work on MEW was concentrated on correlating information developed and working out procedures by which aviation could be made safer and more efficient in congested areas through use of the radar device. The airlines subsequently made an agreement with the City of New York, CAA, and the AAF in a combined project for relocation of the powerful radar set in the vicinity of LaGuardia Field, so that it could be used more effectively in observing traffic in the New York area and thus provide additional information on which to improve and develop it. The CAA had contributed in excess of \$50,000 to that project for 1947. The scheduled airlines appropriated approximately \$60,000, and the City of New York supplied material and personnel in excess of \$30,000, exclusive of the site for the unit. Operating cost for that type of radar on 24 hours service was from \$50,000 to \$60,000 a year. The AAF was assisting very materially in moving the equipment. The scheduled airlines were actively supporting the FIDO project—the improvement of ceiling and visibility in zero-zero conditions through utilization of a system of burning low-grade fuel. The project was supported financially by the Navy, and early in 1947 the CAA asked Congress for \$200,000 to add to its support. As soon as experiments proved the present type of equipment satisfactory, the unit was to be installed at one of the large municipal airports. The costs were to amount to \$400,000, and FIDO was to be available late in 1947. The scheduled airlines provided for the modification of the General Railway Signal automatic posting board installed at LaGuardia Field for

use in handling air traffic in the New York area. That equipment proved of great advantage in the safe control of traffic. The modification would further improve the efficiency and safety of the device.

As a further improvement of safety and efficiency of landing under adverse weather conditions, the airlines advocated the installation of low-powered radio transmitters on the approach path of the airplane at distances of 3,500 feet and five miles from the end of the runway. They were used in connection with the automatic direction finder equipment in the airplane to give the pilot a positive fix as he approached the field. More than 50 of the transmitters were obtained through the efforts of ATA from the Army and Navy on loan and delivered to the CAA for immediate installation at key points. The CAA obtained 40 additional transmitters from War Assets for installation at high-density traffic spots. The scheduled airlines advocated the use of airborne radar as a safety device, and with the assistance of the large electronic manufacturers, were seeking to develop a satisfactory commercial version of the airborne radar used during the war. The device, when completed, promised to improve navigation and terrain clearance, and facilitate the detection of thunderstorms.

In addition to the work of the ATA in behalf of the scheduled airlines in evaluation and improvement of airborne radar, Transcontinental & Western Air and American Airlines were actively pursuing a program of experimentation in use of airborne radar, and had spent about \$200,000 in that field alone, in addition to their work with the



CURTISS-WRIGHT CW-32 CARGO PLANE

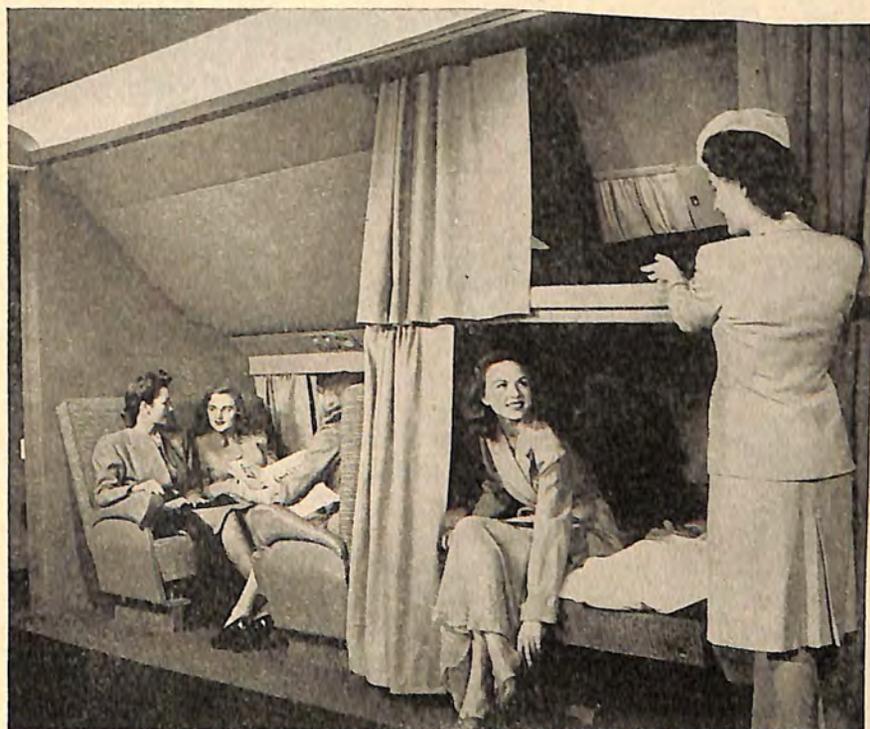
Army and Navy and the manufacturers to develop a satisfactory airborne radar for commercial use.

In cooperation with the CAA, the scheduled airlines made detailed studies of the traffic control areas in New York, Washington, Boston, Pittsburgh, Cleveland, Philadelphia, Cincinnati, Chicago, Detroit, San Francisco, Los Angeles, El Paso and Albuquerque, with the idea of improving safety in operations. The studies resulted in the creation of a triple airway between Richmond, Washington, New York and Boston; a dual airway between Detroit and Chicago and a by-pass around Cleveland; and a dual airway from Pittsburgh to Washington. Also as a result of these studies, three low frequency ranges were installed, seven VHF ranges, and three H type facilities; approximately 25 range courses were shifted, numerous frequencies changed, and innumerable traffic control procedures initiated or altered. This entire program was designed to improve safety and efficiency of airway traffic. In addition, the airlines were seeking to develop the ultimate safe and efficient methods of air navigation and traffic control, and of landing under adverse weather conditions. Seven highly trained ATA specialists were working on problems to be encountered during the next five years, a total of \$250,000 was spent on that program during 1946, and in excess of \$200,000 was appropriated for the first six months of 1947. Besides the collective effort of the airlines toward the improvement of safety and efficiency, American Airlines, United Air Lines, Transcontinental & Western Air and Pan American had active air navigation-traffic control units working on various methods and devices to improve safety under adverse weather conditions. Those companies spent more than a half million dollars in 1946 on that project alone.

In addition to the ATA efforts toward nation-wide improvement of safety and efficiency in aviation, some personnel devoted their entire time to safety and efficiency of operations in international commercial aviation. It entailed working with our own Governmental agencies and various international groups, such as PICAQ, to insure international development of operational standards as high as those maintained for U. S. flag air carriers operating at home and abroad.

There also was constant improvement of general operating methods, personnel training programs, maintenance equipment and procedures and aircraft and accessory design. The ATA held that every instrument landing runway should be equipped with high intensity runway lights, and approach lights should be extended for 3,000 feet from each end of those runways, that this type of installation should be standard at all airports which scheduled airlines were required to

serve under instrument conditions. The lights should be the newest type of high intensity light. The CAA was installing 1,500 feet of neon approach lights at selected spots, but the ATA found them unsatisfactory, and the length to which the approach lights were extended was not adequate. ATA held that the instrument landing system, known as the ILS, should be installed, with localizer and glide path in two directions at the busy airports and in one direction at the airports having less traffic, further that everything possible should be done to accelerate the installation program so that automatic approaches could be made under adverse weather conditions at the earliest possible date. Utilization of the ILS with the airborne equipment, including automatic pilot and an electronic bracketing device, constituted a proven method of low, safe approaches under adverse weather conditions, ATA maintained, adding that GCA could be utilized as an added precaution and safety measure for monitoring those approaches, as well as being available as stand-by emergency equipment. The



SECTION OF DOUGLAS DC-6 SLEEPER



DOUGLAS DC-6 INTERIOR

ATA experts also maintained that Ground-Controlled Approach, GCA, should be installed at all airports having heavy traffic, that GCA information should be available in the airport control tower to coordinate traffic properly. The airlines trade association also urged that a study should be made to determine where low frequency ranges would be relocated to provide straight-in approaches, thus eliminating the necessity of circling the airport under adverse weather conditions, that this should be done, notwithstanding that the omni-directional range and distance-measuring equipment, planned for installation by the CAA, might eliminate use of present-type facilities. The new installations were not to be effective for at least three to five years. ATA urged that FIDO should be installed at several strategic high-density traffic points in the United States to provide the pilot a safe ceiling and visibility under otherwise zero-zero conditions.

At the beginning of 1947, the expanded international routes authorized for United States carriers radiated from 21 cities to every corner of the world. They involved eight domestic carriers new to

overseas operations. The authorized route mileage was divided as follows: American Overseas 9,066, Braniff 7,600, Chicago & Southern 3,693, Colonial 1,600, Eastern 1,957, National 439, Northwest 14,640, Pan American 100,612, Panagra 10,666, TWA 20,869, United 2,400, UMCA 382, Western 1,564.

While the international service was being expanded steadily, it was impressive enough early in 1947. Pan American was operating 59 foreign schedules, among them once a day between New York and London, twice a week between New York and Vienna, twice a day between San Francisco and Honolulu, twice a week to Manila, five trips daily between Miami and Buenos Aires, 20 daily to Havana, twice a day to Mexico City. American Overseas had eight trips weekly between New York and London, twice a week to Stockholm, once a week between Washington and Amsterdam, and several other schedules. Northwest among its schedules had a daily trip between New York and Anchorage, Alaska. Colonial flew New York-Montreal service nine trips daily and to Ottawa twice daily, besides other schedules. TWA had a twice-weekly service between New York and Cairo, once a week to Athens, thrice weekly between New York and Paris, once a week to Rome, besides many other schedules. Among the foreign lines already operating to the United States were the British BOAC four times weekly between New York and London, Air France twice a week between New York and Paris, Scandinavian Airlines thrice weekly between New York and Stockholm and KLM twice weekly between New York and Amsterdam. Those schedules were only the start of a complete world-wide network.

Through action of the United States Senate in ratifying the international civil aviation treaty covering the less controversial matters prepared at the Chicago Conference of 1944, the United States became the 10th signatory nation to establish a permanent International Civil Aviation Organization and a basic set of standards to govern world air traffic. It was due to come into force on March 1, 1947, when ratified by 26 of the 52 nations, including the United States, which participated in the Chicago meeting. The first Assembly of ICAO was scheduled for May 4, 1947. A Provisional ICAO had been functioning at Montreal, the organization's permanent headquarters. The PICAO, in 1946 comprising 46 nations, was progressing with technical flying practices and standards throughout the world, but it did not have any economic powers; that is, it was concerned with how to fly, but not where to fly. The United States announced that it would withdraw from the "five freedoms" international air transport agreement because of the failure of big air-power nations to adhere to it. The action

did not mean, however, that the United States was abandoning the principle of the "five freedoms," because it had already negotiated bilateral air-freedom agreements with 29 nations and would seek more such pacts with the other nations represented at the Chicago Conference. Failure, at least temporary, of the multilateral policy was attributed to the controversial elements of international air control, including traffic and landing rights.

The international route pattern, so far as concerned the United States, was virtually completed by major CAB decisions in 1946. American Airlines, Braniff, Chicago & Southern, Eastern, National and Western were awarded Latin American routes in competition with Pan American and Panagra, which obtained additional grants there. In the same proceeding, CAB granted Colonial a route from Washington and New York to Bermuda. United States cities affected by the new Latin routes were El Paso, San Antonio, Fort Worth-Dallas, Houston, Laredo, Brownsville, Corpus Christi, New Orleans, Miami, Tampa, Washington, New York, Los Angeles and San Diego. A number of the services were held up until agreements could be reached with several Latin American countries. The CAB Pacific decision made Pan American a round-the-world carrier and created another two-carrier global service over the combined routes of TWA and Northwest, connecting at Shanghai. The Pan American North Atlantic and Pacific routes joined at Calcutta. The Northwest route was: New York-Chicago-Seattle to Manila, via Minneapolis-St. Paul, Edmonton, Anchorage, the Aleutians, the Kuriles, Tokyo, Seoul (Korea), Harbin, Mukden, Dairen, Manchuria, Peiping, Nanking and Shanghai. That line started its Alaskan sectors late in 1946, and was due to send to Tokyo three trips weekly early in 1947. Pan American's existing authorization was extended from Manila to Batavia (Java) via Saigon and Singapore; from Hong Kong to Calcutta via Saigon, Bangkok and Rangoon; from Midway Island to Hong Kong via Tokyo and Shanghai; from Honolulu to Wake Island; and from Noumea, N. Cal., to Sydney, Australia. The TWA route was extended from Bombay to Shanghai, via Calcutta, Mandalay, Hanoi, and Canton. United Air Lines had previously been granted a route from San Francisco to Honolulu, and was planning to begin two round trips daily in early 1947. CAB finally rounded out the route pattern proposed in 1944 when in August, 1946, it awarded Pan American two routes to Johannesburg and Capetown, South Africa, one via the Azores, Dakar, Monrovia, Accra and Leopoldville; and the other from Natal (already on its South American route) via Ascension Island and Angola on the west coast of Africa.

Despite the difficulties of a reconversion period replete with problems both general to American business and peculiar to international civil air operations, Pan American World Airways rounded out 1946, the first full year of peace, with new records for the volume of passengers, mail and express moved in overseas flight. A detailed, long-range planning program, worked out well before the war, made it possible for Pan American speedily to resume civil operations over its prewar airways and at the same time to move forward rapidly in the development of new routes and services. Keystone of this planning was a sound new financing program to cover postwar development, including purchase of new flight equipment costing \$100,000,000. Consequently, when the war ended, and the first modern four-engine aircraft, Douglas DC-4s and Lockheed Constellations, became available for commercial use, Pan American pressed them into service on its transatlantic routes to Europe and Africa, on its transpacific airways and in its many Latin American operations. Meanwhile, it was awaiting delivery of the first of the great four-engine aircraft embodying all the advances of wartime development and research, the double-decked Boeing Stratocruisers and the Republic Rainbows, as well as the advanced type twin-engine Clippers for shorter runs, the Consolidated Vultee 240 transports.

While its prewar commercial airways were being reactivated, Pan American pushed extensions of routes granted by the CAB in both the Atlantic and Pacific areas, as the necessary landing rights were obtained by the Government from the various foreign countries concerned. These extensions, meeting at Calcutta, India, gave Pan American the only one-carrier American-flag air route around the world except for connections across the United States to link its Atlantic and Pacific gateways. A number of U. S. domestic carriers having been authorized to compete with Pan American overseas, the company in 1946 presented to the CAB at public hearings its case for coast-to-coast and border-to-border service within the U. S., seeking authority to operate high-speed, long-haul, non-stop service linking the 13 U. S. gateway cities it had been authorized to serve on its international routes. In the Pacific, operational survey flights were completed on routes to Japan, China, French-Indo China, Thailand, Malaya, Burma, Java and India.

Pan American's Atlantic Division, based at LaGuardia Field, New York, broke all commercial records for over-ocean flying in 1946. The 69,000 passengers carried by this division during the year more than tripled the total for the previous year. Clippers roared in and out of New York on flights to London, Shannon, Vienna, and Leopoldville,

Belgian Congo, day and night to pile up 1,162 crossings of the Atlantic, in addition to a shuttle service to and from Bermuda, flying a total of 157,950,000 passenger miles. The Clipper fleet, first Douglas Sky-masters and later all Lockheed Constellations, flew 5,437,000 plane miles while averaging three Atlantic crossings daily. Despite a six-weeks nationwide grounding of the Constellations by the CAB, Pan American's Atlantic division completed 93 per cent of its scheduled miles by calling in planes from the company's Miami and San Francisco headquarters and by running extra sections later. Besides passengers, the Clippers transported 837,800 pounds of revenue express; 359,500 pounds of United States mail, and 181,000 pounds of foreign mail. The mail figures, aided by a reduction in foreign mail rates that took effect in the Fall, climbed steadily during the closing months of 1946. Pan American pushed its Atlantic Clipper route mileage to approximately 23,000 miles. The most substantial addition to the total was the inauguration on June 15 of twice-weekly service to Vienna, which pioneered the first direct commercial air service between New York and Middle Europe, 4,240 miles requiring 16 flight hours via London, Brussels and Prague. Addition of the Vienna flights raised to 26 the number of weekly ocean crossings by 1947. In addition there were extra Shannon runs and daily Bermuda round-trips.

On its first commercial flight for the Company, a Constellation Clipper roared down to Bermuda in 2 hours, 22 minutes with 42 passengers aboard. Demonstrating just as much speed in trans-Atlantic hops, a Clipper swooped into Lisbon 9 hours, 58 minutes out of New York, while a sister ship spanned the Atlantic to Shannon in 9 hours, 10 minutes. Both flights were non-stop, and the planes averaged nearly 350 miles an hour with the aid of tail winds. The Lisbon flight carried 25 passengers and a ton of express, and the Shannon flyer, a payload of more than 2,600 pounds, including 15 passengers.

Pan American's Pacific-Alaska Division, with headquarters at San Francisco, changed over from wartime operations under a Navy contract to expanded service for civilian passengers, mail and express. The old war horses of the transocean routes, the 42-ton-Boeing-built flying boats, were replaced by speedier four-engine land planes and scheduled frequencies between San Francisco and Honolulu increased 300 per cent; plane seats, available, 556 per cent. Flying time was reduced by more than five hours.

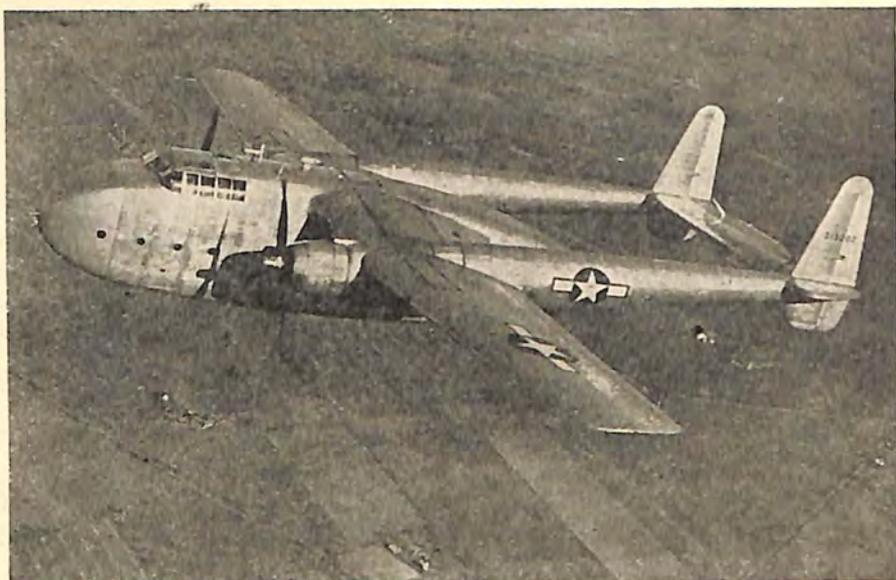
On June 1, regular service was resumed over the line's South Pacific route, from San Francisco to Honolulu, Canton Island, Suva, Noumea and Auckland, New Zealand. In December, 1946, the sign-

ing of the United States-Australian air agreement gave the green light to preparations for regular Clipper service from San Francisco direct to Sydney, Australia. Service to Manila, via Honolulu, Midway, Wake and Guam, was also resumed, but deterioration of wartime communications facilities on the Central Pacific islands made it necessary to order a temporary suspension of Clipper routes over this route west of Hawaii. This route was reactivated early in 1947.

Among special missions during the year was a series of special charter flights undertaken for the United Nations Relief and Rehabilitation Administration to speed the transport of key relief officials and supplies to China in the course of which Pan American made the first flights with civil aircraft over the short northern route and the sub-Arctic.

Four-engined flight-equipment went into service on virtually all routes in Pan American's Latin American network in 1946. Twenty-two Douglas DC-4 type Clippers went into service in this division, with headquarters at Miami, and 20 more were due to join the fleet early in 1947. Ground facilities, maintenance shops, airways, navigational aids and personnel were expanded proportionately as new routes were opened, schedules increased as much as 300 per cent and flight times between North and South American cities cut sharply. With the new Clippers, fast direct flights were made down the east coast of South America, and daily non-stop flights were begun between Miami and Puerto Rico, Panama and Curaçao. In July, 1946, the division linked New York and Latin American capitals directly for the first time, with service from LaGuardia Field via San Juan, Puerto Rico. Another new gateway was added in December, when service was begun between Houston, Texas and Central and South America. The Latin American division in 1946 carried approximately 738,850 passengers on all routes, 89 per cent above the 1945 total of 390,426 and 310 per cent over the 180,220 passengers in 1941.

In passenger miles flown during 1946, Pan American showed a 71 per cent increase over 1945 and a gain of 459 per cent over 1941. The totals were: 525,047,073 passenger miles during 1946; 306,107,550 during 1945, and 93,951,697 during 1941. Also reflecting the tremendous expansion in post-war operations were the total ton-miles flown during 1946, up 450 per cent over 1941 and 68 per cent over 1945. The 1946 ton-mileage totaled 66,348,241, compared with 39,518,746 ton-miles in 1945 and 12,062,302 in 1941. Biggest percentage of increase in any department was in the air express division, where total shipments rose 761 per cent from 1,754,014 pounds in 1941 to 15,106,845 pounds in 1946.



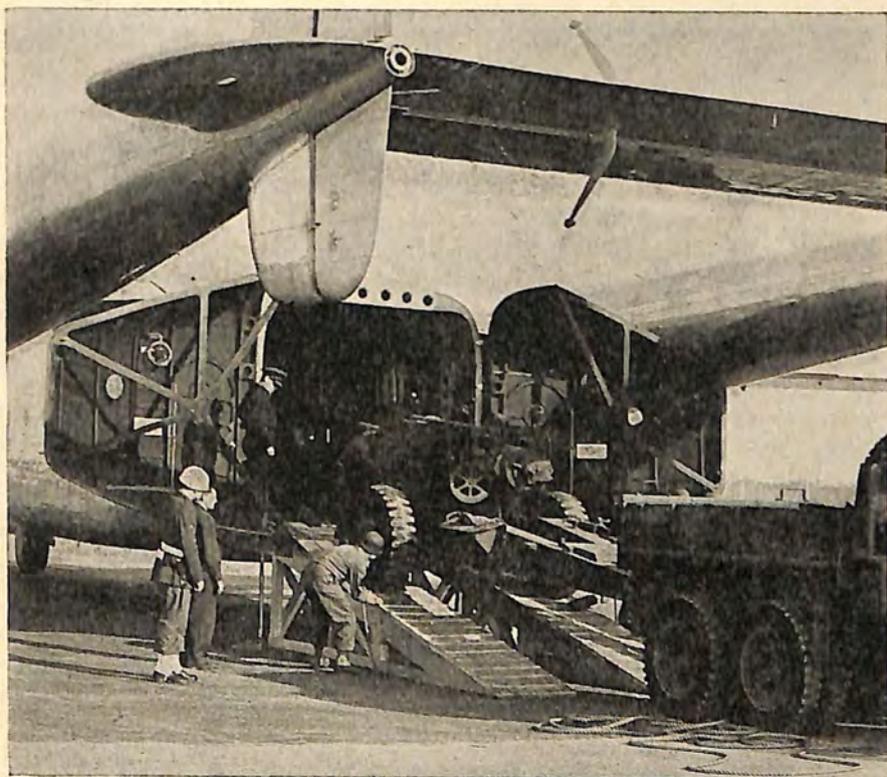
FAIRCHILD C-82 CARGO PLANE

Despite the sharp decline in overseas soldier mail after the end of the war, airmail shipments in 1946 showed a slight gain over 1945. This was due in large part to lower airmail rates put into effect by the Post Office Department in October. Airmail carried on all PAA's Latin American routes in 1946 totaled 3,482,804 pounds, compared with 3,334,841 in 1945 and 1,244,293 in 1941.

Despite rising costs and talk of higher fares which was general in the transportation industry at the close of 1946, Pan American made a fourth postwar reduction in fares, affecting more than 3,000 specific rates.

TWA's Trans World Airline started its overseas service to Ireland and France on February 5, 1946, and during the year extended operations to Bombay, India, with 11 intermediate stops. In 1946, Trans World Airline flew over 5,000,000 miles, carried 32,739 revenue passengers a total of 108,706,663 revenue passenger miles, and at the same time flew over 1,500,000 mail ton-miles and 900,000 express and freight ton-miles. At the beginning of 1947 TWA was operating 15,169 of its authorized route miles and planned early extension of service between Washington and Shanghai via Cairo, Bombay, Mandalay, Hanoi and Canton.

American Overseas Airlines in 1946 opened new routes, the first air carrier to start direct air service from the United States to the Scandinavian countries, the Netherlands and Germany. These additional routes combined to mark a 65 per cent increase in the company's route mileage over 1945. Traffic figures for the close of 1946 indicated an increase of nearly eight times the total of passengers, and twelve times the volume cargo over 1945. During the suspension of U. S. co-terminal service from Boston, Washington, Philadelphia, and Chicago during the summer due to a temporary shortage of equipment, AOA maintained its number of weekly transatlantic trips. Early in 1947, the company was operating 16 round trips weekly to Europe for a weekly distance of 119,226 miles flown—a jump of 140 per cent over the weekly route mileage in a year. During 1946, AOA's Flagships flew 5,188,615 route miles, an increase of nearly 400 per cent



LOADING FAIRCHILD C-82 PACKET

over 1945 operations. An average of 93 passengers a day was flown over the Atlantic in 1946, a total of 34,137 passengers, a 682 per cent increase over 1945, and a total of 115,276,881 passenger miles. AOA flew 1,067,583 pounds of cargo, 922 per cent over 1945, and 615,992 pounds of air mail, more than twice that carried in 1945. AOA flew 15,047,751 ton-miles, 600 per cent more than in 1945.

As a further step toward better passenger service, special training courses were conducted for AOA personnel dealing directly with passengers both on the ground and in the air. AOA ticket agents, passenger service representatives and stewardesses were briefed on general conditions in foreign countries as regards local travel and accommodations and requirements necessary for entrance to individual countries including customs regulations.

The steamship lines of the United States recognized the tremendous future of air transportation and planned to operate their own air services in conjunction with their established shipping business. There had been various applications for Government permission to operate such services since 1939 when American Export filed for certification on the North Atlantic route. Eleven companies formed the Sea-Air Committee, including Atlantic Gulf and West Indies Steamship Lines, Grace Line, Matson Navigation Co., Moore-McCormack Lines, Oceanic Steamship Co., Seas Shipping Co., American South African Line, United Fruit Company, Waterman Steamship Corporation, United States Lines and American President Lines. The Committee headquarters was located in Washington, with the avowed purpose of bringing about a factual understanding of the relationship of American shipping to overseas transportation, whatever the media. Having been refused air certificates by the Civil Aeronautics Board, nine of the companies petitioned the CAB through their Sea-Air Committee on July 31, 1946, for a reappraisal of the Board's policy as regards steamship line participation in overseas and foreign air transport.

The petitioners pointed out that "Through the vast network of organizations that the sea carriers already have built up in foreign countries, there exist not only valuable agencies that will afford advantages for our own citizens traveling in, or shipping products to, distant lands, but also effective soliciting organizations that will attract air traffic from a wider area than our established air carriers can hope to serve, all of which will enhance the general welfare of our country and will promote the needs of our foreign and domestic commerce."

They also stated: "There is nothing that precludes the CAB from developing, fostering and encouraging air transportation through sea as well as through other carriers, particularly where economic neces-

sity will compel sea carriers to furnish air service, if they are to meet an ever-increasing foreign competition. The very fact that they recognize the necessity of supplementing their sea carriage with air service is persuasive of the fact that they will, if permitted, effectively furnish and develop such a service, and the Board, if it grants them certificates, will be fostering and encouraging air transportation as contemplated by the Act."

All except one of the eleven companies of the Sea-Air Committee had filed applications with the CAB for certificates of convenience and necessity. The one exception was United States Lines, whose agency agreement with Pan American was still in effect despite the recent order of the CAB for U. S. Lines to show cause as to why this agreement should not be terminated. The refusal of certificates had been



THE MARTIN 202 AIRLINER

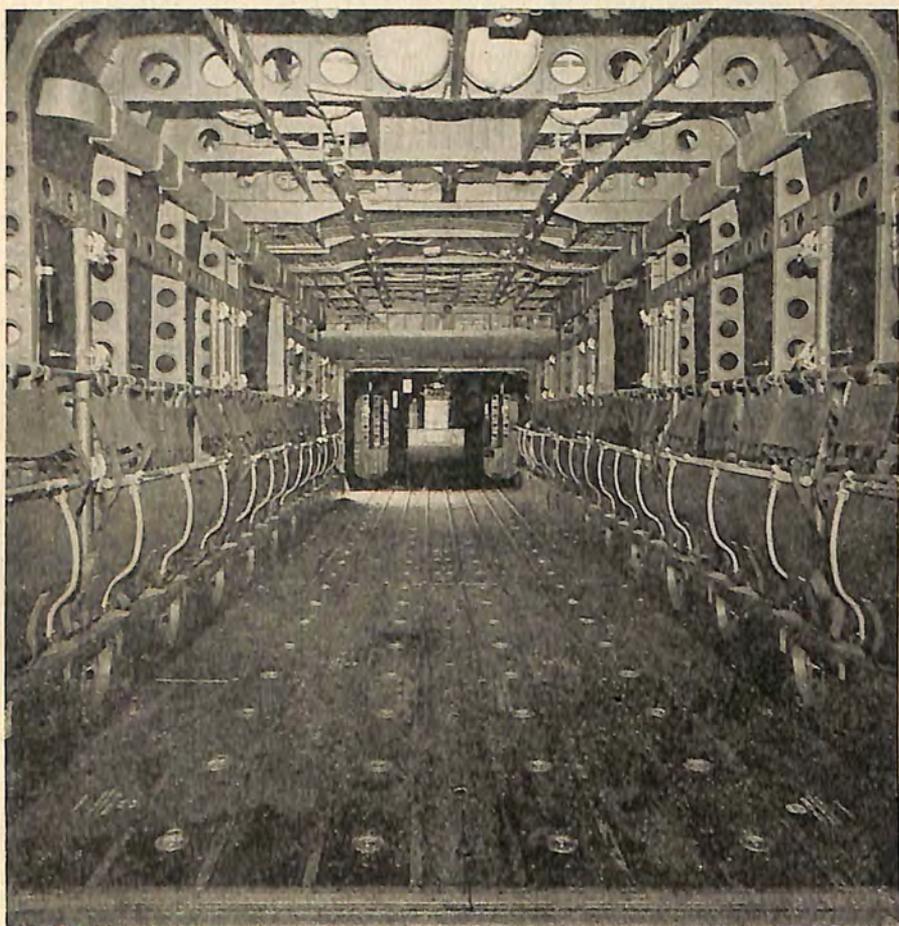


LOUNGE ON THE BOEING STRATOCRUISER

based upon the interpretation by the CAB of Sections 401 and 408(b) of the Civil Aeronautics Act, 401 providing "The Authority shall issue a certificate authorizing the whole or any part of the transportation covered by the application, if it finds that the applicant is fit, willing, and able to perform such transportation properly, and to conform to the provisions of this Act and the rules, regulations, and requirements of the Authority hereunder, and that such transportation is required by the public convenience and necessity."

Section 408(b) stipulated that: "Any person seeking approval of a consolidation, merger, purchase, lease, operating contract, or acquisition of control, specified in subsection (a) of this section, shall present an application to the Authority, and. . . Unless, after such hearing, the Authority finds that the consolidation, merger, purchase, lease, operating contract, or acquisition of control will not be consistent with the public interest or that the conditions of this section will not be fulfilled, it shall by order, approve such consolidation, merger, purchase, lease, operating contract, or acquisition of control, upon such

terms and conditions as it shall find to be just and reasonable and with such modifications as it may prescribe *Provided*, That the Authority shall not approve any consolidation, merger, purchase, lease, operating contract, or acquisition of control which would result in creating a monopoly or monopolies and thereby restrain competition or jeopardize another air carrier not a party to the consolidation, merger, purchase, lease, operating contract, or acquisition of control: *Provided further*, That if the applicant is a carrier other than an air carrier, or a person controlled by a carrier other than an air carrier or affiliated therewith within the meaning of section 5 (8) of the Interstate Commerce Act, as



INTERIOR OF FAIRCHILD C-82 PACKET



LOCKHEED CONSTELLATION

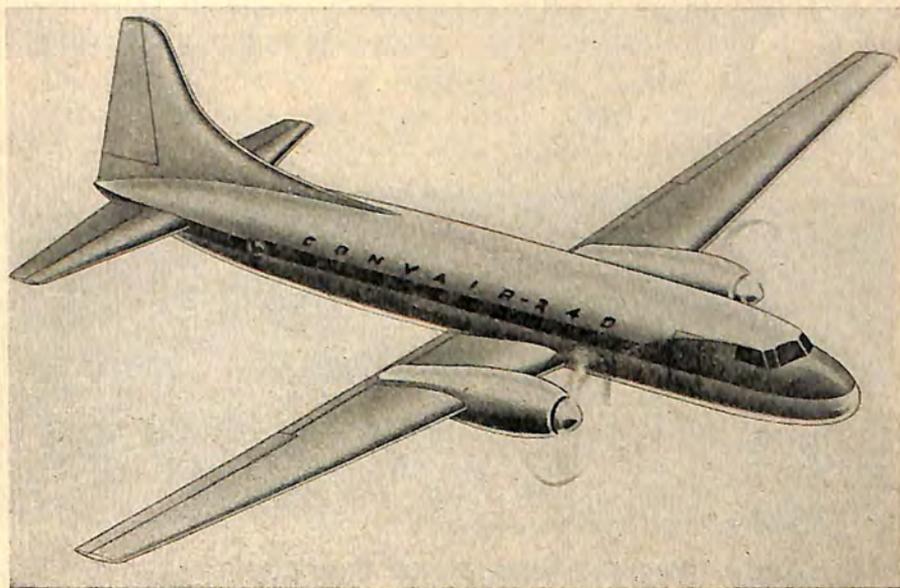
amended, such applicant shall for the purposes of this section be considered an air carrier and the Authority shall not enter such an order of approval unless it finds that the transaction proposed will promote the public interest by enabling such carrier other than an air carrier to use aircraft to public advantage in its operation and will not restrain competition."

The Sea-Air Committee pointed out that Section 2 of the Civil Aeronautics Act stipulated: "The encouragement and development of an air-transportation system properly adapted to the present and future needs of the foreign and domestic commerce of the United States, of the Postal Service, and of the national defense."

The Committee declared that U. S. maritime companies demonstrated their fitness, willingness and ability as cited in Section 401 by their interest in aviation prior to the passage of the Act. United Fruit operated the first public service airline in Central America in the early 1920's. Matson Navigation initiated transpacific air studies in 1929, and on June 20, 1935, concluded an agency agreement with Pan American to expedite the setting up of the first transpacific air service. The United States Lines concluded an agency agreement with Pan American on July 1, 1935, to facilitate air service on the North Atlantic route. It was W. R. Grace & Co., owner of Grace Line and other interests, that jointly pioneered with Pan American the first air service to the West Coast of South America, known as Panagra, in 1929. Subsequent to the passage of the 1938 Civil Aeronautics Act

still a fifth steamship line, American Export, applied for permission to operate an air service in conjunction with their shipping services across the North Atlantic. A temporary certificate was granted by the Board in 1940, but was promptly rescinded at the cessation of hostilities, and American Export ordered to divest itself of control of the airline.

In 1946, Waterman Steamship Corporation bought a substantial interest in TACA. In collaboration with Pennroad Corporation, Waterman bolstered shaky TACA finances with a large cash advance, and received in return convertible notes and a variety of purchase options on both outstanding and unissued stock. TWA's entire interest in the company was involved in the transaction. Thus Waterman at last obtained the operating hand in an overseas air service for which it had been trying for seven years. The TACA network branched from Central America into the Caribbean and South America. An operating company in the TACA chain held permits of entry into the United States. With its TACA holdings, Waterman's aviation interests assumed sizable proportions. During 1946, the corporation's aviation arm—Waterman Airlines—flew a scheduled intrastate service in Alabama and conducted vigorous non-scheduled operations



CONSOLIDATED VULTEE 240 TRANSPORT

which extended to the Pacific, Europe and the Middle East, as well as their area of primary trade interest, the Caribbean. A significant comment on Waterman's operating abilities developed during hearings, in October, 1946, on the corporation's application for a temporary certificate from New Orleans to Puerto Rico, which followed the CAB denial of the steamship line's earlier request which had been incorporated in the Latin American route case. The Waterman air branch reported a \$19,000 profit for three months non-scheduled operation of a single DC-4. This was accomplished in a period when scheduled carriers were recording sharp drops in revenue.

Matson Navigation Company in 1946 operated a passenger and cargo air service on a contract basis between points on the Pacific coast and Honolulu using DC-4s. It carried more than 500 passengers and substantial cargo. Matson also operated a maintenance, overhaul and modification center at Oakland, Calif., on C-54 type transports begun during the last war with a personnel of 638.

The Sea-Air Committee held that those activities not only demonstrated the companies' ability and fitness to operate airline services, but showed that aviation could derive great benefits from the steamship techniques built up by a century or more of successful international trading. The committee maintained that interchangeability of weather reports, ship and plane positions, "know-how" with respect to exchange, customs, travel habits and trade conditions, were invaluable assets which air transportation needed for its future development.



ERCOUPE WITH BEECH PROPELLER

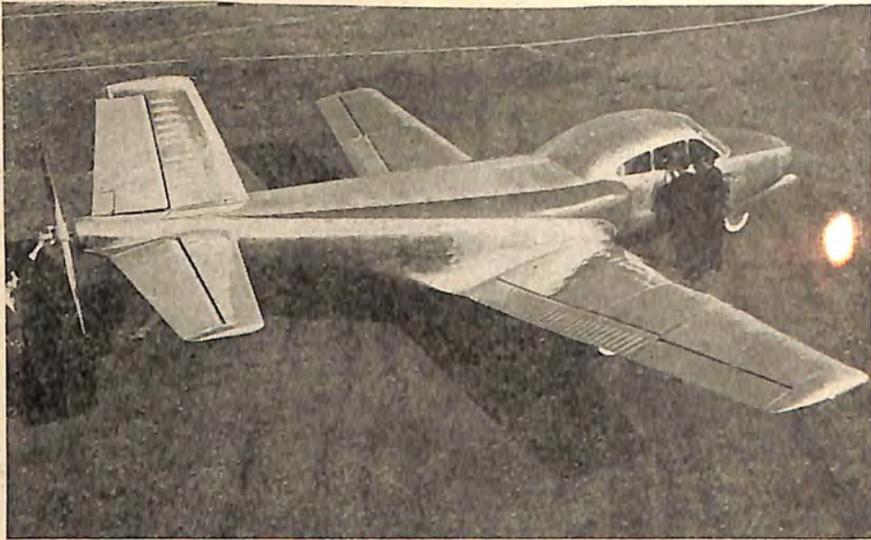
## CHAPTER VI

### PRIVATE AND NON-SCHEDULED FLYING

More Than 30 Different Models of Personal Aircraft Available to Private Owners—Survey by Personal Aircraft Council, Aircraft Industries Association—Personal Planes Become More Useful—Economy of Private Flying Compared to Surface Travel—Activities of Aircraft Owners and Pilots Association—The Civil Air Patrol.

**A**T THE beginning of 1947, there were 400,061 licensed pilots in the United States. Of the total, 7,654 were airline pilots, 203,251 were commercial licensees, and 189,156 were private pilot licensees. A majority of the commercial licenses had been granted pilots who had served in the air forces during the war, and whom the CAA had invited to accept commercial licenses. Many of them were operating private and executive planes in all kinds of operations. There were 85,000 aircraft certificated by the CAA on January 1, 1947. Nearly 80,000 of them were operated by private owners, business houses, charter services and schools.

There were more than 30 personal aircraft models, including helicopters, for the private owner to consider when buying a flying machine for business or pleasure. They ranged from two to seven-place machines. No less than 17 companies were actively competing for sales in this field alone, and there were as many more companies, groups and individuals hard at work on experimental models, some conventional, others radical and dangerously so. It was much easier to buy a plane than a motor car, and one's purchase could be financed in precisely the same way. At the overall personal plane production peak in August and September, 1946, manufacturers were reporting deliveries to dealers and other buyers, including export, aggregating more than 4,000 aircraft a month. To that total should be added the hundreds of larger aircraft, normally in the airline and feeder line classes, which were bought by companies and individuals for their own use in personal transportation. The aerial service operators bought many of the small transports as well as large numbers of light planes. Government surplus supplied the market with additional planes of all classes. Veterans and schools took a majority of the



DOUGLAS CLOUDSTER

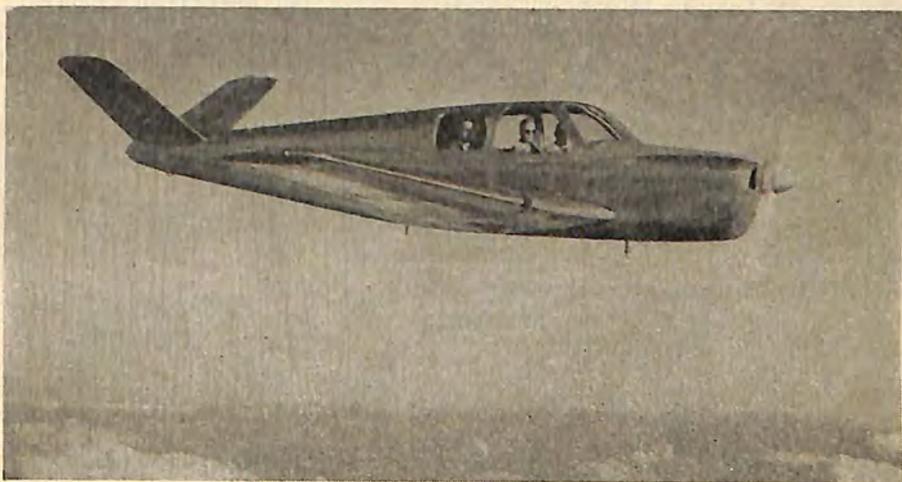
surplus sold in the domestic market. Of all the new planes sold in 1946, the flying farmers and ranchers bought a majority. This was especially true of light aircraft like the Piper Cub which had such slow landing speed that it could operate from relatively small fields day in and day out, and thus required very little in the form of a landing field. The export markets promised to be a rapidly developing sales outlet for personal aircraft in 1947, as well as for heavier planes.

One of the most comprehensive surveys of the status of personal flying was made by Joseph T. Geuting, Jr., manager of the Personal Aircraft Council, Aircraft Industries Association. "Research in personal aircraft is going on continually," he said. "Tests of new planes are being made. They are being subjected to every possible hardship in flying to make them more worthy and more useful to private owners.

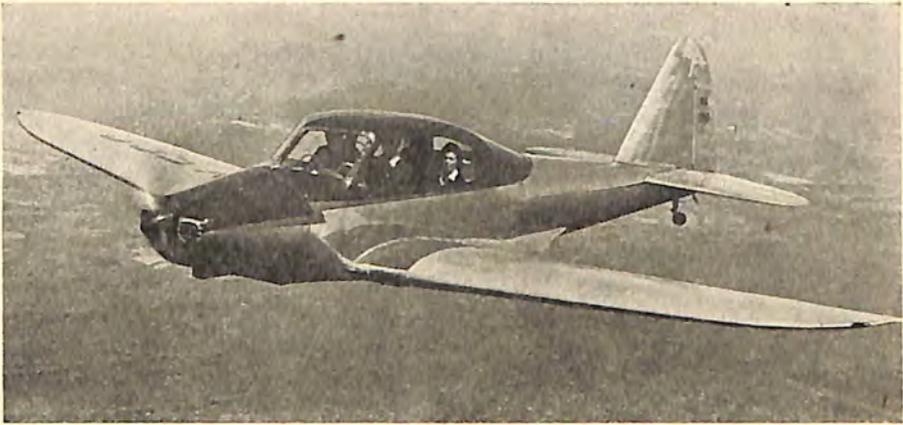
"Oil companies are now using small planes for pipe line inspection and they'll use more after small airplanes become more easily accessible. Quick action, only possible through prompt inspection by speedy planes, will save thousands of dollars. Cattlemen find the small plane practically indispensable and wonder how they ever got along without it. Strayed cattle are easily discovered and turned in the right direction. Cattle roundups are handled by airplane in a fraction of the time

formerly needed for work by horseback. Where men can fly, merchandise can also speed through the skies. Small replacement parts can be flown by personal plane as can emergency shipments. Air freight moves at approximately 25 times the speed of water transportation. Many of the largest corporations in America have adopted company owned airplanes for the purpose of transporting their top executive personnel. Up to the present time, this has been confined more or less to highly paid executives. But new planes now serve profitably as vehicles for the transportation of the most moderately paid employees. One aircraft corporation has made some interesting cost breakdowns in this field. According to these comparative travel cost statistics, if a company pays an employee as much as \$96 a week, for example, that company can better afford to send him alone on a trip in a plane with a paid pilot than have him take a train to the destination. When two employees travel together, their company can afford air transportation, rather than the usual time-consuming surface traveling, even if the rate of earning is as low as \$20 a week per individual. Further, if three employees are routed from plant to plant, or city to city, then the plane operates more cheaply than even the cost of rail coach tickets alone, without regard to salary costs.

"Salesmen find that the use of such an airplane makes it possible to cover their territory more often without increasing their transportation expense. It permits them to get home more often and stay there longer. One aviation leader predicting that flying will become the



BEECHCRAFT BONANZA

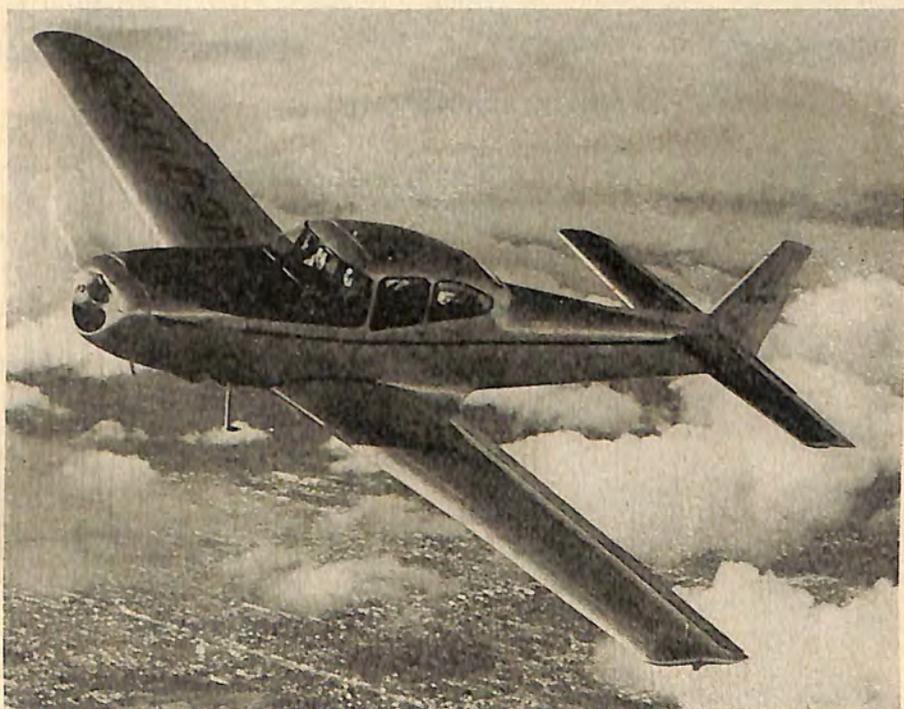


PIPER PA6 SKYSEDAN

most popular means of transportation for business or just for fun explains: 'Flying is the most flexible means of transportation the world has ever seen. You can travel by boat only where there is water, by automobile only where the highway leads, by train only where the tracks are. The air is everywhere.' The doctor, particularly the one who must cover an extended territory or be ready to reach patients miles away with the least loss of time is an ardent advocate of personal flight. Other professional men, veterinarians, lawyers, clergymen use the personal plane to reach their clients. Farm agents cover more territory. Business executives make quick check-ups in the field. One field that has developed remarkably and shows signs of being one of the most interested in the use of the small plane is that of farming. Frankly, this has surprised many of us, but then the whole field of aviation is one of surprises. There is now a national organization of flying farmers with chapters in the various States. This is an extension of the original flying farmer group that started in Oklahoma a few years ago. It is impossible to list the various ways that have been reported. It seems that they use the plane in just about every imaginable way to aid them in their work and to give their families flying pleasure. Apart from the matter of flying to other towns to see relatives or flying to various fairs and conventions, they use the plane daily in their farm work. Some of the more common uses are inspecting crops, checking cattle herds and fences; shooting coyotes and other pests; getting farm machinery and parts with minimum delay; delivery of light produce to market; flying food or mail to

snowed-in or isolated neighbors; flying to market to check market conditions; aiding in crop planting plans and developing new land; seeding, dusting, fertilizing; flying medicine and doctors to the sick and the sick to hospitals.

"We have tried to check the ways by which personal planes are used by families, and discovered that they are used in just about every way that an automobile can be used, especially on trips that are reasonably long or over rough terrain. One family told us that by using their plane they could reach a town that was nearby as the crow flies but which took hours to reach over two mountain crests when the family auto was used. In the family plane they were able to skim right over to town within 20 minutes or so. People are flying to vacation resorts in ever-increasing numbers. Miami and other places in Florida now expect a number of these planes to alight with a load of people every hour or so. Many resorts, looking ahead to this influx of vacationists by air, are planning extensive air fields and other



NORTH AMERICAN NAVION



REPUBLIC SEABEE AMPHIBIAN

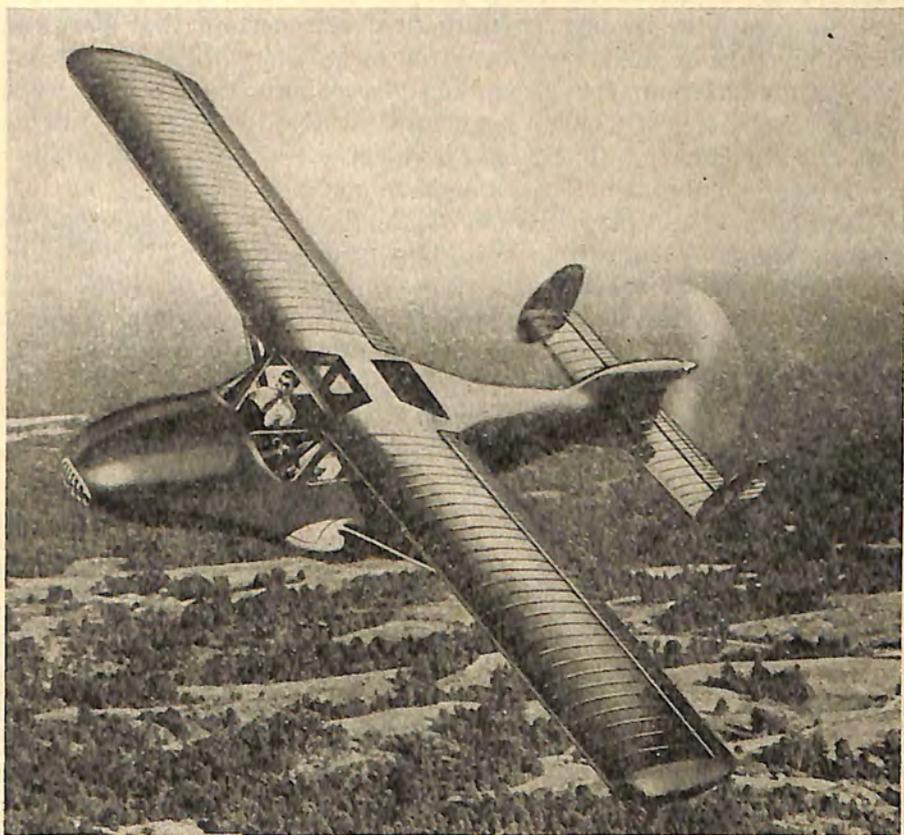
conveniences for air-minded travelers. A popular diversion for personal plane fliers is the flight tour. These take various forms. The aviation departments of several States have planned round-the-State tours conducted two or three times a year. Other groups have arranged longer tours, to Florida or California, or other points of interest. These are not small matters, often hundreds of flying families join in. That is only a hint of what may be expected tomorrow when planes are readily available.

“Many enthusiasts predict that with the growth of personal aviation, the outlying sections of prominent cities will grow apace, and many real estate men take the idea seriously enough to be securing options 50 to 100 miles from town. Fishing and hunting trips by air attract hundreds. Many travel to Canada or the northern part of our own country for game that is scarce elsewhere. Fishermen fly to Florida and the Gulf. In a matter of hours they can switch from their home centers or places of business to the remotest sections of the country, spend whatever time they have on hunting and fishing, then return home over night. The flying shopper is now a reality. Department stores welcome the flying family that comes to town to shop,

with special airfields and special transportation to and from the store.

"Personal flying never can become universally popular until there are landing places wherever the flyer may wish to go.

"Development of the automobile was stymied, as we all know, for many years until suitable roads were built. Of course, the personal airplane needs no special roads, the air is vast, but it does need places to land, to takeoff, to be stored and serviced. In addition, an adequate number of landing facilities spaced not too far apart would take care of at least part of our other only serious overall problem, weather. 'The airport is the basic facility of aviation just as the highway is the basic facility of automotive transportation, or harbor facilities are basic to water transportation,' explains the CAA. People, towns and the Federal Government realize this and are starting to do some-



WACO ARISTOCRAFT

thing about it. It will take time, particularly with delays caused by the slow functioning of the Federal and State Governments, and many communities will not await the ponderous machinery of politics and government. They now are building their own landing facilities; but of course, right now they are handicapped by the restrictions imposed by the building program.

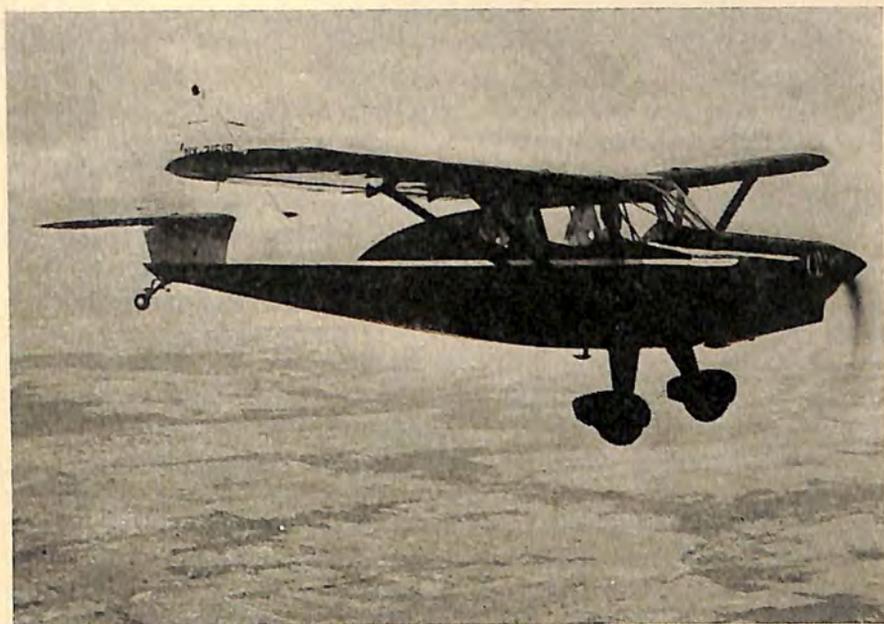
"In initial studies, the Personal Aircraft Council found that one of the greatest obstacles to an appreciation of this problem was a lack of terms to describe adequately what was needed. Over the years, the word airport has come to have a generally accepted meaning as a terminal landing facility costing many thousands, or perhaps I should say, many millions, of dollars, with elaborate hangar and other installations, and used by the scheduled airliners. In a few places, it may be that these airports will provide some space and service for personal planes; but with the rapid growth of the airlines and their limitations in regard to landing facilities, it seems certain that personal planes must have their own facilities everywhere. To distinguish between the different types of landing places, according to their uses, the Personal Aircraft Council suggested the words Airparks, Flight-stops and Air Harbors. These have been accepted into general aviation vernacular, and appear in Government and aviation papers.

"An airpark is a place suitable for landing aircraft, a community enterprise built specifically as a landing facility for non-scheduled or personal aircraft. Airparks with runways 2,000 feet long by 300 feet wide will accommodate the citizens of the community who want to fly, as well as those from other communities who want to visit or shop, or handle other business. Because of their relatively small size, airparks need not be unduly expensive. Many communities plan to use them as civic centers for pleasure and business as well, with restaurants, stores, hotels, libraries, golf courses and other recreational facilities. Airparks will be civic and community responsibilities in the same sense as the roads and streets on which we drive our cars.

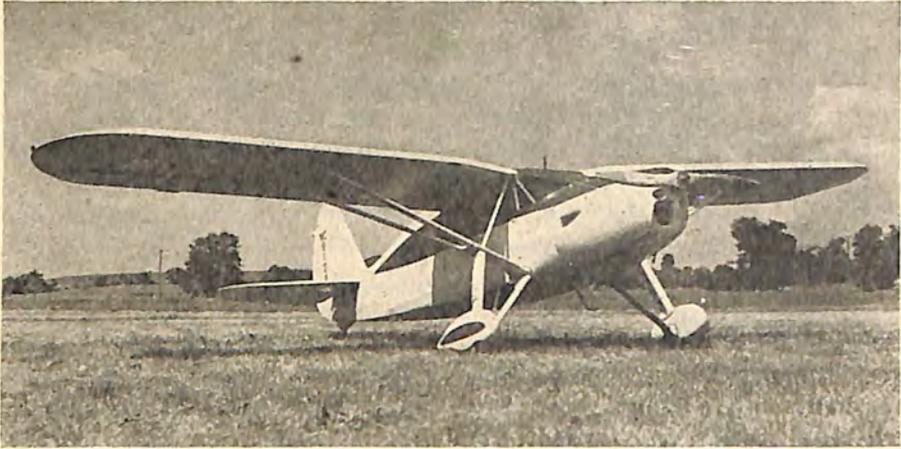
"Following the suggestions of the Personal Aircraft Council, a model airpark has been constructed in what might well be considered as an average small town, Eldon, Mo., population 2,500. A site was chosen adjacent to the residential area, only a few blocks from the downtown area, and was incorporated within the city's limits. Total cost of that airpark is about \$25,000. The field, built by the citizens of the community, has been leased to an airport management firm which has agreed to maintain a Government approved flying school, charter and plane rental service and maintenance and repair service for aircraft. Records are to be kept of all income and expense, so that

the results can be given to other communities desiring similar facilities.

“Other types of landing facilities vary because of size and facilities, but are designed to do their part in aiding personal air travel. Two other types are Flightstops, which are intermediate landings between cities, spaced at intervals for convenience of private flyers; and Air Harbors, located on bays, rivers, or lakes adjacent to a community. During the last year, we have seen passed in Congress, a Federal Airport Program allotting \$500,000,000 of Federal funds to build more than 3,000 new airports in the next seven years. In almost every instance, the Federal funds must be matched evenly by local funds. Thus there will be in all \$1,000,000,000. Seventy-five per cent of the money will be distributed by States on a basis of area and population, with 25 per cent used by the CAA as a discretionary fund to balance out the national program. The national program will give the United States a skeleton framework of the facilities necessary for a nation on wings. However, the great majority of communities will not be included in the Federal plan. To provide an adequate network of airparks, each of the more than 16,000 incorporated communities will



NEW STINSON VOYAGER



FAIRCHILD F-24

require a landing facility of some type. Some will need more than one. None of the Federal airport money can be used for construction of private airports. The Act restricts its use to public projects. This means that any State, territory, city or municipality or other political subdivision is eligible for Federal airport building funds. Private airport developers, however, can get technical help on planning from their State aeronautics agency or the CAA."

All 48 Wings of the Civil Air Patrol organized Search and Rescue Missions, and were equipped to cooperate with the American Red Cross in emergencies and disasters. Many Wings had ambulance planes, and those that did not were equipped to fly medical personnel or supplies to points where they were urgently needed. During 1946 more than 4,000 CAP missions were flown for medical aid or for the purpose of searching for lost planes or personnel. As a result, hundreds of lives were saved. In a majority of the States there were well-organized patrols of CAP flyers for the purpose of detecting forest fires and flood dangers. Since the demise of the CCC and the demobilization of the members of the armed forces who might have aided in these projects, the activities of the CAP assumed additional importance. Many of the States in the North and the West were particularly active in forest patrols. The patrols were assisted by the ground crews and communications technicians, who in many cases set up air-to-ground radio facilities for the purpose of warning the public of impending disasters. More than half of the CAP Wings had agreements with police authorities whereby the various police departments

could call upon the CAP for assistance in policing large gatherings and in the apprehension of criminals. Many stolen cars were recovered through CAP efforts, and one arsonist was caught by a CAP patrol in the act of starting a forest fire. In every Wing there were a number of flying clubs organized by CAP members. The average club had an active flying membership of 10 or 12. There were more than 200 of these organizations throughout the United States. During 1946 many Wings instituted programs of air marking. This program, for maintaining extensive safety measures, was being carried on by CAP cadets and senior members as well. Whenever paint was not available, a number of Wings arranged air marking designs in stone of contrasting colors.

Indicative of the general interest in private flying was the Aircraft Owners and Pilots Association, with headquarters in Washington, D. C. It claimed 30,000 members in the United States and Canada. In 1946, AOPA's "service to members" department answered over 8,000 requests from members for specific advice, guidance and information, in addition to the general information which was forwarded through the regular monthly special AOPA edition of Flying and the confidential Washington newsletters. One of the highlights of this department's activities was the development of the AOPA airport rating system which made it possible for all to profit by the experiences of their fellow members with regard to the best airports to patronize. Another service which had widespread interest was the AOPA insurance service.

Twenty-seven local AOPA units were reactivated in 1946. Under the guidance of the national service office, they accomplished many worthwhile achievements, such as simplification of border crossing procedures, raising funds for airport improvement, plus group flights, contests and other activities, combining pleasure with the advancement of private flying. AOPA actively participated as the voice of private flying on numerous technical committees in the field of radio, electronics, international, Federal and State law, aeronautical research, design and development. It contributed to the work of the crash injury research project of the National Research Council, and much progress was made in the field of cockpit design from the safety point of view. AOPA worked with FCC in the licensing of aircraft radios and radio operators, greatly simplifying means of licensing of airborne radio stations and the third class radio operators license. It acted in an advisory capacity in altering the Civil Air Regulations, eliminating many unnecessary restrictions formerly applying to private flying. During 1946, AOPA campaigned against unscrupulous repair base

operators, hasty and unwise legislation at all Government levels, unsafe flying techniques among members, and unwise practices of manufacturers and dealers. AOPA's plans included several new money saving services to members, projects in airmarking, airport development and improvement, streamlining of airport directory service and various campaigns to make flying more useful, less expensive and safer.

Honeymoon Isle, a semi-tropical island in the Gulf of Mexico, 25 miles northwest of Tampa, was being transformed into a most unusual airport development. A 3,000-foot airstrip, 200 feet wide, was built, and two-room guest cottages, a seaplane base, a hotel and other sporting and recreational facilities were to follow to make it a private flyer's center.



BELL 47 HELICOPTER DUSTING

## CHAPTER VII

### AVIATION TRAINING AND EDUCATION

Opportunities in the Aviation Professions and Trades—Veterans Trained for Jobs in Air Transportation and the Aircraft Factories —Tens of Thousands of Veterans Take Flying and Mechanics Courses — Aviation in the Public Schools — Courses for Aviation Teachers.

THE opportunities which aviation offered for a career did not diminish with the end of the war. They increased tremendously. Almost without exception the aircraft manufacturers were calling for aeronautical engineers by the hundreds, especially those who were working on the huge bombers and transports and the score or more of different projects involving jet propulsion. In the Army and Navy experimental laboratories, in the many college research centers and in a number of the aviation development agencies of the Federal Government the lists of technicians were being expanded month by month. Student pilot certificates issued by the Civil Aeronautics Administration increased by more than 20,000 during one month of 1946, due largely to the fact that flight training was available to war veterans under the G.I. Bill of Rights. It was the same with regard to the courses in aircraft and aircraft engine mechanics. The aviation trades schools invariably were crowded to capacity by veterans determined to make a career in one of the countless fields involving flying.

When the employment in air transport reached new high levels late in 1946, more than 30 per cent of the 87,000 employees in our domestic and foreign airline operations were war veterans who had been either newly trained or retrained for specific duties. They included flight and ground personnel, both men and women. Most of the veterans were new employees of the airlines. In March, 1946, the CAA reported the scheduled air carriers with 560 planes in operation, making an average of 152 employees per plane. At the beginning of 1947, there were 826 planes in operation, and the average number of employees per transport was 52. The veteran employment program provided courses for pilots, operations, maintenance, communications and special training for the physically handicapped.



SIKORSKY S-52 HELICOPTER

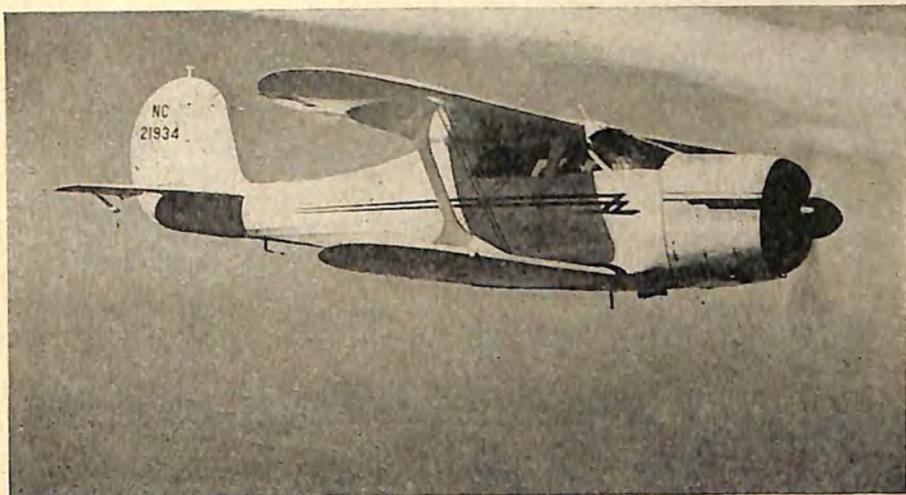
In the United States at the beginning of 1947, there were 1,516 CAA-approved aviation schools giving at least one and in some cases all the six different classifications of flight training. They included primary flying, commercial flying, instrument flying, flight instructor, basic ground school and advanced ground school. With the Service Schools for flight training provided by the air forces of the Army and Navy they constituted the foundations of American strength in the air, providing a vast reservoir of airmen available for any future emergency. A majority of the schools were enjoying capacity enrollment because veterans were taking advantage of the G.I. law to get flying instruction at Government expense, and they made excellent students, serious and ambitious to become experts in an era of flying. The 1,516 flying schools represented a three-fold increase in 12 months. There had been only 560 CAA-approved schools in January, 1946.

There also were 55 CAA-approved aircraft mechanics schools in the United States, as compared to 35 in January, 1946. Some of those schools went far beyond the average mechanics courses. Cal-Aero Technical Institute at Glendale, Los Angeles County, Calif., had been training aviation experts since 1929. It was Government-approved for veteran's training, and also had the approval of the aircraft manufacturing industry. Cal-Aero, which was under the personal management of Major C. C. Moseley, who had placed more than 6,000 gradu-

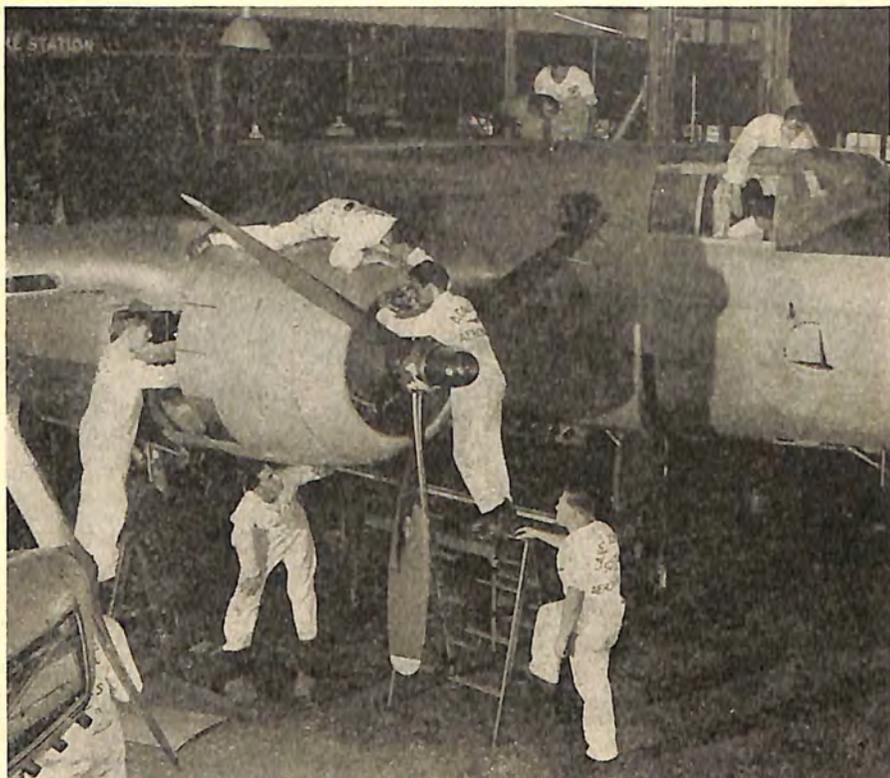
ates on good jobs in the industry, was located at Grand Central Airport close to Los Angeles and Hollywood. At the airport were numerous aviation businesses which offered Cal-Aero students many opportunities for extra study and experience. Cal-Aero had a large number of students who were not veterans. They represented nearly half the States and a score of foreign countries. They had their choice of courses in aeronautical engineering, master aviation mechanic, specialized engine, specialized airplane, post graduate aeronautical engineering, special aircraft sheet metal, and two home study courses in aeronautical drafting and aircraft blueprint reading.

Veterans also were attending the Northrop Aeronautical Institute, a division of Northrop Aircraft, at Hawthorne, Calif. In scientifically designed new courses, the students were getting concentrated instruction, which would result in their graduation as qualified aeronautical engineers and airline maintenance mechanics. The Northrop school occupied three especially designed buildings at Northrop Field, and maintained a staff of 80 experienced personnel to teach aircraft engineering, design, manufacture and maintenance to meet the ever increasing needs of the aircraft and air transport industries.

On October 1, 1946, there were approximately 750 students enrolled at Northrop, with facilities ample to provide for between 200 and 300 additional students, as soon as they could be absorbed in the various courses of instruction. The Institute was under the direct management of technical training specialists who created and operated



BEECHCRAFT MODEL G17S



STUDENTS AT ACADEMY OF AERONAUTICS

the training division of Northrop Aircraft during the war years, and before that, directed and operated other successful technical schools.

The Academy of Aeronautics at LaGuardia Field, New York, was under the direct supervision of Charles S. (Casey) Jones, its founder, and it reported heavy enrollment of veterans taking the aircraft or engine mechanics courses, or both. Stewart Technical School of Aeronautics, New York, also reported heavy enrollment of students taking the mechanics courses, as did the Roosevelt Aviation School at Roosevelt Field, Mineola, N. Y.

The Civil Air Patrol's training program was recognized by the War Department in October, 1946, when orders were issued that "for CAP cadets hereafter enlisted or inducted into the Army, notation will be entered that a course in Civil Air Patrol training has been completed." The CAP training course consisted of 80 hours of classroom

instruction and field problems dealing with various phases of aviation training. The CAP obtained from the AAF two radio frequencies—2374 kcs. and 148,140 kcs.—for its training program in communications as well as emergency radio work. CAP cadet encampments were to be held at AAF installations in 1947.

A CAP survey revealed that in one State only one secondary school in ten offered aviation courses, and only one-seventh of the aviation teachers ever had been in an airplane. In that State, the CAP was to give graduate courses in instruction during the Summer of 1947, extending the program throughout the country in 1948, after which, it was believed, instructional duties would be assigned to the air R.O.



AT CAL-AERO TECHNICAL INSTITUTE



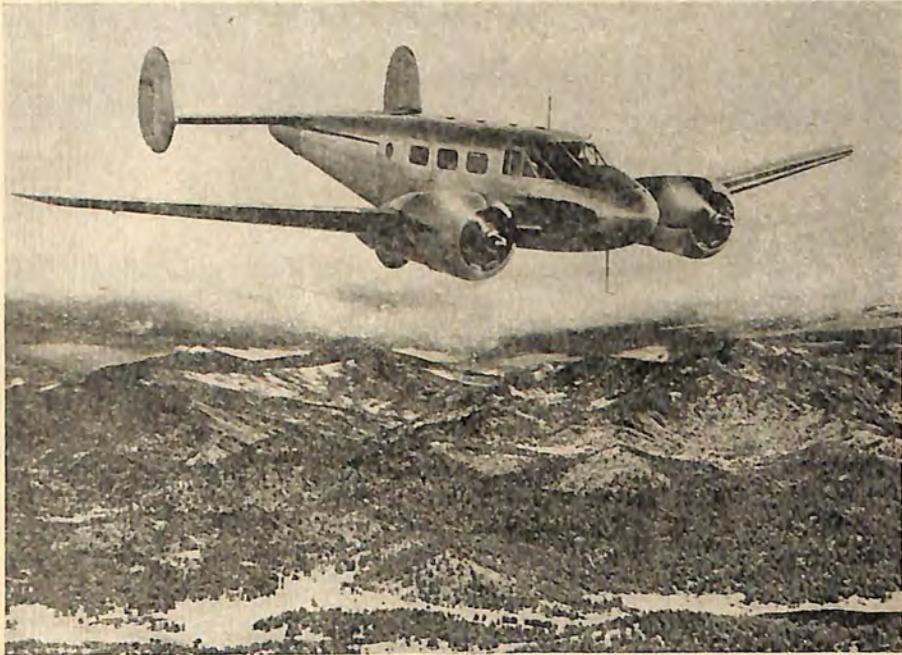
PIPER CUB J-3 SPECIAL

T.C. CAP officials also had a program to organize pre-flight training for 50,000 cadets a year.

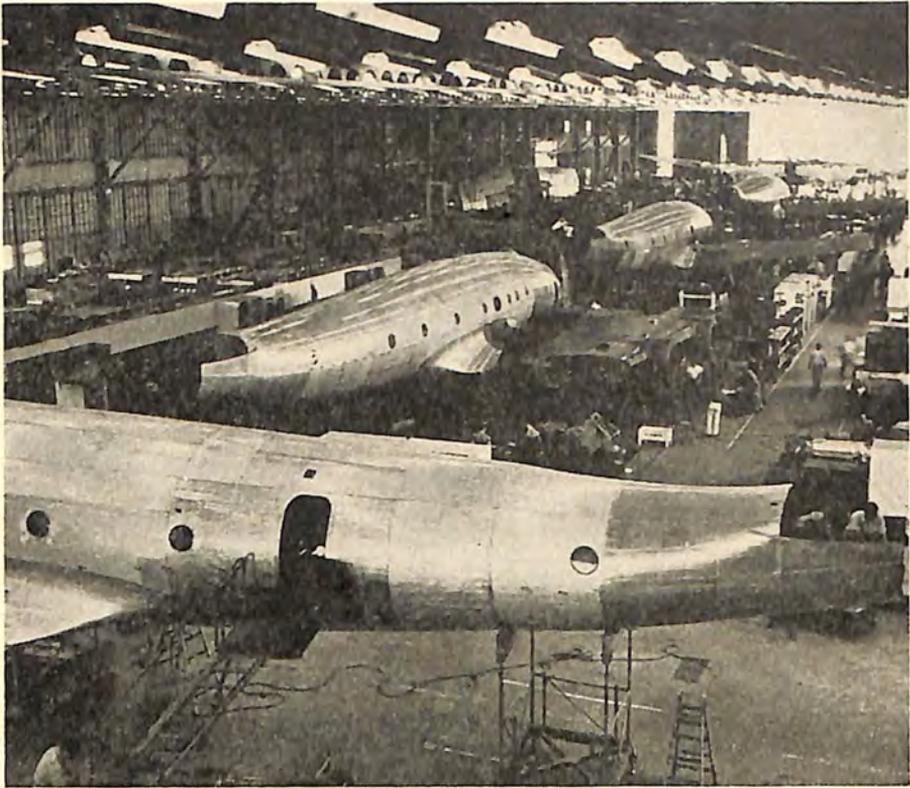
More than 44,000 persons, approximately one out of every five employees in the aviation industry at the beginning of 1947 were veterans of the Army, Navy, Marines or Merchant Marines, the Aircraft Industries Association found during survey of 14 major aircraft companies. They included more than 1,400 disabled or physically handicapped veterans who were working in the industry. Many job openings for non-working veterans, particularly certain skilled workers still were available. Nine of the 14 companies participating in the survey, stated that there still was need for engineers, engineering graduates, skilled or semi-skilled machinists, tool designers, aircraft engine mechanics, milling machine operators, pattern workers, fabrication specialists, aircraft assemblers, sheet metal workers, and other skills dealing with aircraft production jobs. To enable both able-bodied and handicapped veterans to better handle their jobs, most of the companies had instituted orientation and rehabilitation programs. In the case of the disabled veteran, special medical attention, personal counsel, and the necessary adjustments enabled him to perform a par-

ticular job. Special four and six-hour shifts were installed by two of the aircraft companies to accommodate veterans attending schools and colleges. Veterans working the six-hour shift, staggered from 8 a.m. to 1 p.m., were paid full wages by one of the companies. Several disabled veterans taking special eight-day in-plant training, received full pay for beginners at the same plant. Despite severe industry-wide personnel reductions following the war, every effort was made to place veterans with employment rights under the Selective Training and Service Act. The industry was cooperating with Federal agencies to employ veterans wherever possible. To offset the loss of the 16,000 veterans who no longer were with the industry since returning from war service, the industry had hired more than 16,000 new employees who were veterans, bringing the total of veteran employees to 44,000. The AIA survey also showed that of the 1,400 disabled veterans re-employed, only six were unemployable after they had been given special training and rehabilitation.

At the end of World War II, the United States had the most powerful military striking force the world has ever seen. The Army



BEECHCRAFT MODEL D18S



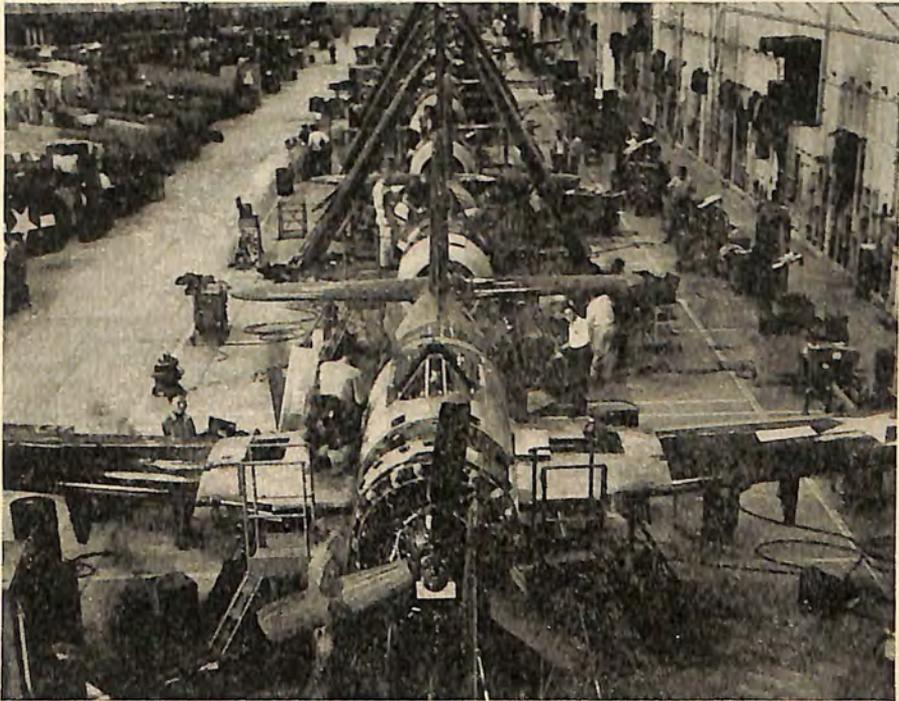
BUILDING LOCKHEED CONSTELLATIONS

Air Forces, and Naval Aviation, drawing men from all walks of life, had developed them into the world's best air soldiers through arduous programs of training and instruction. But with the capitulation of Japan, the veterans of the Army Air Forces, nearly three million men and women, whose qualifications ranked with those of military aviation experts, seemed destined to be disbanded. In order to preserve this storehouse of aviation knowledge, and believing that these well-trained men and women should have a voice in presenting to the American public the requirements for air power in order to safeguard the defense of the nation, the Air Force Association was organized, with the approval and cooperation of the Army Air Forces. James H. Doolittle, leader in 1942 of the first air attack on Tokyo, and later the commanding general of the 8th Air Force in Europe, headed the group of temporary officers and directors of the Air Force Association. Nine of

the directors were former AAF officers and seven former enlisted men. The task of building an organization and attracting members occupied a large part of the efforts of the Air Force Association during 1946, and more than 50,000 former AAF men and women had joined the Association by the end of the year, with a goal of 200,000 by late Summer, 1947.

AFA established Wing organizations in each of the 48 States and chartered a large number of local Squadrons in communities throughout the country. A national program had among its several objectives the education of the membership and the public at large in the development of air power, support and assistance in the expansion of Reserve and National Guard training, promotion of youth interest in aviation, encouragement of aeronautical training in public and private schools. Sponsorship of a medal to be awarded annually to the outstanding Air ROTC senior student at each university on the basis of scholarship and leadership.

Air Force Association squadrons, in addition to furthering the



RYAN FR-1 FIGHTER PRODUCTION

AFA's national program, embarked upon vigorous local programs, which included sponsorship of aeronautical courses in high schools, sponsorship of model air meets, adoption of Air Scouts and other boys' groups and provision of educational material for public consumption on military and civilian aerial accomplishments.



LUSCOMBE SILVAIRE

CHAPTER VIII  
AIRPORTS AND AIRWAYS

One Town of Every Four Has an Airport—First Year of the CAA  
National Airport Plan—800 Airports to Be Built or Improved—  
Operations at Airport Postoffices—Low Cost of Small Air-  
port Lighting—Beginning of Radar Service—CAA  
Expands and Improves the Federal Airways System.

ON JANUARY 1, 1947, the Civil Aeronautics Administration reported, there were 4,490 airports and landing fields in the United States, 1,015 of them lighted for night flying operations. About one town of every four had an airport. There were 851 Class 4 and 5 airports capable of use by the largest transports being built or planned for the near future. There were 485 Class 3 airports for present day transports, 1,249 Class 2 airports for feeder line or private owner transports, 1,396 Class 1 airports for smaller type planes and 509 other fields below Class 1 standards. The nation's airports included 1,929 commercial, 1,424 municipal, 201 CAA intermediate and 936 others which included Army, Navy, Civil Air Patrol, Federal and private. Texas had more airports than any other State—a total of 417. California ranked second with 356, Florida third with 204, New York fourth with 199, Michigan fifth with 163 and Pennsylvania sixth with 158. Texas was the only State with 100 lighted airports, California was second with 93. The complete table by States will be found in Flying Facts and Figures.

The national airport plan was authorized by act of Congress in 1946. It contemplated the expenditure of \$520,000,000 in Federal funds over a seven-year period, but Congress actually appropriated about \$48,000,000, with some indications that not all that amount would actually be available in 1947. The first year's program, announced by T. P. Wright, Administrator of Civil Aeronautics, in January, 1947, called for construction or improvement of 800 airports at an estimated cost to the Government of \$33,899,265, with local or State government sponsors providing an additional \$37,692,600. The Federal expenditures included \$26,676,466 from amounts apportioned among the States on the basis of area and population, as provided in the Federal Airport Act, plus \$6,690,849 assigned to 30 States from

a discretionary fund, and \$531,950 from funds apportioned to Alaska, Hawaii and Puerto Rico. After deducting the \$2,250,000 provided for planning, research and administrative expenses, there remained a balance of \$8,850,733 for further allocation and contingencies.

The program announced early in 1947 covered only smaller airports—Classes 1, 2 and 3. The Act required CAA to submit to Congress a list of proposed larger airports at least two months in advance of the fiscal year in which they were to receive funds; and the CAA could not meet that requirement for the fiscal year 1947 because the Act had not become law two months before the start of the fiscal year July 1, 1947. It was planned to have a proportionately larger part of the funds for 1948 spent on Class 4 and larger airports to bring the program into balance. The 1947 program called for construction of 232 new Class 1 airports, the type suitable for personal flying; 109 new Class 2 airports, suitable for personal flying and local commercial service; 44 new Class 3 fields, suitable for use of smaller transport planes; and three new seaplane bases. Projects for improvement of certain existing airports included 82 Class 1 fields, 177 Class 2 and 153 Class 3. The Federal expenditure for the improvement of existing and construction of new Class 1 airports was \$6,539,795; for improvement of existing and construction of new Class 2 airports \$9,968,958; for improvement of existing and construction of new Class 3 airports \$17,363,262. Total airport costs for both Federal Government and sponsors were broken down as follows, according to preliminary estimates: \$55,965,448 for the landing area program; \$5,087,800 for buildings other than hangars; and \$10,538,617 for land.

Typical of the 31 airmail field postoffices operating in leading cities throughout the United States was that at National Airport, Washington, D. C. There thousands of pounds of incoming and outgoing airborne letters and parcels for delivery to and from every American State and possession, plus more than 500 of the principal foreign cities across the world, were handled daily by a specially trained staff of airmail postal clerks. To speed the flight of these letters and postal parcels, scheduled mail planes were either landing or taking off from the airport on an average of every 4½ to 5 minutes. An average of 1,000 pounds of outgoing airmail an hour was cleared through the field postoffice during the daily rush. In August, 1946, alone, more than 264,000 pounds of domestic airmail, exclusive of foreign-bound matter, was dispatched from Washington, while during the peak months of war years the figure skyrocketed to 700,000 pounds. Officials also estimated that 25,000 individual pieces of registered mail were handled there weekly, while the foreign mail amounted to 18,000 pounds a

month. All told, the field office handled an average of 70,000 packages of letters a week. Some 10,000 pouches of incoming mail flowed through the field station every week. The mail was funneled in and out of the airport continuously by a special fleet of City Post Office trucks.

Inside the field postoffice was a bulletin board listing the trip numbers, arrival and departure of planes, and the gates through which they could be reached. In addition to permanent slots set up in the workroom for dividing airmail by States and localities, a special section was maintained to speed along registered and foreign mail. Window service was offered for the convenience of airport patrons mailing parcels on the spot. Like most of the other airmail field postoffices, the Washington division had outgrown its quarters. Although only established in June, 1941, all its 4,615 square feet of space were jammed to capacity. An appropriation had been made to construct a new field postoffice more than double the size of the old unit, but a scarcity of materials was holding up the project temporarily. It was to cover 9,500 square feet of space. Even though cramped for space, the field postoffices of 1947 were far different from the first unit established at Cleveland November 17, 1927, with one clerk and more prestige than mail. The number of airmail stations had steadily increased until



NORTHROP PIONEER

1,013 clerks were required to keep the letters and parcels moving on and off the planes. Stations were in operation at Albuquerque, N. M.; Atlanta, Ga.; Billings, Mont.; Boston, Mass.; Buffalo, N. Y.; Cheyenne, Wyo.; Chicago, Ill.; Cleveland; Columbus, O.; Dallas, Tex.; Denver, Colo.; Detroit, Mich.; Fort Worth, Tex.; Indianapolis, Ind.; Jacksonville, Fla.; Kansas City, Mo.; Los Angeles, Calif.; Memphis, Tenn.; Minneapolis, Minn.; Nashville, Tenn.; Newark, N. J.; New Orleans, La.; New York; Omaha, Neb.; Philadelphia, Pa.; Pittsburgh, Pa.; St. Louis, Mo.; Salt Lake City, Utah; San Francisco, Calif.; Seattle, Wash.; and Washington, D. C. Two additional units at Houston, Tex., and Cincinnati, O., were to begin operation in 1947, bringing the total to 33.

Small airports can be lighted for night flying at a cost of about \$2,600, the CAA reported, on the basis of an experimental installation at Aretz airport near Lafayette, Ind. It was made for the "study of effectiveness, original cost and maintenance problems by the Experimental Station of the CAA. A two-color airport boundary marker light was developed," the report stated. "Results thus far show that the lights identify the airport for a pilot flying at 1,000 feet from a distance of 15 to 18 miles, and in an exceptional case, the lights have been seen from 30 miles away. Operating cost for current on the basis of the first 30 days amounts to about 15 cents an hour.

"Two colors for airport boundary lights were suggested originally by F. C. Breckinridge, light expert of the Bureau of Standards, and such a system has been in operation at Indianapolis municipal airport for three years. Under direction of Mark Gilbert, CAA lighting expert, certain revisions have been made in the original system to adapt it to small airports. Low original cost and low maintenance cost were important goals. With Lawrence Aretz, owner of the airport, supervising installation of the boundary and obstacle lights and an illuminated wind cone, the entire cost for his field, measuring about 1,000 by 2,850 feet, came to less than \$2,600. By contract, this cost would be increased, Gilbert believes. The tubular lights, mounted in pairs parallel to the ground, show red on the side toward the airport, warning the pilot taking off that he must be in the air when he crosses the boundary; and green from the outside, showing him it is safe to land beyond the light. A new kind of gas tube light containing especially purified neon gas is used for the red light and a similar tube filled with argon gas provides the green light. The lights are mounted in front of reflectors in a unit covered by tempered plate glass impervious to extreme heat and cold changes. Each light is visible from 10 degrees below the zenith, and through a horizontal angle of 150 degrees.

Enough heat is generated by the tubes to keep the glass cover free of snow and ice. The units are expected to cost not more than \$100 each. By using ceramic electrodes in the tubes, it is possible to operate the lights at 750 volts instead of the 15,000 volts used at Indianapolis. This materially decreases maintenance costs, obviating short circuits caused by such things as spider webs in the Indianapolis system. The lights are 20 times as bright as the neon tubes used in electric signs. Because most private fliers do not operate in instrument weather, the usual spacing of 300 feet for boundary lights was increased to about 900 feet at the Aretz field. With three lights on the short and four on the long sides of the rectangular field, the definition of the landing area is satisfactory. A few additional lights would be necessary in odd-shaped fields, or those shaped like a T or an L. The Aretz installation includes four 45-foot poles to carry obstruction lights and a folding steel pole for the illuminated wind cone."

New York City airports were to have radar services in 1947. The plan was described officially as follows: Plans are for "early installation of a large, high-powered radar set on the grounds of Queens College, three miles east of LaGuardia Airport. In an action initiated by the New York City Airport Authority, and with the fullest cooperation of the Army Air Forces All-Weather Flying Division, the Civil Aeronautics Administration and the Air Transport Association, the radar, which has been in operation for developmental and experimental purposes at Airborne Instruments Laboratory in Mineola, N. Y., will become available as soon as installation at the new site is completed as an aid for the CAA in directing and controlling air traffic in the New York area. Mounted on two 100-foot high steel towers, the Microwave Early Warning (MEW) search radar and associated height finder originally developed by the Services for wartime use, is capable of "seeing" the aircraft flying in the New York area and approaching and leaving all the major airports therein, and indicating their exact position and altitude to ground-based operators and control personnel. With this exact knowledge of the position of each aircraft which is thereby made available, more efficient traffic control with increased safety is anticipated.

"This installation has been made possible only through the closest collaboration of the various organizations who are contributing materiel, manpower and finances. Credit must be given the New York City Airport Authority and the Department of Marine and Aviation of the City of New York, for its leadership in initiating the efforts to obtain the installation with its obvious benefits for the New York area. The Army Air Forces through its All-Weather Flying Division

is providing the costly radar equipment under bailment contract to Airborne Instruments Laboratory, and will move the equipment from its present location to the Queens College site. The City of New York is providing the site and is assuming the costs of the necessary construction at the site. The Civil Aeronautics Administration, through its Technical Development Section and the New York Regional Office, will provide the necessary operational and maintenance personnel, and will meet the operating costs. The Air Transport Association is contributing installation costs for the modifications to the equipment required for the move and for further research toward increasing the usability of the radar gathered information. An additional contribution from this source has been the considerable amount of research and developmental work already done in adapting the equipment from military to civilian usage. Airborne Instruments Laboratory, the group which has done the developmental work and is to have direct charge over the work of relocating the equipment, is an affiliate of the ATA.

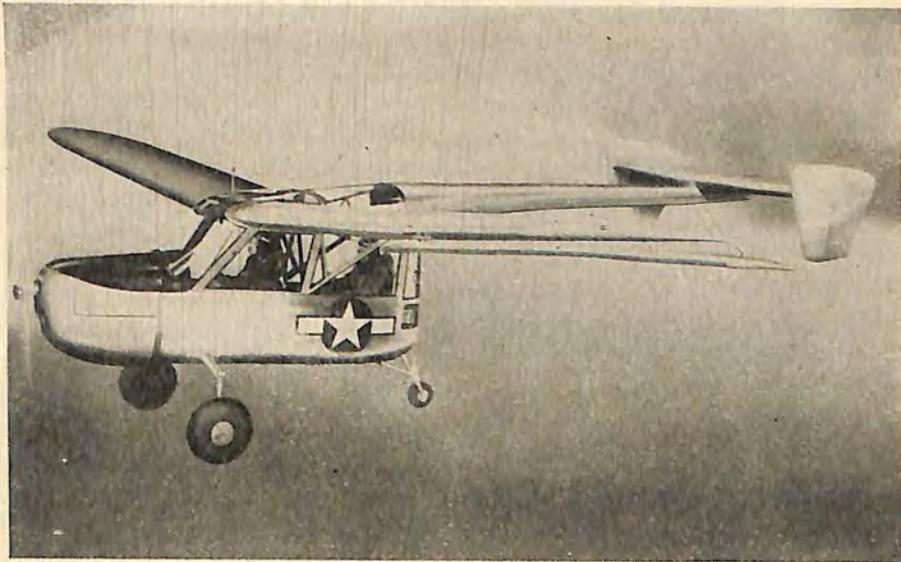
"The radar itself, when seated on top of the two 100-foot towers, comprises an equipment which, rotating constantly, gives a picture of all aircraft, providing range and direction data from the radar's site, and a second equipment which can be directed at any particular segment of the circle to determine the altitude of planes in that segment. The rotating search unit can be adjusted to sweep the whole area, three, six or twelve times a minute, giving instantaneous indication on a radar scope of the position (in range and azimuth) of each aircraft at the moment it is in the path of the radar beam. The height finding unit can be rapidly aimed at any desired segment. The radar information is to be relayed from the Queens College site to the CAA Airways Control Center at LaGuardia Field, where the traffic control personnel will use the radar scope information to supplement the existing traffic control data."

In an address before the Institute of the Aeronautical Sciences in October, 1946, T. P. Wright, Administrator of Civil Aeronautics, gave a comprehensive report on the Federal Airways System. "We in the United States now have the best airways system in the world. We have more experience than any other nation in the development, establishment, maintenance and operation of an airways system. Other nations, notably Mexico, Canada and several other members of the British Commonwealth, have approved and adopted our system.

"Radio ranges and lights (the latter to a lesser extent though still important to many users) still are the backbone of the airways today. Low frequency ranges are spaced at about 200 miles along the 40,000

miles of aerial paths we maintain. The CAA leases 138,000 miles of land lines for communications. It maintains 25 airway traffic control centers strategically placed about the country, and operates some 125 airport traffic control towers. We find ourselves today with congested airports. Under present instrument conditions using low frequency equipment, our traffic controllers can bring in on one runway at most 10 aircraft an hour. If that airport does not have a parallel runway for use in takeoff, this figure may be still further lowered. This is not enough. The ideal, of course, is to approximate good visibility conditions during instrument weather, and bring in 60 planes an hour safely. This still is not enough as we view the certain increase of scheduled flying. This then is possibly the major problem today. It is the subject of hard and continuous study and development by the CAA and others. Many solutions are suggested, some practical and some fantastic. It is our task to select and apply the best because ours also is the responsibility to see that there is no waste of funds.

"Air traffic control affects airport design and size and cost. In times of congestion under instrument conditions, there are today, actually, only a few apparent solutions. We might restrict our major airports to scheduled air transport. That in turn might imply that the scheduled carriers ought to consider owning their own exclusive fields.



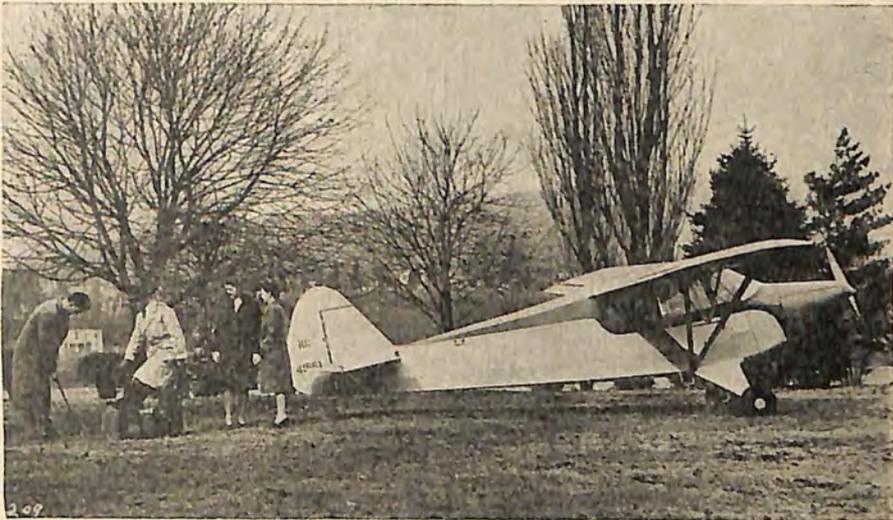
BOEING ARMY L-15A

We might designate several airports properly separated at big cities and assign incoming planes to spread the traffic. That would mean each airline would have to maintain service crews for planes and facilities for passengers at several terminals, an expensive procedure. Or, we might build our airports so big that we could use a comprehensive system of parallel or tangential runways. Still another solution would be the design of aircraft with landing and takeoff characteristics so much improved that it would affect our whole traffic-handling problem. The problems are difficult and possibilities of corrective measures many, but continued development and painstaking study will discover the proper solutions. But one important device which will help answer the demand for a system of landing by instruments in bad weather is now ready for use at many locations. I refer to the CAA instrument landing system. It has had wide acceptance in principle and will get substantial use in scheduled air transport in 1947. The Provisional International Civil Aviation Organization Standards Committee in its recommendations for standards and practices recommended the adoption of the SCS-51 or similar type of instrument landing system. The SCS-51 developed during the war is the portable version of the CAA system. The CAA instrument landing system is no suddenly developed device. As far back as 1928 when aeronautical radio as a whole was relatively undeveloped, a series of studies were undertaken in the Department of Commerce by its Aeronautics Branch and the Bureau of Standards. As a result, a 3-element system was originated which consisted of localizer radio beams thrown out in a vertical plane down the central line of the runway; a glide path plane at about  $2\frac{1}{2}$  degrees to the horizontal which gives the pilot the correct angle of descent and which intersects the localizer to form a proper pathway in the air; and marker beacons which by flashing lights on an instrument panel in front of the pilot show the distances from the touch down point. The process of flying the system is simplified for the pilot by the use of an instrument consisting of two pointer needles actuated by signals from the localizer and glide path beams showing him his relation to the on course path. Supplementary aids associated with it are automatic direction finder stations and approach light lanes, the former as an aid in accuracy of flying approach procedures, and the latter as a means for assuring early visual contact with the ground.

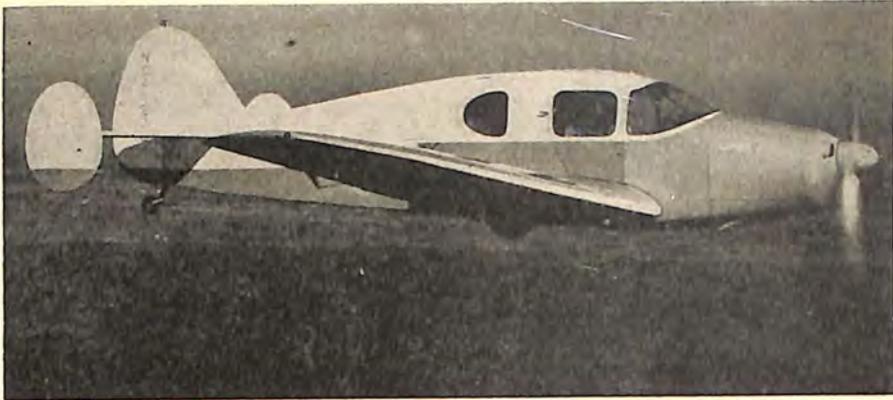
"We expect to have approximately 52 of these instrument landing systems in operation by 1947, and the airlines are proceeding with their training of pilots and equipping of planes to use this aid to bad weather landing. The CAA is confident that this system will contribute substantially to safe handling of planes in instrument conditions

and that, when the pilot's skill and technique have been developed, will make it possible in bad weather to land in the order of 30 planes an hour. In its final form, it is contemplated that the system will be hooked up with the auto pilot, further increasing its effectiveness, thus making automatic instrument approach, and possibly eventually instrument landing, possible.

"In addition to the instrument landing systems installed at civil airports, there are about 27 military installations which will be available for use by any pilot in an emergency. Thus, the airways will have more than 75 instrument landing systems available for use by 1947. The airlines planned to have all the scheduled transport planes equipped with instruments necessary to utilize this bad weather flying aid by 1947. Practically all airline planes already are equipped with localizer and marker beacon receivers, and most are equipped with racks for the glide path receiver and with glide path receiver antennas. Thus all that remains to complete the installation of the airborne instrument landing equipment is the placing of the glide path receivers to their racks in the planes and connecting them to the instrument panel. The Radio Technical Commission for Aeronautics recently conducted tests at New York, using the localizer, marker beacons and compass locator stations only. As a result of these tests, we are confident that we can bring in a plane in safety every three or four minutes. This timing will



PIPER J-5C SUPER CRUISER



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be further improved possibly to two or three minute intervals when using the glide path in addition. We are interested also, though possibly to a lesser extent, in lowering the ceilings for scheduled airline operation and thus improving frequency of schedules made good. A reduction of ceiling minimums from 500 to 200 feet, with commensurate reduction in visibility requirements, with equal safety is our first objective. This will contribute materially to schedule regularity as the number of unflyable days per year at most airports will be reduced from six or seven per cent to one or two per cent. We are going ahead on radar as rapidly as money, personnel and equipment are available. The Army is lending the CAA three of the newest Ground Controlled Approach radar systems, which we will install and operate at LaGuardia, Washington National and Chicago airports. The war-developed GCA required five or more operators with commensurately large operating cost if the system were to be generally applied to our civil airways. The manufacturer of the latest type hopes so to reduce requirements of operating personnel as to make wider application practicable. The CAA, however, would not be justified at present in proceeding more rapidly than the above program indicates until further service tests point more positively to the next appropriate step.

“Of great importance is the transition now under way from the low frequencies of our present range system to very high frequency. Started early in the war, here again installation was interrupted. We are going forward now with the equipping of nine complete airways with four-course aural-visual ranges in the 112-118 mc band. One has been in successful use since early in 1946, and others

are approaching completion. Chief advantage of these ranges is that they are substantially static free, thus they are available when most needed. The development illustrates one of our problems, which will be understandable to anyone engaged in development work. Right in the midst of our changeover program (LF to VHF), our engineers found an improvement. They had reached the point in their development of the omni-directional range principle where the durability and practicability of its use instead of the four-course, aural-visual was indicated. This turned out well, however, because the change from one to the other proved to be relatively simple and inexpensive. As a result, all these VHF ranges will be omni-directional when the nationwide system is completed. These VHF omni ranges are for short distance use, usually over the land. For long, over-water hops, a high-powered low frequency omni-directional range has been developed. It also will serve over desert and jungle areas, where it is not possible to build the many VHF range sites required, one each 100 miles. War developed Loran is the current standard for long range over-water operations. Also over the continental United States, we will have a long range system. This will be for use by airplanes making long flights, usually on great circle courses, and at high altitudes. It will consist of 15 omni-directional ranges, operating on low frequency and using about 40 kilowatt power. These 15, to be used as is any



PIPER CUB FINAL ASSEMBLY



FIRESTONE ARMY XR-9B HELICOPTER

omni-directional range, will cover the United States, parts of Canada and Mexico and large coastal areas of both oceans by a grid. A pilot can take bearings on at least two anywhere in the country, thus obtaining a fix.

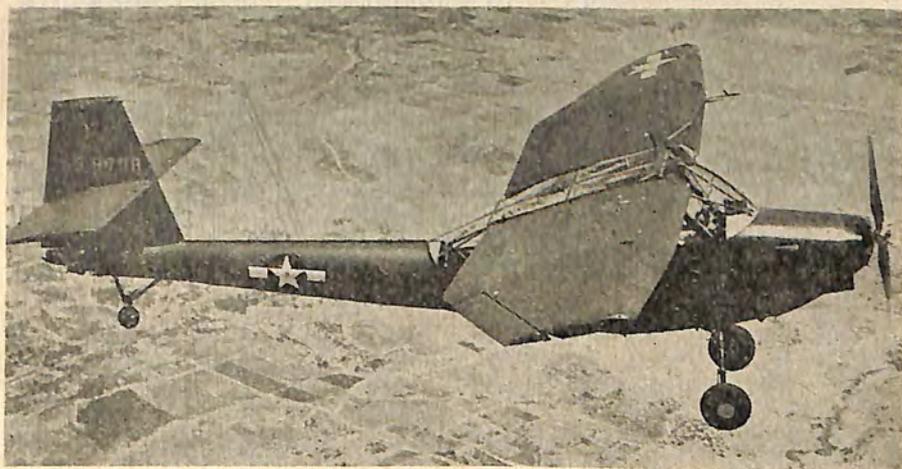
“Certainly in the future are several important developments in radar. We received \$80,000 for radio and radar work in our last year’s budget! This year we have about \$180,000. For next year, we have asked for five times that much, all insignificant when compared to requirements as measured by funds expended for such purposes during the war. Our job, however, is to translate the remarkable achievements of the military in the use of radar during the war to civilian use, to make it practicable as a civilian airways aid. Many other airway aids are under development at our experimental station at Indianapolis.

“Instrument landing probably is the most important, and we are continuing to develop the CAA three-element system. One important

improvement of the instrument landing system now under development and previously mentioned is the completion of work for automatic instrument landing through a hook-up with the automatic pilot. We are doing this at Indianapolis; the Army is working along similar lines; and the Sperry Gyroscope Company is developing a system that contemplates doing the same thing but utilizing micro-wave frequencies. These are very promising developments which offer great hope for even safer, more frequent and better executed landings in instrument weather.

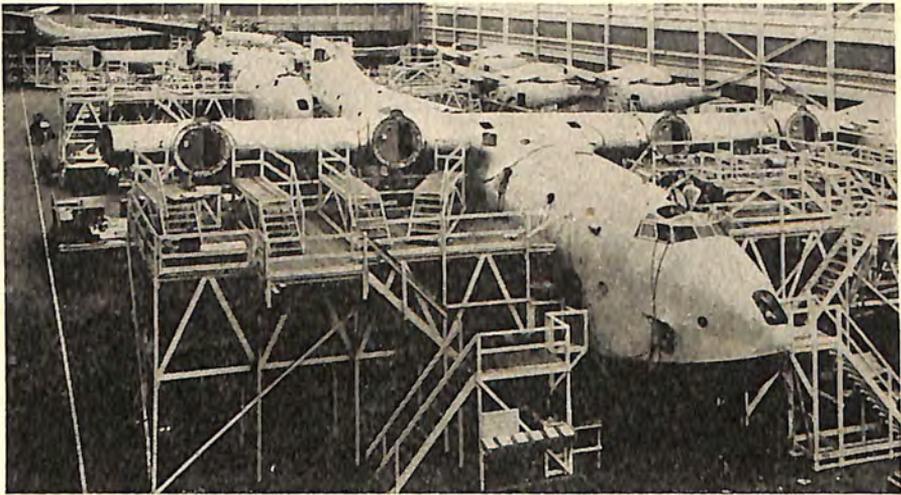
"I have referred previously to the marker beacons and the radio ranges which provide fixes for the pilot. We have under development a distance measuring device which will tell the pilot his distance from a ground station, and will make possible the removal of the marker beacons along the range courses, thus relieving us of the maintenance problem which the operation of these markers entails. This equipment in the plane will be light and inexpensive, and will give the pilot a direct indication of his distance in miles from the beacon on the airport to which he is flying. Thus, through the use of this distance indicator in conjunction with the azimuth information provided by one omni-directional range signal, he will be able continuously to establish a fix anywhere within receiving distance of the ground station.

"In another project, we are studying individual lights of miscellaneous kinds and uses. One of these is a 30,000,000 candlepower



CONSOLIDATED VULTEE L-13 LIAISON

light which emits flashes very briefly and with such intensity that even in daylight and at long distance a pilot is guided to an airport. Another is a neon tube showing red on the inside and green on the outside to mark the boundary of an airport. Another system aims at an improvement over previous methods of marking the boundary of runways; and still another is an extension light for marking runway boundaries in deep snow. We plan, then, on the use of VHF omni-directional ranges supplemented by the distance indicator for comparatively short flights on and off the airways; high powered low frequency omni-directional ranges for long great circle high altitude flights; and CAA instrument landing system supplemented by GCA-radar at large airport terminals; these we will supplement with other aids as they are developed and proved to be suitable. Search radar is planned for important traffic control towers."



MARTIN NAVY MARS ASSEMBLY LINE

CHAPTER IX  
FEDERAL AGENCIES IN AVIATION

Work of the National Advisory Committee for Aeronautics—National Bureau of Standards—The Fish and Wildlife Service—U. S. Forest Service—Office of Foreign Liquidation Commissioner—Aviation Division, Department of State — Federal Communications Commission—U. S. Weather Bureau.

**M**ANY of the non-military agencies of the Federal Government increased their aviation activities after the war, while those which had participated in the war effort found their work undiminished. Their activities are described in the following pages, with the exception of the Civil Aeronautics Administration and the Civil Aeronautics Board, the various accomplishments of which are found in other chapters.

**National Advisory Committee for Aeronautics**

The National Advisory Committee for Aeronautics is a group of 15 men appointed by the President, serving without compensation and selected for their responsibility and leadership in the aeronautical progress of the nation through their special knowledge of research needs. Chairman of the Committee is Dr. Jerome C. Hunsaker, Massachusetts Institute of Technology. Vice-Chairman is Dr. T. P. Wright, Administrator of Civil Aeronautics. The remaining members of the Committee are: General Carl Spaatz, Commanding General, Army Air Forces; Vice Admiral A. W. Radford, Deputy Chief of Naval Operations (Air), U. S. Navy; Rear Admiral L. C. Stevens, Assistant Chief, Bureau of Aeronautics, U. S. Navy; Dr. Vannevar Bush, Director, Joint Research and Development Board; Mr. W. A. M. Burden, Assistant Secretary of Commerce; Dr. E. U. Condon, Director, National Bureau of Standards; Dr. Alexander Wetmore, Secretary, Smithsonian Institution; Dr. Francis W. Reichelderfer, Chief, U. S. Weather Bureau; Mr. Arthur Raymond, Vice President-Engineering, Douglas Aircraft Co.; Mr. Ronald M. Hazen, Chief Engineering, Allison Division, General Motors Corp.; Mr. William Littlewood, Vice President-Engineering, American Airlines and Orville Wright, Dayton, O.

In addition, the main Committee is assisted by eight Technical

Committees and 18 Subcommittees comprising more than 250 of the nation's outstanding aeronautical authorities from government, the military services, the aircraft industry and the airlines.

Dr. George W. Lewis serves as Director of Aeronautical Research, a position he has held ably and with distinction for more than 25 years. The Executive Secretary of the NACA is Mr. John F. Victory, a position he has held since the first meeting of the Committee in 1915.

The Langley Memorial Aeronautical Laboratory is under the direction of Dr. H. J. E. Reid; the Aircraft Engine Research Laboratory is administered by Mr. Edward R. Sharp and the Ames Aeronautical Laboratory by Mr. Smith J. DeFrance.

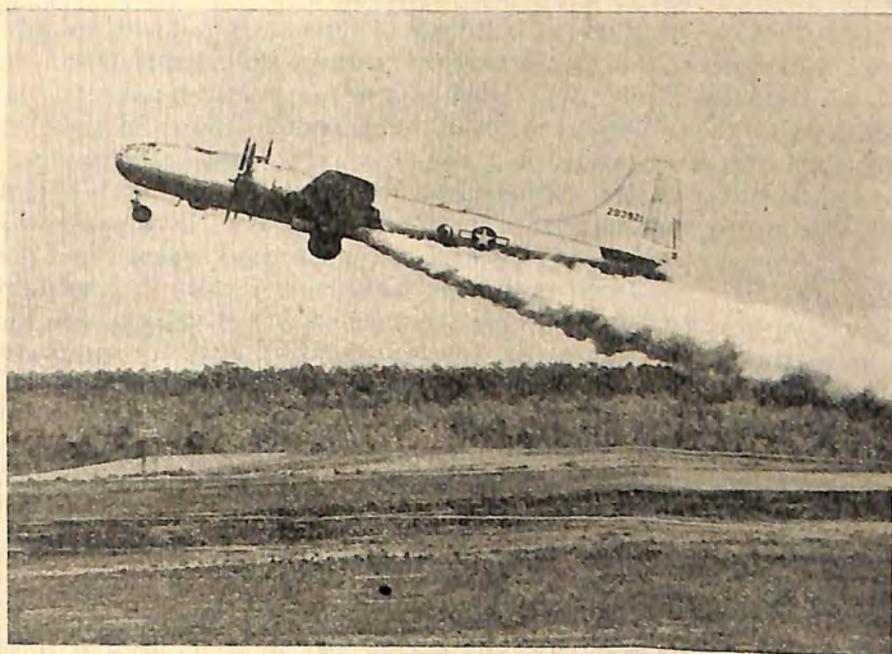
The conversion of the NACA from its role of basic research to applied military research during the war aimed at the improvement of performance of existing military aircraft curtailed basic research with the result that substantially all of the reservoir of aeronautical knowledge accumulated during the peace years was exhausted at a time when new research findings were forced to slow to a trickle. In addition, the introduction of jet propulsion and the increase in airplane speeds to well over 600 miles per hour, the entrance to the transonic zone, introduced a whole new world of scientific problems demanding solution. The year following V-J Day witnessed the completion of the wartime applied research projects of the Army and Navy and a return by the NACA to its basic research role.

The demands of national defense, the safety and comfort of aerial transportation and the reliability of the lightplane require accelerated research on fundamental problems. The NACA is currently engaged in penetrating the new, unknown frontier of sonic speed while concurrently broadening its basic knowledge of existing aeronautical problems. The promise of really high speed flight for the transportation of peoples and goods in increasing the tempo of the world's social and economic life and the necessity for the rapid development of guided missiles and supersonic combat aircraft for the preservation of the peace demands an energetic and skillful attack on the problems posed by this new era in aviation. The National Advisory Committee for Aeronautics is executing this program with the vision and foresight created by its 32-year-old history and with the tools and manpower that a wise Congress has provided. America must lead in the air and NACA research assures this nation's possession of the fundamental aeronautical knowledge required for attaining this goal.

#### **National Bureau of Standards**

The work of the National Bureau of Standards in research, test

development and testing in the field of aeronautics was largely in cooperation with the Bureau of Aeronautics, Navy Department; Army Air Forces; the National Advisory Committee for Aeronautics; and the Civil Aeronautics Administration. Broadly, the field of work covered selected problems and investigations in metallurgy, in aerodynamics, and on aircraft and meteorological instruments, aircraft power plants, lubricants, fuels, radio communications, aircraft and airport lighting, electroplating, structures, and on materials, such as textiles, rubber and ceramics. Much of the field of work of the Bureau in physics and chemistry was of interest directly or indirectly to aeronautic engineers and scientists. Studies of wind-tunnel turbulence and of flow in boundary layers continued in cooperation with the NACA. Investigations in the field of low turbulence showed that damping screens are an effective and practical means of decreasing wind-tunnel turbulence. The pressure drop through damping screens resulted in some power loss, but this disadvantage could be minimized by using a number of screens of low pressure drop in series, and by placing the



B-29 JET-ASSISTED TAKE-OFF

U. S. Army photo

screens in the section of the tunnel where the speed was a minimum. When screens were fine and uniform, the turbulence could be reduced to levels so low that tunnel noises were a significant part of the remaining disturbances.

Studies of boundary-layer phenomena at low turbulence on a thin flat plate, parallel to the wind direction, resulted in discovery of laminar boundary-layer oscillations and the complete confirmation of the Tollmien-Schlichting stability theory. The oscillations resulted from selective amplification of small random disturbances by the boundary layer, and were an important phenomenon in connection with the preservation of laminar flow. Oscillations were the primary cause of transition to turbulent flow when the stream turbulence was less than 0.1 per cent and when laminar separation was absent.

Fundamental studies of the turbulent boundary layer had been in progress for some time, with particular emphasis on turbulent separation. By working with a thick boundary layer and special hot-wire anemometers, it was possible to measure the distribution of turbulent intensities and turbulent shearing stress. Such data contributed to an understanding of the processes going on within a turbulent boundary layer, and, it was believed, would eventually lead to an understanding of the characteristic behavior of the layer.

Wartime experiments at the Bureau of Standards, followed by full-scale tests at the Naval Air Material Center in Philadelphia, demonstrated the feasibility of using liquid oxygen to increase aircraft engine power at altitude. During the war, fundamental studies of gaseous combustion were suspended in favor of work for the Navy on combustion chamber design and performance, combustion efficiency and fuels for gas turbines and jet-propelled devices. The Navy work was being continued with added emphasis on fundamental aspects, and the investigation of basic combustion phenomena was to be resumed in 1947. An improved thermocouple pyrometer was developed for indicating the temperature of hot gases in gas turbines. By means of a covering of silver, the radiation loss from the thermocouple was reduced to a few degrees. However, both shielded and bare junctions of adequate mechanical strength responded too slowly to changes in temperature for application to the control of gas turbines, and means of reducing the time lag were being investigated. A study of temperature sensing and control devices for jet engines was undertaken for the Army Air Forces.

A flow bench was developed for testing the air and fuel sides of aircraft carburetors simultaneously without use of large blowers. This altitude test bench showed the performance of the completely assem-

bled carburetor, including those parts required to compensate for the lower pressure prevailing at altitude, and hence had many advantages over the type of flow bench in common use. Determinations of the flow characteristics of 16 engine-driven aircraft fuel pumps, operating on both volatile and non-volatile fuels, were completed. The results included basic data from which the performance, at any altitude and on any fuel of known properties, could be calculated. Improved methods of testing aircraft booster pumps were being studied. An emergency remedy for the excessively rapid wear of aircraft generator brushes at high altitudes, encountered early in the war, was provided by the use of chemically impregnated brushes. In 1943 the Bureau undertook a further study of the problem, measuring friction and wear in the laboratory under various controlled operating conditions. Of the factors thus far investigated, commutator cooling was most effective in reducing the wear of non-impregnated brushes under high-altitude conditions. In connection with spark plugs for jet engines, the sparking voltages of various types of spark gap were measured in still and moving air at several pressures. In connection with the ignition requirements of high-output reciprocating engines, measurements were made on experimental spark plugs having surface-type gaps to determine the effect of electrode materials and configurations on sparking voltage as a function of pressure. The effect of circuit constants on the voltages produced by a conventional aircraft-engine ignition circuit incorporating a series gap was also investigated.

Extensive tension and compression tests were made of several high strength aluminum alloy sheet materials, and the results were prepared in the form of charts convenient for use. The charts contained curves of stress versus strain, strain deviation, tangent modulus and combined modulus in compression, local elongation and elongation versus gage length in tension. Sheet stringer panels with closed section stringers were tested to arrive at empirical formulas for estimating their strength. The instability of open section stringers attached to sheet was studied both theoretically and experimentally. A theoretical and experimental study of the plastic bending of beams was completed. Extensive experimental and analytical studies were made of the reinforcement around circular holes in order to seek a rational solution of this difficult problem. A long range program of analysis and tests of semimonocoque structures was started for the Navy in cooperation with the Massachusetts Institute of Technology. A method of determining influence coefficients of wings with sweep-back and with large cut-outs was worked out for that program. The method was to be checked by static and dynamic tests on model wing beams. The prob-

lem of landing impact of large airplanes was studied analytically and by means of drop tests of flexible models. The program of fatigue tests was continued with axial fatigue tests of riveted joints of the new high strength aluminum alloys, tests to determine the effect of mean stress on fatigue life of specimens with a controlled stress concentration, and flexural fatigue tests of wing beams. Construction was started on a machine for applying alternating loads of variable amplitude to fatigue specimens. An extensive program of performance tests of wire strain gages of types used by the aircraft industry in large quantities was completed for the NACA. The work on wire strain gages was going on with a more detailed study of fundamental properties such as zero shift. Apparatus was built for calibrating accelerometers under sinusoidal, pulse, and steady accelerations. An accelerometer of the vacuum tube type was developed and submitted for trial by several flight research laboratories. A crash dynamometer was developed.

Exposure tests of aircraft metals in sheet form and built-up structures (wings) were continued. The tests covered commercial aluminum and magnesium alloys and aluminum alloy, magnesium alloy and corrosion resistant steel wings under conditions of continuous exposure in a marine atmosphere, and in atmospheric exposure with intermittent wetting with sea water at high tide. A testing program of newly developed anodic coatings for magnesium alloys was started. A report on the results of marine exposure tests of corrosion resistant steel sheets was published as a NACA technical note. Stress corrosion tests were conducted on high strength aluminum alloys and on wrought magnesium alloys. Specimens were tested in corrosive media in the laboratory and in the weather in metropolitan and marine atmospheres. Weather specimens were stressed in tension and by bowing. The effects of chromium plating on the mechanical properties of SAE x4130 steel heat-treated to a tensile strength of 180,000 lb/in<sup>2</sup> were being determined.

The effect of variations in composition and heat treatment upon the resistance of austenitic stainless steels (18% Cr 8% Ni) to intergranular embrittlement was studied. Results obtained to date indicated that variations in carbon content within the ranges normally encountered commercially were relatively unimportant, provided that the ratio of the stabilizing element (columbium or titanium) to carbon was sufficiently high. The ratios required in order to assure immunity to intergranular attack depended upon the heat treatment. Determinations of the linear thermal expansion of rolled aluminum alloys aged at various temperatures were completed for the NACA in an in-

vestigation of the physical properties of these alloys at elevated temperatures.

The only completely automatic guided missile to see combat service in World War II was the Bat. Like its namesake, the Bat sent out signals and then guided itself to its victim by the returning echoes. Under the joint sponsorship of the National Defense Research Committee and the Navy Bureau of Ordnance, the Bat was developed at the National Bureau of Standards with the cooperation of the Massachusetts Institute of Technology and the Bell Telephone Laboratories. The basic missile was a glider of unconventional design in which all control was obtained through elevons on the trailing edges of the sweptback wing. There was no rudder control. Primarily guidance of the flight was attained by gyro control. The radar-homing nose functioned to correct any evasive tactics the target might attempt after the Bat was launched. This it accomplished by deriving and developing a correction signal from comparison of the echo strength of opposite quadrants. Since the Bat constantly corrected itself during the flight, the pilot was free to leave the target area as soon as the missile was launched. At no time was he required to come within effective anti-aircraft range.

Control force indicators of the remote indicating type were designed and constructed for use in flight testing. A portable anemometer of low range and high sensitivity consisted of a propeller and a magnetic tachometer. Oxygen apparatus for aircraft personnel, particularly for utilizing liquid oxygen, was being developed. Instrument tests and computations were made incidental to determining the altitude in flights made by the Army Air Forces in 1946 to establish new world records. The evaluation of experimental lubricants for aircraft instruments continued, with the perfect lubricant still to be obtained.

During the war the Bureau of Standards developed a material for determination of carbon monoxide and a simple method of applying it, sensitive enough to determine quickly any quantity of the gas of physiological significance. A preliminary report on the preparation and use of the material was published.

A quick and sensitive method for measuring water vapor was developed for particular application to aviators' oxygen. By its use it was practicable to determine compliance with the Army-Navy specification of 0.02 mg. of water vapor per liter of oxygen at the rate of more than one cylinder per minute and without using enough oxygen to visibly affect the reading of an ordinary pressure gage attached to the oxygen cylinder.

The experimental investigation of plastics for use in aircraft could



U. S. Army photo

## ROBOMBS LAUNCHED FROM PLANES

be classified under four headings, namely coatings, adhesives, investigation of effects of variations in laminating techniques, and evaluation of the properties of plastic laminates. The work on coatings involved development of new and improved airplane dopes for covering fabric, improvement of aircraft lacquers, development of fire-resistant finishes for fabric-covered aircraft, investigation of fungicides for doped fabrics, and investigation of the interrelationship between plasticizers and polymers used in formulating aircraft coatings. Investigations were under way to determine the nature of adhesion to obtain basic data needed for the development of improved adhesives suitable for use on aircraft. Test methods used for evaluating adhesives and the properties of various basic adherend-adhesive combinations were also evaluated in the laboratory. The effect of variables in reinforcement construction and fabrication technique on the properties of laminated plastics was being investigated. Glass fabrics and thermosetting resins were used. The ultimate objective was to produce laminates with uniformly high strength.

The tensile, compressive, flexural and impact properties of a group of typical high-strength plastic laminates were evaluated over the temperature range  $-70^{\circ}\text{F.}$  to  $200^{\circ}\text{F.}$  Methods for measuring the shear properties of laminates were developed, modified and evaluated. Data were obtained on the shear properties of plastic laminates. The effects of accelerated service tests, used by various laboratories for simulated aircraft exposure conditions, on various typical plastic laminates were investigated. The tests included various combinations of

high and low temperatures, high and low relative humidities and immersion in organic liquids typical of those found in aircraft fuels. The relation between the strength properties of standard molded plastic test specimens and the strength of specimens cut from typical moldings and the effects of postforming on the properties of phenolic laminates were investigated.

#### The Fish and Wildlife Service

Through greater use of airplanes and aerial photography during the 1947 midwinter inventory of wild ducks and geese, the Fish and Wildlife Service of the U. S. Department of the Interior achieved a more complete coverage of the duck wintering areas than has been possible in previous inventories. This inventory, made annually as a part of the Service's efforts to keep advised of the status of migratory waterfowl, supplied an accurate measure of trends in the waterfowl populations, which data are essential for the formulation of the annual waterfowl hunting regulations. The 13th annual inventory, made between January 7 and 17, 1947, was planned on a more extensive basis than ever before, so that the Service might obtain the most accurate possible counts of duck concentration. Instead of being nation-wide as in former years, it was continent-wide and included Mexico, Central America, Alaska, and Canada in addition to the United States. For years it has been almost guesswork as to the number of waterfowl wintering to the south of the United States, but with plane coverage of the important wintering areas in Mexico, Guatemala, Honduras, Salvador, Nicaragua, Costa Rica, and Panama will come a more complete understanding of our continental waterfowl populations. More than 1,000 observers cooperated with the Service in making the inventory. They included State and Federal conservation officers, wildlife technicians, ornithologists and other field men selected for their qualifications and interest in waterfowl survey work. The Army, Navy, Coast Guard, several State conservation departments, and private planes were used through the cooperation of those agencies, in addition to the Service's recently acquired planes.

The Service has found that the airplane fits almost perfectly into waterfowl management investigations. It was an ideal tool for wildlife researchers to use in prying into the habits, requirements and migrations of waterfowl. Plans were being made in the Division of Wildlife Research for using planes for everything from appraising duck and goose populations on the breeding grounds in Canada and Alaska each year to obtaining an annual trend in the number of muskrat lodges on wildlife sanctuary and refuge areas. Increasing cover-

age and value of the winter inventory of waterfowl was only one of the uses to which planes were being put in waterfowl management research.

Two flyway biologists had planes to assist them in keeping better tab on the ducks and geese throughout the year on their flyways. The planes permitted the biologists to migrate with the waterfowl and follow population trends more closely. On the breeding grounds the planes permitted new census methods which could be applied over extensive areas. During the Fall migrations the flyway biologists used the planes to follow the birds and locate their concentration areas, and they provided a better understanding of the shifts in waterfowl populations.

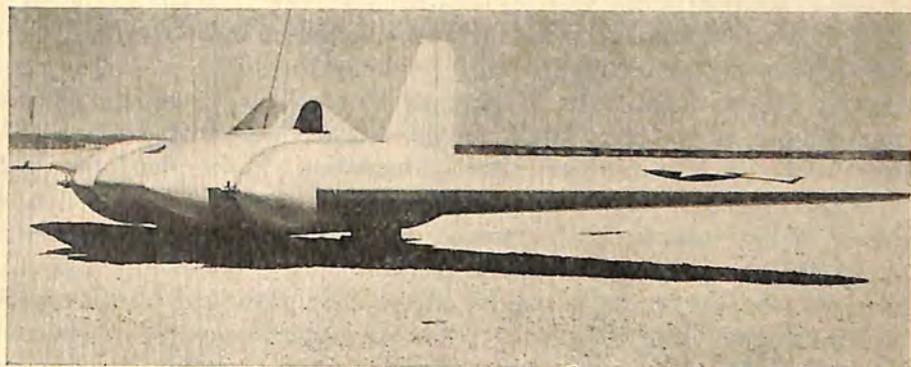
In western States where botulism, or duck sickness, frequently takes a heavy toll of waterfowl in out-of-the-way habitats, planes were used by research men to locate the areas and to obtain a concept of the losses. One such area at the north end of Great Salt Lake in Utah was located, and determined to have lost 50,000 ducks in less than a week.

The planes also permitted biologists to spot sections of rivers, lakes and marshes where Canada geese nested, and to obtain information on production through counts of nesting birds and broods. Later in the Spring, the brooding and rearing concentrations could be located and thus much time saved in locating the traps for banding the wild birds. Other uses to which planes were to be put by the men engaged in waterfowl management investigations included flying in supplies and equipment to workers banding ducks and geese in isolated areas; obtaining data on extent and effect of drought conditions in drying nesting pot-holes and sloughs of breeding grounds; through use of pontoon planes, getting to isolated waterfowl areas to examine them afoot and determine breeding potentials, nesting requirements, and hatching success; and appraising accuracy of ground counts of waterfowl through use of aerial photographers.

Several other Divisions of the Service found airplanes most useful. The Division of Wildlife Refuges had in service two planes acquired from the War Assets Administration. One was a Stinson L-5 based at the Lower Souris National Wildlife Refuge in North Dakota and the other was a twin-engined Grumman-Widgeon amphibian based at the Everglades National Wildlife Refuge in Florida. The Stinson plane was used for making waterfowl observations on the refuges in North and South Dakota, Nebraska and Minnesota; for checking the condition of water-control structures; for law enforcement patrol; for big game population checks; to facilitate studies of refuge conditions

incident to the development or revision of management plans, and for making muskrat house counts to determine the take of rats that could be safely authorized for the trapping season. Much time was saved, and areas otherwise practically inaccessible were covered by the plane in making waterfowl nesting studies, refuge population counts and muskrat house counts. For example, in the case of muskrat house counts, the ground time required to make a census varied from 3 to 9 man-hours an acre, whereas the 69,000-acre Mud Lake Refuge rat-house count was completed in 3 hours and 35 minutes flying time. The Grumman-Widgeon was used in flyway studies of bird wintering concentration in Mexico and Central America, and later flew to Miami for use in patrolling the large and inaccessible Everglades National Wildlife Refuge and adjacent coastal islands and keys, for wildlife law enforcement patrol, wildlife population studies, and to facilitate the preparation of development and management plans.

During the last 6 months of 1946, the Division of Predator and Rodent Control acquired 4 planes from the War Assets Administration, a Piper Cruiser, stationed at Boise, Idaho; another Piper Cruiser, stationed at Denver, Colo.; a Howard, stationed at Boise; and a Cessna, stationed at Denver. In addition, 8 other planes were used on predator control. In Montana 4 Cubs and Stinsons were under contract to be flown in the Ft. Peck and Beaverhead areas. In Utah another plane was under similar contract. At Elko, Nev., a Piper Cub owned by Nevada Grazing District No. 1 had been leased to the Service for control operations in Elko County; in Oregon a Piper Cruiser was used from time to time on a mileage basis; and in North Dakota, a Piper was operated for the Service occasionally. With those planes



NORTHROP GLIDER BOMB

U. S. Army photo

the Service operated coyote control in Oregon, Nevada, Utah, Idaho, Montana, Colorado, Wyoming and North Dakota. The planes were used for placing poison stations and for pursuing and shooting predatory animals. Plans for future coyote control with airplanes were dependent upon results in 1947. Judging by past experience, the results would be good, and requests for expansion of the work promised to be numerous.

In Alaska, to enforce the provisions of the game laws, the Division of Game Management had 3 planes based at Fairbanks, 2 at Anchorage, and one at Ketchikan. They were used on game and fur patrols, being operated on floats in southeastern Alaska, and on floats and wheels in interior Alaska in the Summer and on skis in Winter. The fleet of 6 airplanes was increased to 8 early in 1947. Patrol by airplane in Alaska was a constant requirement because Alaskans were among the most airminded persons in the world. Trappers flew to their trapping grounds by plane and many of them actually worked and ran their traplines by means of privately-owned planes. Rigid patrol was required to prevent the use of airplanes in hunting down and killing the large game herds of Alaska, which could only result in the decimation and virtual extermination of that valuable wildlife resource. Those game and fur patrols were made throughout the length and breadth of the vast territory embracing about 590,000 square miles and 26,000 miles of coastline. In connection with the work of protecting and conserving the valuable commercial fisheries of Alaska, the Service's Division of Alaska Fisheries operated 3 airplanes in the Territory. A Noorduyt Norseman was based at Anchorage, a Waco in Bristol Bay, and a Stinson was operated out of Juneau. A Republic Seabee was scheduled for delivery in 1947, and plans were initiated to acquire a Grumman Goose from the War Assets Administration.

Aircraft for patrol purposes proved effective in discouraging illegal fishing operations and in apprehending violators of the Alaska commercial fishery regulations. Equipped to land on water, the planes served as an important adjunct to the surface fleet in patrolling approximately 20,000 miles of Alaska's coastline. Fishermen operating during closed seasons or in closed waters were readily detected from the air by law enforcement personnel of the Service. The value of airplanes as a means of enforcing the Alaska fishery regulations was emphasized from the results of a 3-day patrol assignment by a Service pilot in southeastern Alaska. During that time he apprehended 10 vessels engaged in illegal fishing operations. All those violation cases were successfully prosecuted, and fines amounting to \$4,725 were assessed

by the U. S. Commissioner. The fisheries of Alaska are its most valuable resource and the basis of its chief industry. It was anticipated that airplanes would play an increasingly important role in the coming years in preventing the depletion of the salmon and other fisheries of the Territory.

Aircraft were utilized by the Division of Fishery Biology in its Alaska Fishery Investigations. They provided transportation of personnel, equipment and operating supplies to remote working areas, and permitted collection of material from places otherwise inaccessible. Regular observations of spawning salmon populations were made in some areas in which both relative number of spawners and relative distribution over the grounds were determined. Aerial photographs were obtained for measuring spawner density, for mapping purposes and for purposes of record. Commercial aircraft were used almost entirely in the past to the extent of about 200 flying hours annually. Their use was largely restricted to a few areas only because of the absence of charter operators in other districts. Through the employment of Service-owned aircraft, necessary aerial supply could be extended to all areas.

The Alaska fisheries spread over several thousand miles of coastline; canneries and other fishing centers are frequently widely separated and entirely isolated. Salmon spawning streams often extend for hundreds of miles into the rugged interior country, and cover enormous areas. For example, the spawning grounds of the extremely valuable Bristol Bay fishery include over 25,000 square miles, reaching into 2 major mountain ranges. No regular means of transportation exists in these areas; they must be covered by means of small boats or by airplane. The use of aircraft is often the sole feasible means of carrying on field activities. It also is a highly economical means. More than 4,000 pounds of operating supplies were transported from Larsen Bay to Karluk Lake, Alaska, in a half day by Service plane in 1947. The formerly used method of transporting those same materials by small craft on the Karluk River required 40 man-days' time and more gasoline than was used by the plane. Similarly, to transport 500 pounds of equipment from Naknek, Alaska, to the Brooks Lake temporary field station took 2 men 3 days, required the running of a hazardous river rapids and a 25-mile trip over a large and frequently rough lake. The same round trip could be accomplished by air in an hour and a half. On salmon-spawning census work, an airplane carrying pilot and observer accomplished in 4 days what had required a crew of 15 men 4 weeks. Aerial photographs provided information which could not be obtained by any other means. Seven-

teen days formerly were required to ship crews by Service vessel from Seattle to Naknek, Alaska. They were sent by commercial aircraft and arrived either the same day or at the latest the following morning out of Seattle. While the savings in salaries alone over air transportation costs was considerable, the savings in time of experienced men was a far more valuable economy.

The Service planned to transport by air in future all crews and supplies into the more remote field areas in the Spring and to bring them out by that means in the Fall. Aircraft were to be used in establishing caches of gasoline and supplies for field parties travelling in outboard motor boats in areas where this type of work was conducted. Biologists were to be flown into remote lake areas at regular intervals to obtain samples of young fish and of the food available for them, thus obtaining information on the amount of seeding and upon growth potential vital in estimating future abundance of the salmon populations. Aircraft were to be used also to transport investigators between the isolated canneries in the collection of important records and other biological data. Similar transport was to be used in moving survey parties from stream to stream in areas where studies were being conducted on barriers and obstructions to the progress of fish from the sea to their spawning grounds. Aerial photographs of important spawning areas at regular intervals were to provide permanent records of population densities. Similar photographs would show streams for mapping purposes and for the exact location of falls and other obstructions. Regular visits to all field parties in remote areas would provide current supplies and permit better supervision of field projects. All those aerial activities were to save tax money and provide a vastly more efficient public service.

#### U. S. Forest Service

The use of airplanes by the Forest Service, Department of Agriculture, was greatly expanded and diversified. Cooperation between the Army Air Forces and the Forest Service both in air patrol work and in fire suppression, particularly on the West Coast, during the war resulted not only in an unprecedented accumulation of knowledge and practical experience in the use of airplanes for Forest Service purposes, but also brought to light possible new and additional uses. Tests of these new possibilities, principally employment of helicopters on fires and the bombing of forest fires from the air, were begun in 1946 under joint AAF and Forest Service arrangements, and were to be continued more extensively in 1947. Though airplanes had previously been used by the Service to drop supplies and equipment

to men fighting fires in remote, mountainous areas, the first effective employment of aircraft to parachute fire fighters began in 1940. In that year a corps of 8 smokejumpers was established at Missoula, Mont., in the hope this would speed up the task of getting fire fighters to blazes in roadless, rugged regions while the fires were still small and comparatively easy to control. During the season, the 8 made a total of 19 jumps on 9 fires. The airborne fire fighters were able to reach their objectives almost before ground crews on horseback or afoot could get well started. Money savings were found to be comparable with this saving in time. Statistics showed that the average time taken by the smokejumpers in 1940 to reach fires was one hour and 41 minutes as compared to 28 hours for ground crews. Also, on the average, it cost \$247 to control a back country fire by smokejumpers as compared with an estimated \$3,500 to put out the same blaze with a ground crew. In 1946, this pioneer force of 8 smokejumpers had been expanded to 231 meticulously trained and conditioned parachute fire fighters. They were on duty at 4 main stations—Missoula, Mont., where the Service maintained a smokejumper training school; Redwood Ranger station, Siskiyou National Forest, southern Oregon; Twisp Ranger Station, Chelan National Forest, northwestern Washington; and at McCall, Idaho. The working circle for each station had a radius of about 400 miles. These men were parachuted to 328 fires, making in all 1,153 individual jumps. Carefully checked estimates indicate that the smokejumpers saved \$376,560 in the actual cost of fighting these fires, and that generally speaking one smokejumper was equal to 5 ground-force men on remote fires. The jumpers suffered no major injuries, and lost time injuries were very few. In addition, the 15 new airplanes owned by the Forest Service and 20 others under contract with private owners made 1,018 trips, flew 2,667 hours and hauled 162 tons of supplies and other freight. In the early days the planes flew 3 or 4 smokejumpers to small fires with the idea of scotching them while they were small, but in 1946 the Forest Service found much use for aircraft in rushing larger numbers of airborne fighters to going fires that were getting beyond control of the initial attack forces.

The success of the smokejumpers led in 1946 to an innovation that might revolutionize forest fire detection and suppression in much of the remote and inaccessible forest land of the Northwest. In a region designated as the Continental Unit, embracing some 2,000,000 acres in Montana's national forests, a system of airplane detection of fires combined with smokejumping patrol proved more effective than the old system of lookout firemen and telephone or radio calls for fire

fighters. In the unit, 43 lookout firemen positions were discontinued, and the money was used for flying patrol, training smokejumpers, and related needs of the new system. Nine lookouts were retained for detection in areas of highest fire occurrence, to report on lightning storms and supply data for the Weather Bureau. Of 29 fires in the unit, 14 were discovered by aerial observers, 7 by lookouts and 8 by others. All the fires were held to small areas through quick action made possible by aerial attack. One that would have otherwise taken 6 hours for first attack, required only 47 minutes by air control, and others that would have required 5 hours travel by ground crews took an average of only 2 hours and 30 minutes by air attack. Convinced that in areas such as the Continental Unit better protection could be obtained by substituting aerial control for lookout firemen, the Forest Service was contemplating another similar plane protected unit in Montana and Idaho.

Tests of AAF helicopters in mountain areas were begun on the Angeles and San Bernardino national forests, Calif., in October, 1945, in cooperation with the 62d base unit of the Air Rescue Service at March Field. The first models tested were found to lack ability to carry the necessary payload of fire-fighting supplies and equipment in spot landings and takeoffs at elevations over 3,000 feet at fire season temperatures. However, new high lift blades on Sikorsky helicopters in July 1946, significantly increased the elevation at which the helicopters could function satisfactorily with the necessary payload. Though not specifically part of the tests, the first use of a helicopter on a going fire occurred September 9, 1946, on the Castaic Fire on the Angeles. A Sikorsky R-5-A in charge of AAF pilots was used on a scouting and mapping expedition over the fire with satisfactory results. As the helicopter was not stripped and had standard blades, it could not land with a reasonable payload, but was able to drop cargo, free fall and close to the ground, at speeds under 15 miles an hour. Also, the performance indicated that helicopters function comparatively well in severe air currents, up and down drafts. While several mechanical factors hindered continuous operation of the helicopters for forest fire work, as was shown by the tests, Forest Service experts believed they could be eliminated. Early in 1947, the manufacturers of several types of helicopters were working on those problems, and further AAF and Forest Service cooperative tests were being planned.

Experiments conducted jointly by the Air Rescue Service of the AAF and the Forest Service in dropping water chemical bombs on forest fires from airplanes were begun in the spring of 1946. The Forest Service had experimented in this field since 1935, and while

much data and valuable technical knowledge were accumulated, it was believed that technical bombing experience acquired by the air forces during the war, particularly in precision bombing and equipment, could overcome many of the obstacles which had limited the scope and success of previous Forest Service efforts. However, the Forest Service experiments helped measurably to establish some guiding principles for the job: 1—Aircraft dropping bombs must be able to carry enough payload to permit employment of bombs containing a large amount of fire-extinguishing agent, and 2—The bombing equipment and techniques must be of such precision character as to insure a high degree of accuracy on small forest fires burning in rough, mountainous terrain. First tests made at the AAF Proving Ground Command, Eglin Field, Fla., were to test suitability of various types of AAF bombing equipment for forest work. Preparations were being made to start actual bombing experiments in the rugged mountain areas of Montana National Forests early in 1947.

Department of State  
Office of the  
Foreign Liquidation Commissioner

In January, 1947, the Office of the Foreign Liquidation Commissioner presented for this edition of the Aircraft Year Book the following account of surplus aviation equipment sales abroad: The disposal of aircraft presents special problems. In the first place, in dealing with items which are designed to move freely from one part of the world to another, a higher degree of central control is necessary than is desirable in the case of other types of supplies which will, for the most part, be used in the area of sale. Global allocations and a high degree of global planning are necessary in the sale of aircraft which are not appropriate in the case of other items. For example, in the case of transport-type aircraft the Government stated at the International Civil Aviation Conference at Chicago in November, 1944, that sales of our surpluses to foreign governments and foreign nationals would be under non-discriminatory terms and conditions. In addition, the possibility of competition with similar American-operated equipment is a much more important factor in the case of aircraft than in the case of other equipment. This again points to the necessity for a higher degree of centralized control. The disposal of aircraft throughout the world is subject to overall direction and coordination by the Interdepartmental Advisory Committee on Surplus Aircraft Disposal, comprising representatives of the Departments of State, War, Navy, and Commerce, the Civil Aeronautics Board, and War Assets Administration. In addition, advice on political and mili-

tary aspects of aircraft disposal is received from time to time from the State Department, the Air Coordinating Committee, the State-War-Navy Coordinating Committee, and the Joint Chiefs of Staff. Pricing policies, clearance of sales, allocations, and determinations of the classes and types of aircraft to be salvaged are the responsibility of the Interdepartmental Advisory Committee. The decisions of the Interdepartmental Advisory Committee with respect to aircraft disposals are made with due regard for their effect on operations by competing American airlines as well as their effect on the aircraft industry in this country, which is vital to our position in world commerce and to our national defense. Sales operations in connection with the disposals of aircraft to foreign customers are the responsibility of the Foreign Liquidation Commissioner. This was true not only of aircraft declared surplus in foreign areas but also with respect to domestic surpluses sold to foreign customers. The latter authority was originally delegated to the Department of State by the Reconstruction Finance Corporation on December 26, 1945, and was ratified by War Assets Administration as successor to Reconstruction Finance Corporation's responsibility in this field. The arrangement had existed on an informal basis for some time prior to the formal delegation. The latter authority was terminated, however, on December 31, 1946, when it was turned over to the War Assets Administration. As early as the Summer of 1944 the Interdepartmental Advisory Committee on Surplus Aircraft Disposal recognized that aircraft of a purely combat type possess no civil or commercial utility and consequently would be unsaleable. The Committee, therefore, recommended that a prescribed list of combat aircraft be considered as commercially unsaleable and that they be disposed of as salvage and scrap by the armed forces when excess to their needs. Under this policy the declaration to and sale of aircraft by the Foreign Liquidation Commissioner has been confined to transport, utility cargo, liaison aircraft and such trainer types as are adaptable to private flying. A further limitation on the availability of commercially saleable aircraft has been the condition of the equipment. Many twin-engine transports declared surplus in overseas theaters had been subject to such heavy stresses and damages in carrying out troop-carrier operations and supplying China via the Hump route that they were beyond the point of repair economically, and therefore had no value other than as salvage and scrap.

In its report of July 18, 1944, to the Surplus War Property Administrator, the Surplus Aircraft Advisory Subcommittee (Pogue committee) stated in respect to foreign markets, "We should attempt to develop the foreign markets as rapidly as we are able in order to

secure the widest possible distribution of American aviation products and the future sales potential which will result from this policy." In order actively to implement this policy, the Foreign Liquidation Commissioner has not confined his sales of aircraft to the countries of location of surplus but has used every means, including the services of our foreign missions, to reach and sell all potential users of aircraft throughout the world. The success of these efforts can be measured by the fact that to date approximately 6,000 surplus airplanes have been sold or leased to foreign airlines, governments and individuals. There are virtually no passenger or cargo airlines in the world today which are not operating either entirely or in part with American surplus equipment.

The benefits to be derived from this widespread use of American aircraft will not be complete unless the operators can be assured of spare parts for continued and proper maintenance. Until November 12, 1946, the Foreign Liquidation Commissioner acted as agent for sales to foreign buyers of surplus aircraft components and parts in the possession of the War Assets Administration. Since November 12, 1946, the WAA has taken over this responsibility from the OFLC. In this way it has been possible to furnish foreign purchasers of United States equipment with the essential minimum of spare parts to meet their immediate needs. The retail selling of components and parts from surplus stocks overseas, except in limited areas, has not been possible or practical because these stocks, in most instances, have been packed and stored in such manner that the extraction of individual items to fill purchasers' orders could not be accomplished. Had the demobilization of the Army overseas been less rapid and drastic, the extraction of individual items might have been accomplished by Army personnel. Accordingly, it has appeared most practical to endeavor to sell these stocks of components and parts in bulk sales either to governments or individuals. In the case of stocks in the United Kingdom, France, India, Italy, China and Australia, these were acquired by the governments concerned in overall bulk agreements. The one remaining large stockpile of aircraft components and parts is located in Germany.

In September 1946, in order to ameliorate the shortage of transport aircraft in this country and alleviate the domestic air transportation problem as well as to provide a greater dollar return to the Government in its aircraft disposal program, the Office of the Foreign Liquidation Commissioner obtained the addition of C-47, C-54 and C-45 aircraft, and components and parts for such aircraft, to Schedule A, Order 6 to Regulation 8 under the Surplus Property Act of 1944.

This permitted the importation without restriction of these desirable transport aircraft and parts into this country, even when sold from surplus stocks located overseas.

Cumulative sales of aircraft and aircraft parts to December 31, 1946, amounted to over \$52,000,000 on materiel which cost the Government approximately \$313,000. The foregoing figures do not include bulk settlements with various friendly nations involving some 2,000 aircraft (mostly of the commercial transport type) which were sold for \$30,000,000, or about 20 per cent of cost to our Government.

#### Aviation Division, Department of State

\*The Aviation Division of the Department of State had responsibility for initiating and implementing policy and action in the Department, and coordinating it with other Government agencies, in all matters pertaining to international civil aviation. Major subjects in this field included the development and operation of airlines and air transportation abroad; negotiation of various international agreements, such as the bilateral and multilateral arrangements covering landing rights and air navigation; and matters relating to airports and airways. The Division assembled basic material and made other preparations for participation in international aviation conferences. It acted as liaison between this Government and the U. S. Representative to the Interim Council of the Provisional International Civil Aviation Organization (PICA0) which was set up at Montreal as a result of the 1944 aviation conference at Chicago. It likewise followed up the other arrangements proceeding from this conference. The Division also represented the Department of State on the International Technical Committee of Aerial Legal Experts (CITEJA), the U. S. National Commission of the Permanent American Aeronautical Commission (CAPA), and other international bodies dealing with aeronautical affairs.

Functions of the Division also included representation on interdepartmental groups having to do with the following: allocation of surplus aircraft; formulation of overall policy by the Air Coordinating Committee; implementation of this Government's civil aviation policy in foreign countries; the training, under American auspices, of foreign aviation personnel in the United States and abroad; disposition of foreign air bases; maintenance of adequate air navigation facilities; air mail; and other subjects involving interdepartmental collaboration. It also obtained military and civil flight permits for U. S. aircraft proceeding abroad and for foreign aircraft visiting this country.

The Aviation Division, which was responsible for the assignment

of civil air attachés to various foreign countries, continued its supervisory functions in this connection. It also directed the handling of civil aviation matters by the U. S. Foreign Service (Embassies, Legations and Consulates), and arranged for the dissemination to other Government agencies and industry of information submitted by those representatives.

During 1946, the Aviation Division, in cooperation with other Federal agencies, made 15 bilateral air transport agreements with foreign governments, and others were being negotiated. Landing and traffic rights, already obtained, provided for service by scheduled airlines east from the United States to India and westward into China, although some agreements still were in process of negotiation with countries along those routes. Four important agreements were signed with Latin American governments for new services authorized by the CAA.

Applications by foreign air carriers, both scheduled and non-scheduled, to serve the United States increased in number, reflecting the rapid development of national aviation companies in other countries. Operations by non-scheduled carriers in particular presented varied problems requiring solution by the interested agencies of the Government. The growth of civil aviation throughout the world increased the need for technical advice and assistance from the United States in helping other countries to establish the necessary safety and economic regulations and the necessary physical facilities upon which growing air transportation could be based. The Division's functions in helping to promote the adoption of American techniques and equipment increased accordingly.

#### **Federal Communications Commission**

With the postwar increase in scheduled airline operations, non-scheduled services and private flying, the Federal Communications Commission expanded its activities in all the various branches of aviation radio involving the allocation of frequencies. About 10,500 licenses for radio stations in the aviation service had been issued by January 1, 1947, and it was expected that the fiscal year 1947 ending June 30 would show more than 100 per cent increase over the 6,205 authorizations issued for the fiscal year 1946. The increased volume of aircraft operations already was taxing the capacity of prewar communications systems to the limit. In order to accommodate future expansion, the entire domestic aviation communication system was being re-engineered. Very high frequencies were being placed into service. New communication and traffic control procedures were being adopted,

and every effort was being made to bring domestic aviation communications to the maximum of engineering efficiency.

The VHF allocations made frequencies between 108 and 132 Mc available for use by domestic aviation on January 1, 1947. Communications on those channels should prove more desirable in intelligibility and reduced weight of equipment. The year 1946 saw the implementation of three new services, the aeronautical public service telephone, the airport utility service, and instrument landing systems. The aeronautical public service telephone provided voice communication between persons aboard an aircraft and a person on the ground on regular telephone facilities. It was used chiefly by industry in the operation of its own aircraft but could become regular service on commercial flights. It actually was being used experimentally to determine its practicability by a major international airline. The airport utility service provided two-way radiotelephone communications between control towers, ground vehicles at airports and taxiing aircraft. In addition to the many Federal instrument landing systems in the United States, the Commission had authorized two private systems operated by airlines for the instruction of flight personnel.

In addition to the efforts directed toward improvements in aviation communications, the safety of aircraft might be further increased by other radio aids to air navigation employing war developed pulse techniques and use of the microwave portion of the radio frequency spectrum. Such techniques could be used for pulse type radio altimeters, obstacle detectors, storm area indicators, anti-collision devices and short range navigation devices aboard aircraft, as well as for completely integrated all-weather air traffic control systems which might include enroute control, automatic approach control, automatic landing and airport surveillance systems on the ground. Radio altimeters employing pulse techniques already were licensed by the FCC on an experimental basis for use aboard some scheduled aircraft, including aircraft flying the North Atlantic. Loran (long range navigation) receiving equipment was in use in some of the commercial transoceanic aircraft. Various types of radar were receiving serious consideration by commercial airlines for obstacle detection, storm warning and anti-collision purposes, as well as for navigational aids. While the value of many of those devices had been proven from a military standpoint, their value in the commercial field of aviation had not been definitely established. For that reason, the airlines were conducting investigations to determine how those tools could be made to best serve commercial interests. Nationally known electronic manufacturing companies, which had been engaged in the production of aids to

air navigation during the war, were prepared to produce comparable equipment for peacetime use by commercial airlines as soon as the trend of thinking had become firm enough to justify the investment required. The trend of thinking which ultimately would lead to co-ordination of an integrated system is guided domestically by the Radio Technical Commission for Aeronautics, on which the FCC was represented. The RTCA had a number of working subcommittees guiding equipment development, operating procedures, minimum standards and similar phases of the commercial aviation radio art. The FCC maintained a continuing study of aviation equipment and aviation operations, so that its staff could form sound opinions, assist in co-operative efforts, and see that the FCC authority was expeditiously applied as required.

In order to meet the communication needs of the rapidly growing number of aircraft it was necessary for the aviation industry to revise much of its thinking. Similarly, it was necessary for the FCC to revise its operating procedures in order that licenses might be issued promptly to those requiring service and in a manner that would result in minimum use of frequencies. In order to expedite the great number of itinerant aircraft applications, the FCC adopted a simplified application form (404-A) from which a license could be mechanically reproduced, thus opening the way to eventual one day license service to the private plane operator. For further simplification in licensing, the FCC adopted two new policies, 1—Provision for the manufacturer, distributor or dealer of aircraft factory-equipped with radio to certify that the equipment and operator were in accordance with FCC rules, and a copy of this certification on the appropriate form (453-B) acted as 30-day special temporary authorization pending action on the formal application for license submitted simultaneously. 2—The Commission authorized a change in the form of authorization issued to air carriers flying outside continental United States in order that those carriers could make use of such frequencies as might be required by the authority which had jurisdiction over the area where the aircraft was operating without obtaining prior approval of the FCC.

In the international field, the Provisional International Civil Aviation Organization (PICAO) had become an active force. The central organization in Montreal had published communications and other standards which were to serve as a framework on which additional standards would be based. Such standards were being prepared for each of the various regions of the world, and were made particularly applicable to local conditions. Looking to the future, the world system had to be organized to come within the framework of the PICAO

regulations. It was necessary that the FCC be represented in all of the regional conferences to achieve the world-wide uniformity of communications essential for American air carriers to participate in the world air transport business. The International Telecommunications Union was to have a meeting in the near future to draw up new radio regulations. Included in those regulations would be a table of allocation, and it would be necessary to see that sufficient frequencies were made available to aviation to permit safe and high-speed aircraft flight.

#### U. S. Weather Bureau

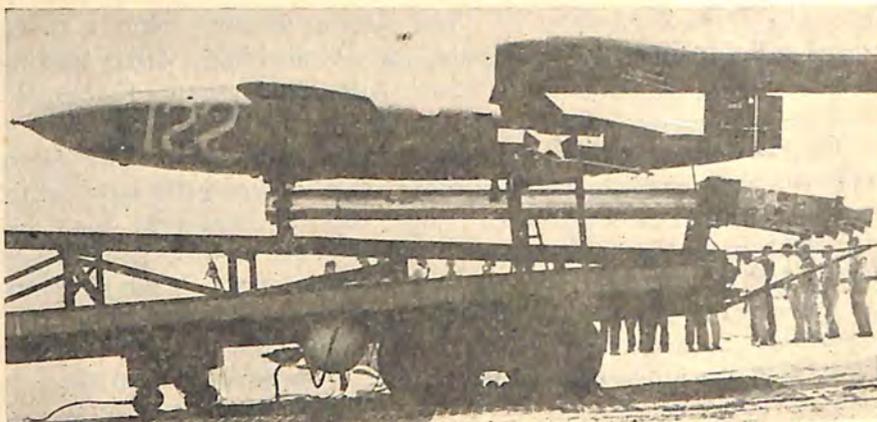
Weather Bureau services to international aviation were expanded considerably after the war. The Bureau took over essential weather reporting and forecasting activities at a number of stations along the overseas air routes where military weather services necessarily had been reduced through demobilization. In several conferences attended by Weather Bureau officials and representatives of foreign weather services, international agreements regarding essential meteorological programs were reached. Such understandings represented a considerable measure of progress toward establishing the complete and well-integrated system of world meteorology required to satisfy the standards established by the Provisional International Civil Aviation Organization (PICAO). The Weather Bureau was cooperating with the U. S. Coast Guard in maintenance of the Atlantic Weather Patrol, which, since its establishment in February, 1940, had proven of inestimable value to air transportation to and from Europe. The weather ships took surface, radiosonde and winds aloft observations on a frequent schedule at fixed positions chosen to give the broadest possible coverage of atmospheric conditions over the ocean. Two of the Pacific weather ship stations were taken over from the Navy by the Coast Guard and Weather Bureau during the summer of 1946. Their observations permitted the forecasters in the newly established international aviation service of the Weather Bureau to anticipate developments along the overseas air lanes and warn of any sudden weather changes likely to endanger safe operations. Plans provided for an increase during 1947 in the number of ocean stations to be operated by the Government and additional stations in the eastern Atlantic to be operated by several European governments.

The year 1946 saw another step forward in international aviation, the organization by the Weather Bureau of the Arctic project, which already had made significant progress in its task of building a meteorological network north of latitudes from which regular weather reports

theretofore had been received. The Arctic weather stations transmitted data of value to domestic airlines, and also had a direct bearing on the safety of flights over the North Atlantic, where weather conditions are profoundly influenced by developments in the Arctic.

On the domestic scene, developments were less promising. There was very little increase in the appropriation for domestic air weather service in the Weather Bureau budget for the fiscal year 1947, beginning July 1, 1946. Operational costs had risen, with a result that during the latter half of 1946 it was found necessary to make some minor retrenchments and considerable readjustments in airway weather operations. New demands multiplied, but very few of them could be met within the limits of existing facilities. Improvements in the Bureau's aviation services, however, were by no means totally absent. On the contrary, the program calling for the installation of the 140 ceilometers authorized by appropriations was pushed forward vigorously. Of those new electronic ceiling-height measuring devices, 97 were in actual operation and the remainder in process of installation. Radio direction-finding apparatus, obtained from military surplus, was installed at about half of the radiosonde stations maintained by the Weather Bureau. These devices, by tracking a radiosonde, permitted measurement of the direction and speed of the winds aloft even under conditions of overcast and stormy skies, with great benefit to flight planning as well as to weather forecasting. Other instrumental advances, some still in the testing stage but expected eventually to prove of practical value to the aviation weather service, included direct-reading wind speed and direction measuring apparatus, an electronically controlled dew point indicator, and equipment for the precise measurement of relative humidity at subfreezing temperatures.

Due to wartime security restrictions, little information had been released on the Analysis Center, organized early in 1942 at the Weather Bureau central office in Washington. In addition to fulfilling its military role as part of a joint weather central, which included the Army Weather central and the Navy Weather central, the Analysis center continued to discharge a most useful function in relation to the Bureau's flight weather service. Every six hours, the Analysis center transmitted in coded form an analysis of the regularly scheduled weather map on a fast schedule over a nationwide teletype circuit. All Weather Bureau stations, large or small, had the help of this service in preparing their own analyses and forecasts. More accurate information thus was made available to the public, and possible differences in the technical interpretation of current weather situations by different meteorologists were minimized. As a result, weather advice



U. S. Army photo

THE AMERICAN JB-2 BUZZ BOMB

given to a pilot at various Weather Bureau offices along his route was stated more nearly in the same terms, so that he was less likely to become confused over the weather situation or to misunderstand the advice. Another service of the Analysis center was the issuance of prognostic analyses. Like the analyses of the current weather situation, these also were sent in coded form over the nationwide teletype network four times daily, and they provided the field stations with a preliminary picture of the analysis 12 to 24 hours ahead. The prognostic analyses were not forecasts of the weather, but only of the analyzed map. Still, they provided the individual forecaster with a check against his own opinion of "what the map will look like," and to that extent aided him in predicting the weather for the benefit of aviation.

At the Mount Washington Observatory in New Hampshire, Weather Bureau observers continued their regular meteorological and icing observations. In cooperation with Harvard University, the Army Air Forces Materiel Command, the Massachusetts Institute of Technology, the General Electric Company, the Goodrich Rubber Company, Northwest Airlines, and other interested organizations, they assisted in the testing of aircraft de-icing equipment. In addition to providing the routine and special weather observations needed for the Mount Washington icing studies, the Weather Bureau analyzed and was preparing for publication a summary of icing data from airplane observations taken over the United States. The purpose of this summary was twofold. It was intended to show the upper and lower altitude limits of icing in relation to temperature and type of cloud, and

to describe, in tabular form, the various kinds and amounts of ice encountered. The Weather Bureau also was cooperating in icing studies at the NACA Ames Aeronautical Laboratory at Moffett Field, Calif.

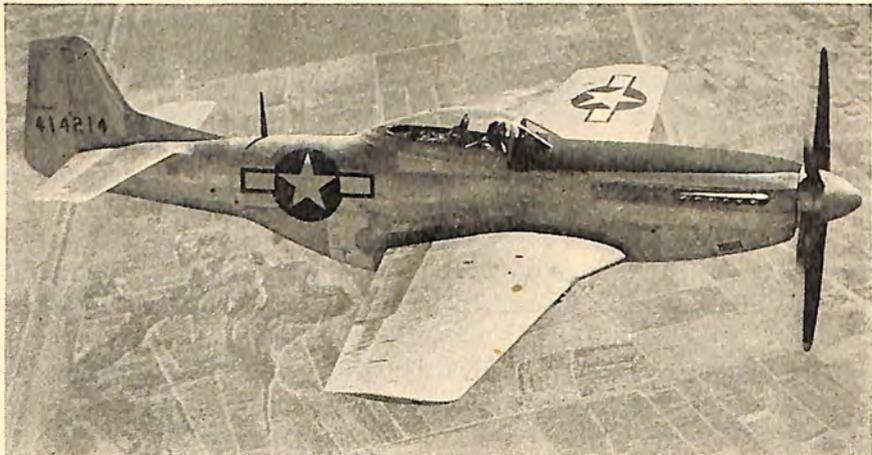
During 1946, the Weather Bureau was requested by the NACA to provide the leadership in a project intended to extend the NACA standard atmosphere above its present ceiling of 65,000 feet to a much greater height. A group of experts accordingly was formed, and a tentative standard atmosphere, reaching to a height of 75 miles, was arrived at by piecing together all available evidence gathered from such diverse sources as observations of meteors, of the anomalous propagation of sound from explosions, radio reflection from the ionosphere and the aurora borealis. Direct pressure observations up to 53 miles by means of V-2 rockets agreed very closely with those pressure values calculated for the extended standard atmosphere. That type of information, which dealt with the characteristics of the increasingly important upper atmosphere, was necessary for the design of aircraft and guided missiles intended to travel at great altitudes.

The first phase of the Thunderstorm Project, supervised by the Weather Bureau and involving the cooperation of the Army, Navy and National Advisory Committee for Aeronautics, took place at a test area near Orlando, Fla., during June-September, 1946. A network of 54 stations, located roughly one mile from each other, was well equipped with automatic-recording instruments to register the surface variations in pressure, temperature, humidity, wind and rainfall as a thunderstorm moved over the test area. In addition, radiosonde, rawin, and radar stations were established to observe and record conditions in the upper air; and a central operational control was established. The radar sets proved to be extremely valuable in tracking the thunderstorm, controlling release of the sounding balloons, and checking the flight of the airplanes and gliders used to study the situation within the thunderstorm itself.

On a contract agreement with the Weather Bureau, the Soaring Society of America supplied three sailplanes, which were elaborately instrumented and sent on a total of 38 flights during the project. A large percentage of those flights was made into heavy convective activity in which on eight occasions the gliders soared to altitudes over 15,000 feet. The power aircraft used were 10 Northrop P-61C or Black Widow night fighters. The NACA, the Weather Bureau and the Army joined in supplying those aircraft with very complete instrumental equipment, which included radar, accelerometer, airspeed-altitude recorder, control-position recorder, radio altimeter, free air

temperature recorder, as well as standard blind-flying instruments. Measures were taken to insure synchronization of the meteorological data taken by the aircraft. Photographing the return signal of the aircraft on a separate scope at the ground radar site permitted the analyst to determine the various flight patterns. A total of over 550 traverses of thunderstorms were made by the Black Widows. It can be seen from the number of flights and the care with which the aircraft were instrumented that a large amount of data was made available. In addition, the surface data, the radiosonde, rawin, and other instrumental records provided an abundance of material with which to analyze the thunderstorms studied with a completeness impossible in the past. That analysis and a similar investigation of midwestern thunderstorms, planned for 1947, promised some of the answers to the serious problems of safe flying in thunderstorms.

The Weather Bureau also was grappling with the so-called multiple airport problem at metropolitan centers, such as New York and Chicago. Due to the disparity between funds available and multiplying demands, the Bureau had been unable to furnish the necessary complement of both flight-briefing personnel and airport weather observers at those aviation traffic focal points. Measures were being taken however, to train and certificate airline employees for the issuance of clearance weather reports until such time as regular Weather Bureau staffs could be provided.



NORTH AMERICAN P-51D MUSTANG FIGHTER

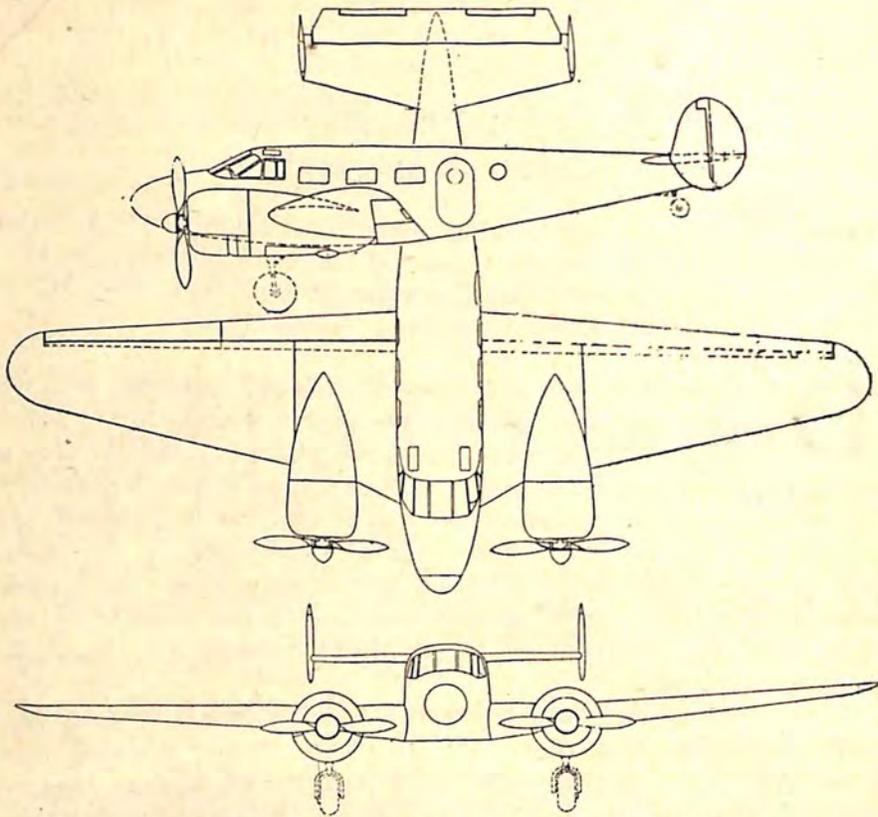
## CHAPTER X AMERICAN AIRCRAFT

Postwar Production—Description of the New Transports—A Large Variety of Personal Aircraft—New and Larger Bombers for the Air Forces—Development of Jet-Propelled Planes—Supersonic Aircraft—Pilotless Planes and Guided Missiles.

**D**ESPITE postwar shortages of essential materials such as metals, fabrics and plastics, the aircraft manufacturers of the United States in 1946 produced 36,204 aircraft, besides a number of experimental machines, and at the same time reconverted hundreds of wartime transports for airline use here and abroad. Of that number, 34,874 planes were shipped to non-military customers, and 30,639 of them, or 88 per cent, were 2-place planes for private owners. The following paragraphs describe the non-secret machines produced during the year, and give some of the details of the company programs for 1947.

The Aeronca Aircraft Corporation, Middletown, O., went into 1946 production on an assembly line basis. During the year they manufactured the Aeronca Champion, a two place tandem airplane and the Aeronca Chief, a side-by-side model, at the Dayton and Middletown plants. In 1947, Aeronca planned to continue producing both the Chief and the Champion, and to begin production on the all-metal, two-place, low-wing, Aeronca Chum, under the Weick patent, licensed by Engineering and Research Corporation.

Beech Aircraft Corporation, Wichita, Kans., continued the steady output of its Model D18S twin-engine executive transport, marked only by schedule dislocations caused by shortage of materials and parts because of strikes in suppliers' industries. In addition to the Model 18 production, Approved Type Certificates were obtained on four new models and manufacture and sale of these were begun. The new models ranged from variants of the twin-engine Beechcrafts to the Model 35 Bonanza which was designed especially for the personal airplane market. The first commercial airplane to come off the Beech production line six weeks after V-J Day was the postwar improved prototype of the seven to nine-place all-metal Model D18S executive transport. Shortly afterward, with the first Approved Type Certificate

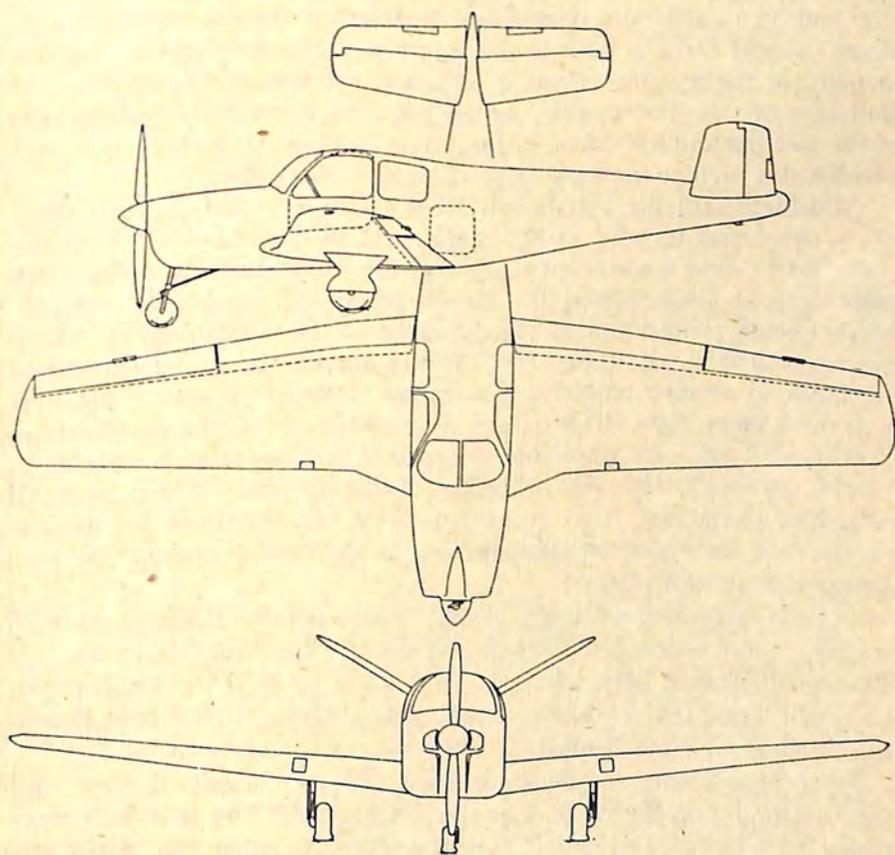


BEECHCRAFT MODEL D18S, D18C-T AND D18C

to be awarded by the CAA under the revised section 03 of the Civil Air Regulations, the D18S was in full production.

Outward appearance of the Beechcraft D18S was similar to previous models; most of the changes being made in the inner structure, which had been strengthened to carry high gross weight and increased payload. The revised landing gear and tail wheel assemblies strengthened the ability of the ship to withstand rough terrain, an outstanding characteristic of previous types of Beechcrafts. On the new model, the leading edge of the wings between the fuselage and nacelles was extended to improve handling characteristics at low speeds. Spot welding and flush riveting of the forward fuselage and wing skin reduced drag. In the cabin interior of the D18S, Beech achieved a high standard of comfort for executive aircraft. Temperatures were regulated

with cold and warm air ducts, individual reading lights and ash trays were furnished, and complete upholstery in attractive aircraft fabrics with matching carpet were offered in a choice of optional color schemes to please the most exacting executive. During the years which Beech had produced Model 18's, the aircraft had operated under the most difficult climatic conditions, ranging from temperature less than 50 degrees below zero in the Arctic zone to the torrid heat of the equator; from the high humidity of the Philippines to the dust of North Africa. Their record of high versatility and performance resulted in their being manufactured in five distinct special-purpose wartime types for the United States and Allied nations. Resumption of production on the Model 18 continued its world-wide commercial



BEECHCRAFT BONANZA

service. During 1946, twin-engine Beechcrafts were delivered to owners in nearly all the 48 States, buyers including many corporations. However, deliveries were not confined to the States, the airplanes were sold to governments, companies, airlines and private individuals in both the Americas and overseas. An early foreign delivery which made history was that of three D18S Beechcrafts purchased by Misr Airwork, S.A.E., Cairo, Egypt. The three planes were flown from the Beech factory at Wichita to Cairo in March, 1946—the first commercial overwater delivery of its kind. Misr was the largest airline in Egypt, and with a subsequent purchase of three more Model 18's, Beechcrafts became virtually the standard aircraft on its extensive Near East network.

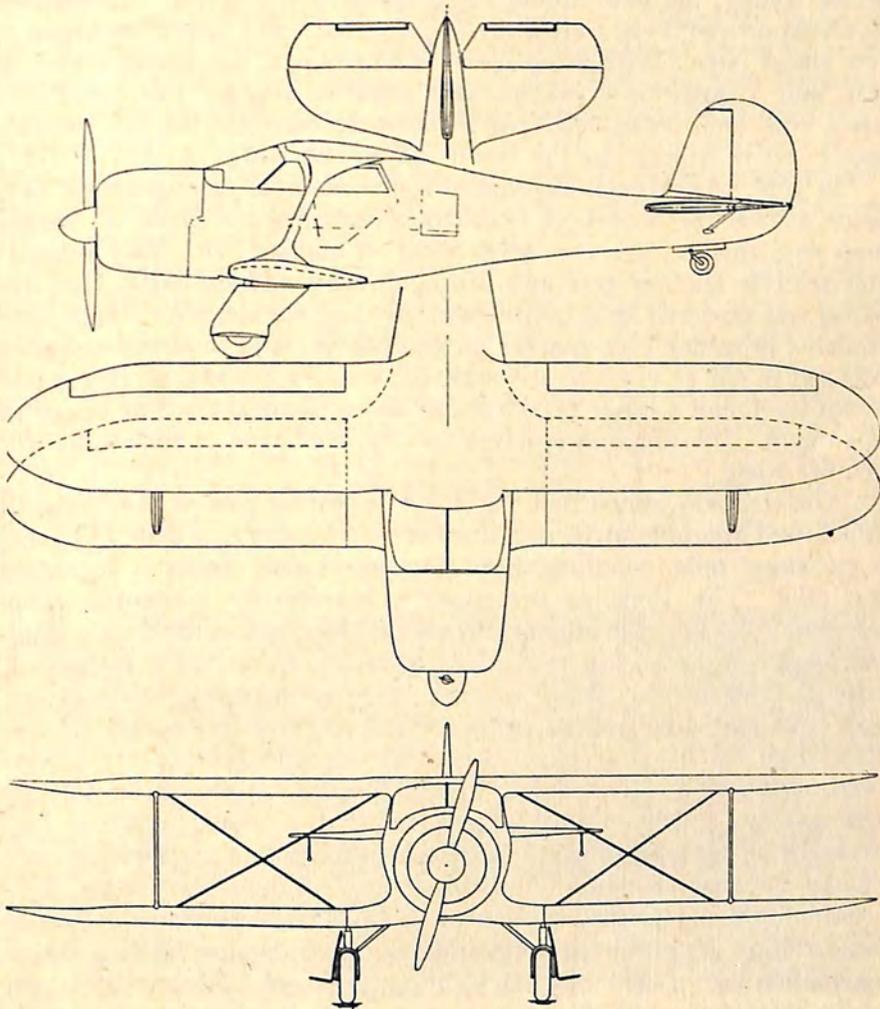
Following certification of the executive transport, D18S, development was begun immediately on an aircarrier (Model D18C-T) version and on an alternate powerplant installation for the executive airplane (Model D18C), both to use 525 h.p. Continental radial engines in place of the 450 h.p. Pratt & Whitney engines of the D18S. Installation of this new engine, which required a complete redesigning of the cowling and air ducts, produced an increase in performance and permitted a further increase of gross weight to 9,000 lbs.

Working with the Pittsburgh Plate Glass Company, Beech engineers developed for the D18C-T the first bird-proof windshield installation to meet the revised CAR requirements. In tests at the CAA laboratory at Indianapolis the Beech-developed windshield successfully resisted penetration of "birds" fired at the windshield at velocities up to 250 m.p.h. The D18C-T was among the first twin-engine airplanes to receive tentative air transport approval under the new and much more rigid CAR 04 aircarrier category. Upon certification, Beechcraft D18C-T's went into immediate service on such airlines as Florida Airways, Hawaiian Airlines, Ltd., Empire Airlines and All American Aviation. The latter company equipped one of its airplanes with mail pick-up attachments, using it as a combination passenger and airmail plane.

At the beginning of 1947, Model D18S Beechcrafts also were in service or on order for airlines and feeder lines for Hawaiian Air Transport Service, Misr Airwork, S.A.E. of Egypt, Ambica Airlines, Ltd., and Tata, Inc., of India, Challenger Airlines of Utah and Robinson Airlines of New York.

Two significant records made by D18S Beechcrafts during 1946 were on non-stop flights of 1,410 and 1,744 mi. The first was made from Wichita to Hartford, Conn., on April 6, when the flight was made in 6 hrs. That Beechcraft made an average speed of 235 m.p.h.

The second established an overwater ferry flight of a Beechcraft D18S from Gander, Newfoundland, to Vilaporto, Azores, at an average speed of 232.5 m.p.h. These flights recalled an earlier non-stop speed record established by a Model 18 Beechcraft in the 1940 Macfadden cross country race from St. Louis, Missouri, to Miami, Florida, a distance of 1,084 miles at an average speed of 234.097 miles per hour.



BEECHCRAFT G17S

Fifteen Model 18's were flown across the North and South Atlantic during 1946.

The second Beech airplane to reach production basis was the post-war improved version of the record-breaking Model 17 Beechcraft. It still incorporated in its design all the features that gave it speed, dependability, luxury and utility. With a re-designed and more efficient cowling, the inclusion of a greater amount of metal construction in the forward airframe, increased rudder area and new high interior styling, the new Model 17, designated the G17S, received its CAA Approved Type Certificate in July, 1946 and deliveries began a few weeks later. With a top speed of 212 m.p.h., a cruising speed of 201, and a range of 1,000 mi., this negative stagger Beechcraft biplane was soon being delivered to business corporations and sportsmen pilots in America and to business users abroad.

In July, 1946, Beech introduced to the medium price personal airplane market the Model 35 Beechcraft Bonanza, a 4-place, all metal, high performance, low cantilever wing monoplane with fully retractable tricycle landing gear and full equipment as standard. The Bonanza was powered by a Continental 165 h.p. engine, with Beech controllable propeller (see chapter on equipment) and its cruising speed was 175 m.p.h. at 115 h.p. at 10,000 ft., with a top speed of 184 m.p.h. at sea level, and a range of 750 mi. at an economical cruising speed of 165 m.p.h. The Bonanza received its approved type certificate in November 1946.

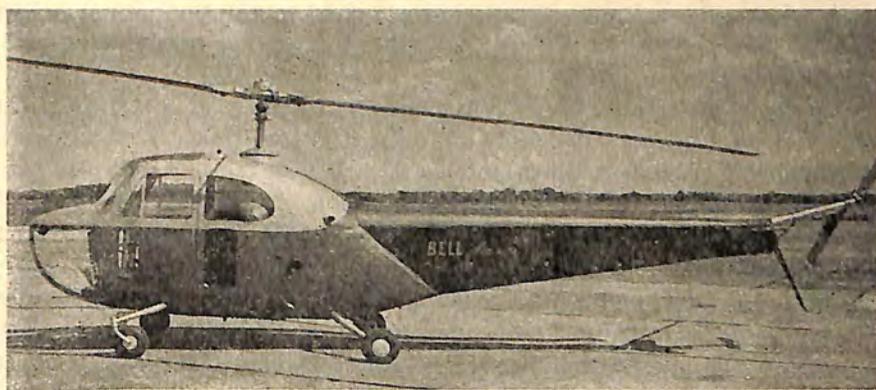
The company stated that the direct operating cost of the Bonanza when used approximately 100 hours a month, was less than 1½ cents a passenger mile, counting three passengers only and not including the pilot. The Bonanza presented a luxuriously appointed cabin interior, upholstered in all-wool aircraft fabrics, with wide deep spring-filled seats and with separate ash trays and sun visors for each occupant. Unrestricted visibility was accomplished by using an exceptionally wide and deep molded, ultra-violet proof Lucite windshield and four large windows. With a Beechcraft designed ventilating system allowing fresh air to circulate gently throughout the cabin interior through five widely separated ducts and with a choice of warmed air from the heater when needed, interior comfort was at all times assured. In the Bonanza all items required for day or night instrument flight were built in as standard equipment. They included a two-way, three-band radio with aural-null loop and azimuth indicator, landing lights, navigation lights, interior cabin lighting, turn and bank indicator, sensitive altimeter, manifold pressure gage and all other standard flight and engine operating gages and instruments.

For the first time on a commercial aircraft the Bonanza had a unique V or butterfly tail. Although of radical appearance, control manipulation of this new empennage, which was first tested and proved by Beech engineers in 1944, was conventional in every respect.

At the beginning of 1947, Beech reported a backlog of 1,500 orders on the Bonanza, with production scheduled to accelerate to 12 of these airplanes a day. Also progressing to an early flight date were the first two prototypes of the new 20-place, four-engine, Model 34 Beechcraft designed as a short haul air carrier transport and feederliner.

Bell Aircraft Corporation, Buffalo, N. Y., broadened the scope of its activities so that they included a comprehensive program of aeronautical research and development, an expanding helicopter business, and a substantial program of commercial manufacture. The company's military work consisted principally of research and development projects on guided missiles, apparatus pertaining to guided missiles and piloted supersonic airplanes such as the XS-1. Bell had contracts with the Army Air Forces and the Navy.

The company was manufacturing three models of helicopters, Model 48 (YR-12), 5-place 600 h.p. for the Army Air Forces; Model 47A (YR-13), 175 h.p. 2-place, for the AAF, Army Ground Forces and the Navy, and Model 47B, 175 h.p. 2-place for commercial markets. In addition, Bell was building new model experimental helicopters for use by the Army Ground Forces. On March 8, 1946, a helicopter commercial license, NC-1H, was issued by the CAA for the Bell Model 47 helicopter. It utilized a patented 2-blade rotor and stabilizer system. The gross weight was 2200 lbs. including a useful



BELL 47B HELICOPTER

load of 677 lbs. The CAA flight tests were conducted up to altitudes of approximately 10,000 ft. Speeds well over 100 m.p.h. were attained. Cruising speed was 80 m.p.h., with a range of between 225 and 250 mi. The Model 47B commercial helicopter was a 2-place, side-by-side aircraft equipped with dual controls. A Franklin aircooled engine was mounted vertically aft of the cabin and drove the main and tail rotors through a clutch and free-wheeling coupling, built integral with the transmission. Transmission and main rotor mast were mounted at the top of the engine. A baggage compartment was accessible from the right side of the helicopter, between the engine compartment and the tail boom. The 47B had a length of 41 ft. 10 in., height (to center line of rotor) 8 ft. 6 in., main rotor disc 35 ft. 1½ in. in diam., tail rotor disc 5 ft. 8½ in. in diam., stabilizer bar 8 ft. 4 in. in diam., wheel base 7 ft. 5½ in. and tread 5 ft. 10 in.

The patented stabilizer bar was mounted on the main rotor mast just below and 90 degrees to the main motor. This bar and the cyclic control system linkage were designed to take advantage of the inertia of the bar. Due to the friction or dampening on the see-saw method of attachment to the mast, the bar had a slight tendency to follow the mast. This following time was decreased by two hydraulic dampers attached to the bar, outboard of the mast, one on each side. Adjustment of the dampers regulated the following time of the bar, to give the desired amount of stability and still leave the pilot with complete and responsive control. The landing gear consisted of 4 wheels mounted to 2 cross-tube assemblies. The 2 front wheels were self-castering and equipped with shimmy dampers and elastic cord to facilitate ground-handling and taxi operations. Two pneumatic shock absorbers, one attached to each cross-member, absorbed the normal loads of ground contact. A tail skid attached to the boom just below the tail rotor protected the structure in the event of inadvertent tail-low landings.

In June, 1946, a Bell 47 helicopter was modified as a crop duster and sprayer and was dispatched to the Central Aircraft Company, Yakima, Wash., one of the country's largest pest control operators, to undergo intensive tests in aerial pest control. After a full summer of work in the Yakima area, it was determined that helicopters can do a significantly better job over other types of pest control, dusting orchards, vineyards, and crops, where the downwash of the rotor blades is most effective. Respecting low crops such as potatoes, peas, beans, squash and onions, the helicopter was found to be as effective as other types of equipment. Central Aircraft ordered 9 Bell helicopters.

A second project undertaken by Bell helicopters dealt with a geophysical survey in northern Canada. Headed by Dr. Hans Lundberg, the expedition employed for the first time a helicopter in combination with the latest type magnetic and electric devices to discover and record new mineral and oil deposits starting in the vicinity of Sudbury, Ontario. After 4 months of operation in the bush country, it was learned that helicopters are ideal machines for geophysical surveys. Chief advantage of the helicopter in this type of work was its time-saving qualities. Using ordinary ground methods, a Canadian survey of an area 12,000 by 10,000 ft. required 70 days to perform, the magnetic operations utilizing the services of 2 engineers and 2 helpers. The same area was surveyed by helicopter using only an engineer-observer and a pilot, and required only one hour.

To provide an adequate supply of qualified airmen to fly the helicopters in industry, commerce mail service, agriculture and other fields, Bell in July, 1946, established a flight training school for civilian pilots. The first class included 4 commercially licensed fixed-wing airplane pilots, selected from a large field of applicants. The course required from 6 to 8 weeks, and approximately 75 hours were devoted to class instruction. Flight training consisted of a maximum of 30 and a minimum of 22½ hours of flying time, divided into approximately equal hours of dual and solo, depending upon individual requirements.

In November, 1946, Bell, working with the AAF and the National Advisory Committee for Aeronautics, completed the XS-1, America's first rocket powered man-carrying plane designed to reach supersonic speeds. The first powered flight was made December 9, 1946. Designed to reach a top speed of 1,700 m.p.h. at an altitude of 80,000 ft., the XS-1 never was intended to be a military airplane, but rather a piloted flying research laboratory, with the function of recording data concerning the effect of transonic and supersonic speeds on aircraft. That data was expected to be valuable in the development of the planes of tomorrow. Described in the simplest terms, the XS-1 was an extremely rugged airframe driven by a powerful rocket engine. Since it was not a combat plane, it had no armament or armor protection for the pilot. For a plane designed to fly at speeds faster than man had ever flown before, the XS-1 employed a rather conventional configuration. Though highly streamlined, the use of the sweptback wing was avoided. The wing was very thin, with a maximum thickness of only 10 per cent of the chord. Power for the ship was supplied by a rocket engine, designed and manufactured by Reaction Motors. It consisted of 4 units, burning alcohol and liquid oxygen, each of which produced

a static thrust of 1,500 lbs., or a total thrust output for the plane of 6,000 lbs. Power output was controlled by selection of the number of cylinders to be fired at one time.

The first XS-1 to fly incorporated a substitute power plant. The original power plant installation was to have incorporated a fuel system wherein alcohol and oxygen would be forced into the burner chambers by a specially designed turbo pump. Because of the unavailability of the turbo unit, it was decided to install a pressurized system first, later using the turbo system as soon as it could be secured. With the alternate system, top speed was estimated at 1,000 m.p.h. at 60,000 ft. The length of the airplane was 31 ft., 10 ft. 10 in. in height at tail, wingspan was small compared to the AAF's latest fighter craft, only 28 ft. The unloaded plane weight was 4,892 lbs., 526 lbs. of which was test equipment. The rocket fuel weighed more than one and a half times the weight of the empty plane, 8,177 lbs. Bell Aircraft's contract called for demonstration of a minimum speed of Mach number .8, plus certain other performance requirements. After initial performance guarantees were met the Army Air Forces, National Advisory Committee for Aeronautics and Bell Aircraft were to continue further test work.

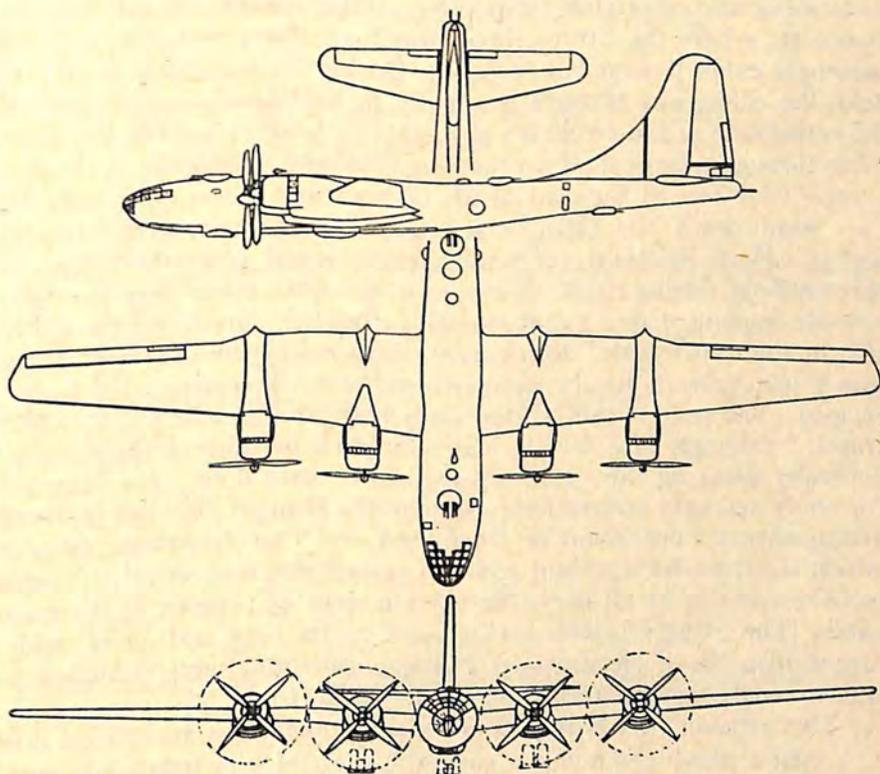
Under contract with the Navy, Bell was experimenting with the use of sweptback wings on full scale aircraft. The first flight tests were with a modified P-63, equipped with 35-degree sweptback wings, with Navy designation L-39. The modified plane, which was not considered a prototype but rather a flying platform on which the sweptback wing design could be tested under actual operation, was used to test sweptback wing characteristics at relatively low speeds.

Bellanca Aircraft Corporation, New Castle, Del., in 1946 produced and delivered 400 Cruisair Senior commercial airplanes and organized a nation-wide group of 54 distributors. The company planned a production of about 130 planes a month in 1947. At the same time, G. M. Bellanca, president of the company, was developing new designs and other projects in the commercial aircraft field. The Bellanca Cruisair Senior, a 4-place plane, was powered by a Franklin 150 h.p. 6-cyl. engine and Aeromatic propeller. Its gross weight was 2,100 lbs., high speed 169 m.p.h., cruising at 150, takeoff run 485 ft. Its wingspan was 34 ft. 2 in. and length 21 ft. 4 in. The Cruisair Senior had such refinements as fiberglass soundproofing, exhaust silencing mufflers, effective cabin heaters, rugs, ash trays, map compartments, built-in radio speaker and direction finding loop.

The Boeing Aircraft Company, Seattle, Wash., employed 13,000 persons in its Seattle and Wichita, Kans., plants, and had a variety of

commercial and military aircraft either in production or under development. Boeing also was doing rocket work for the Army Air Forces, as well as other long range experimental and development work for the Services. The Boeing Stratocruiser, a double-deck transport and its cargo-carrying counterpart the Stratofreighter were peacetime developments from the B-29 Superfortress which devastated Japan and ended the war in the Far Pacific.

The Stratocruiser was powered by 4 Pratt & Whitney 3,500 h.p. Wasp Major engines and 4 Curtiss 4-blade electric reverse pitch propellers. It had a length of 110 ft., wingspread 141 ft. 3 in., and the top of its tail was 38 ft. from the ground. Its weight empty was 77,405 lbs., gross weight 135,000 lbs. with fuel load, and landing weight 121,700 lbs. Its operating range was 4,200 mi., operating altitude 25,000 ft., ceiling 30,000 ft., cruising speed 300 to 350 m.p.h. Wing and tail



BOEING B-50 SUPERFORTRESS

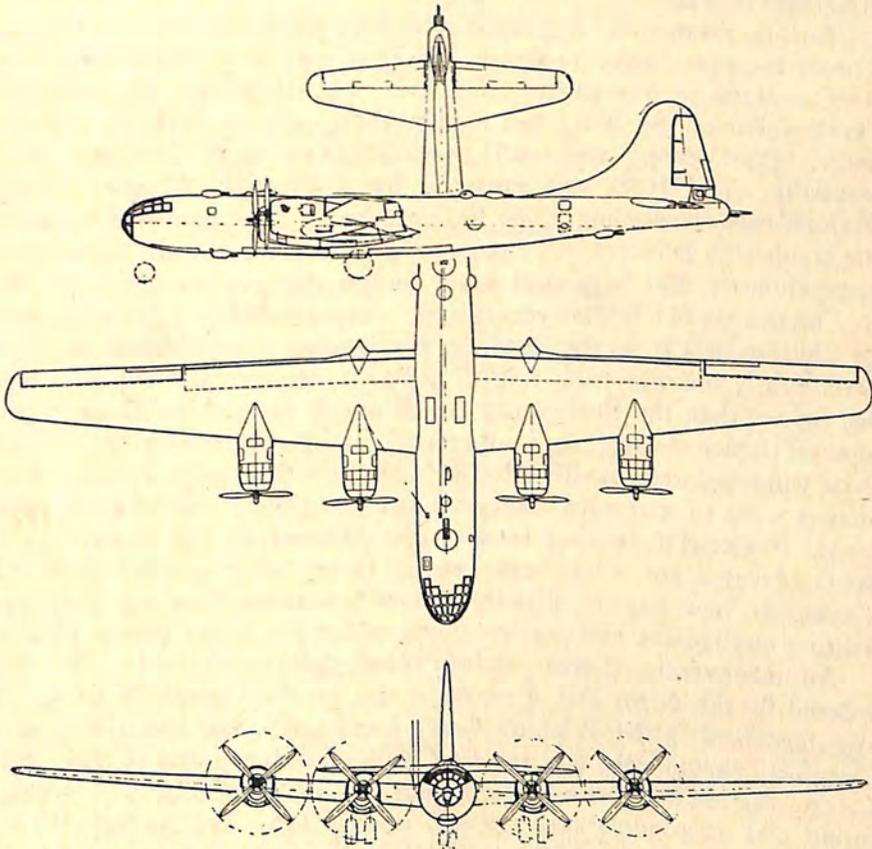
surfaces were similar to those of the B-29. The Stratocruiser's main passenger cabin was 74½ ft. long, completely altitude conditioned except for tail cone and wheel wells. The system maintained sea level conditions up to 15,000 ft. and 6,000 ft. conditions at 25,000 ft. While the standard arrangement was for 80 passengers, the Stratocruiser could be equipped as a commuter transport carrying 114 passengers; or as a sleeper plane carrying 65 day passengers with 30 berths plus 14 lounge seats. Cargo capacity was 900 cu. ft.—9,000 lbs. At the beginning of 1947, Boeing had orders for 55 of the Stratocruisers, including 20 for Pan American Airways at a value of \$25,000,000, and the other orders from American Overseas Airlines, United Airlines, Northwest Airlines, British Overseas Airways and Scandinavian Airlines.

The Boeing-designed altitude conditioning system flew the passenger cabin on an independent flight plan. For example, at all altitudes up to 15,000 ft., the cabin remained at sea level atmospheric condition, eliminating uncomfortable ear-popping during ascent and descent. At 25,000 ft., where the Stratocruiser was high above turbulent air, the passenger cabin flew at but 6,000 ft. During the approach to an airfield, the cabin was brought gradually to field level, independent of the actual rate of the airplane's descent. Passengers entered the main cabin through a large door on the port side near the middle of the airplane. They moved forward or aft to luxurious siesta-type seats, or they went down the circular stairway to the lower-deck, 14-seat lounge. Here Stratocruiser passengers enjoyed pleasant change of surroundings during flight. Forward of the main cabin were the comfortably appointed men's and women's dressing rooms, one on either side of the center aisle. Immediately forward of the dressing rooms was a semi-private luxury compartment which accommodated 8 passengers. The seats in this section were made up into 4 berths for night travel. Although each airline had individual berthing arrangements, generally speaking the seats forward of the main door were designed for ready and easy convertibility into berths at night. Typical berthing arrangements were found in Northwest and Pan American sleepers which accommodated 27 and 29 berth passengers, respectively. American Overseas in its all berthable version slept 45 persons in the main cabin. The Stratocruiser's berths were 72 in. long and 42 in. wide, larger than those on standard Pullman cars and were designed to accommodate two persons in luxurious comfort.

The Stratocruiser was built for airline operations at a direct cost of 1 cent a passenger mile. It carried a crew of 5 in transcontinental service—3 in the operating crew and 2 in the steward's compartment;

and for transoceanic operations 4 in the operating crew and 3 in the steward's compartment. In normal operations it could operate from New York to London in less than 12 hrs.

The Boeing Stratofreighter, cargo version of the Stratocruiser, was designed for a payload of 41,000 lbs. in cargo space with a volume of 6,140 cu. ft., nearly twice that of a boxcar. Designed to operate at the unprecedented low direct cost of 3.9 cents a ton mile, the Stratofreighter had 4 separate cargo compartments, each separately accessible for maximum versatility, and each with provision for rapid, economical loading. Short haul cargo was conveniently loaded or removed from the 3 lower-deck holds at truck bed level without disturbing the main deck load in the fourth and largest compartment. The



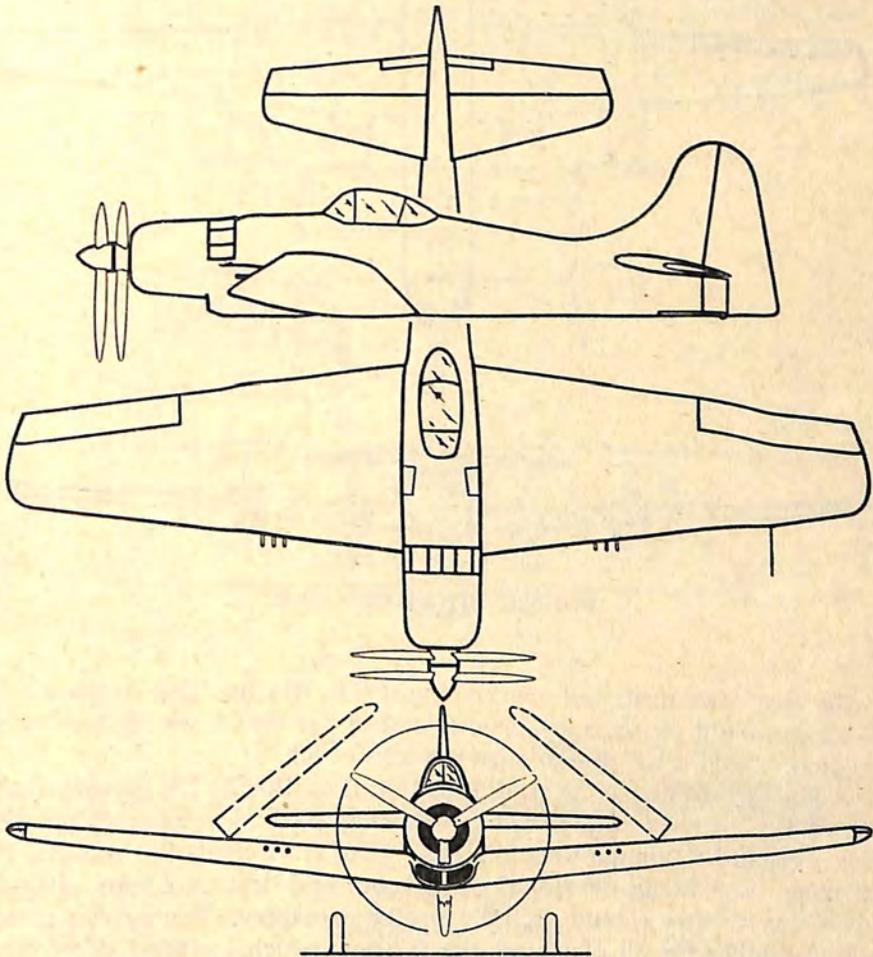
BOEING ARMY B-29 SUPERFORTRESS

upper deck was 74½ ft. long, nearly twice the length of a railroad boxcar. Incorporated in the Stratofreighter were advanced refrigeration and heating systems, thermostatically controlled to provide special temperatures in each of the 4 compartments if desired. Designed to function on the ground as well as in the air, the heating system maintained 60 degrees Fahrenheit within the airplane despite outside temperature as low as 67 degrees below zero Fahrenheit, while the refrigeration system could be set to keep the cabin at 45 degrees even though temperatures outside ranged as high as 100 degrees. If scheduled to carry a mixed load of flowers, vegetables, seafood and live commodities on a given flight, it was possible to separate the cargo, maintaining cabin conditions best suited to the product being carried in each compartment. The Army Air Forces ordered 9 Stratofreighters in 1946.

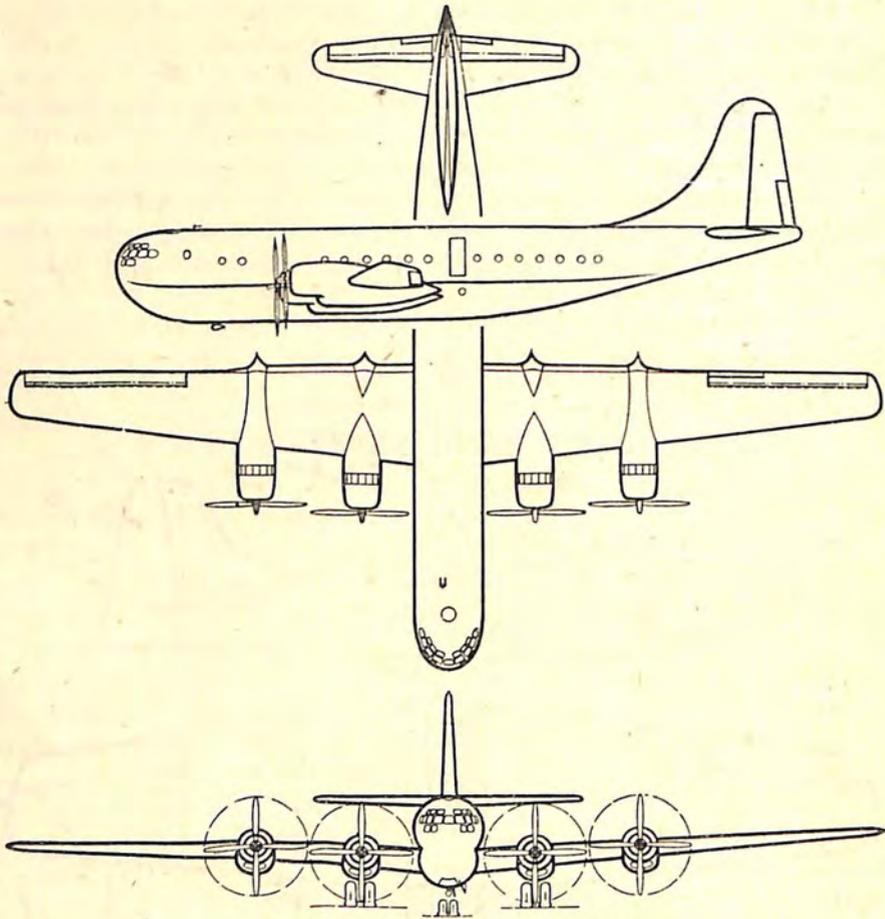
Boeing, meanwhile, continued to receive orders from the Army Air Forces for very heavy bombers. In 1946 133 B-50 Superfortresses were ordered in 2 separate contracts. The B-50 was an extended development of the B-29, but similar to it only in outward appearance. Speed, range and load-carrying ability were increased substantially. The B-50 was powered by 4 Pratt & Whitney Wasp Majors, each developing 3,500 h.p. at takeoff. The new engines gave the bomber 59 per cent more power than the B-29. In all, there were approximately 250 large and small design changes on the B-50, including the use of a lighter yet stronger aluminum alloy in the wing and an addition of 5 ft. to the height of the bomber's vertical tail surface. Structurally the new wing was 16 per cent stronger and almost 1,000 lbs. lighter than the Boeing 117 airfoil which carried the B-29 to the topmost ranks of America's superbombers. Basic redesigning of the B-50 wing included modification of wing covering splices, connection of spar webs to spar cords and connections of wing coverings to spar cords. Pneumatic de-icing boots were replaced on the B-50 with a gas-combustion anti-icing heat system. Other wing changes included a complete new nacelle structure, new fast-acting landing gear retracting mechanism, and accommodations for the larger power plants.

An unconventional Army liaison plane, designated the L-15A, was ordered by the Army Air Forces for use by the Ground Forces. It was developed in the Wichita plant. Designed as an aerial observation post, particularly for spotting and directing artillery fire, the L-15A was readily distinguished from conventional craft by a transparent pod or gondola fuselage and upside down tail surfaces. The new Boeing was powered by a 125 h.p. Lycoming engine, and was capable of taking off over a 4-story building in a distance less than 2

city blocks and landing over a similar obstacle in an even shorter space at speeds as low as 32 m.p.h. The gondola enclosure, housing power-plant, pilot and observer, hung below the level of all flight surfaces. This gave the pilot and the observer full visibility in all directions, including directly below and directly aft. Although using a wheel landing gear, the airplane was equipped for ski or float installation. A 21-gal. fuel tank afforded a range of 2½ hrs. With the addition of an external fuel tank suspended under the gondola fuselage, the range was increased to 5½ hrs. The length of the L-15A was 26 ft. 1.2 in.,



BOEING XF8B-1 NAVY FIGHTER



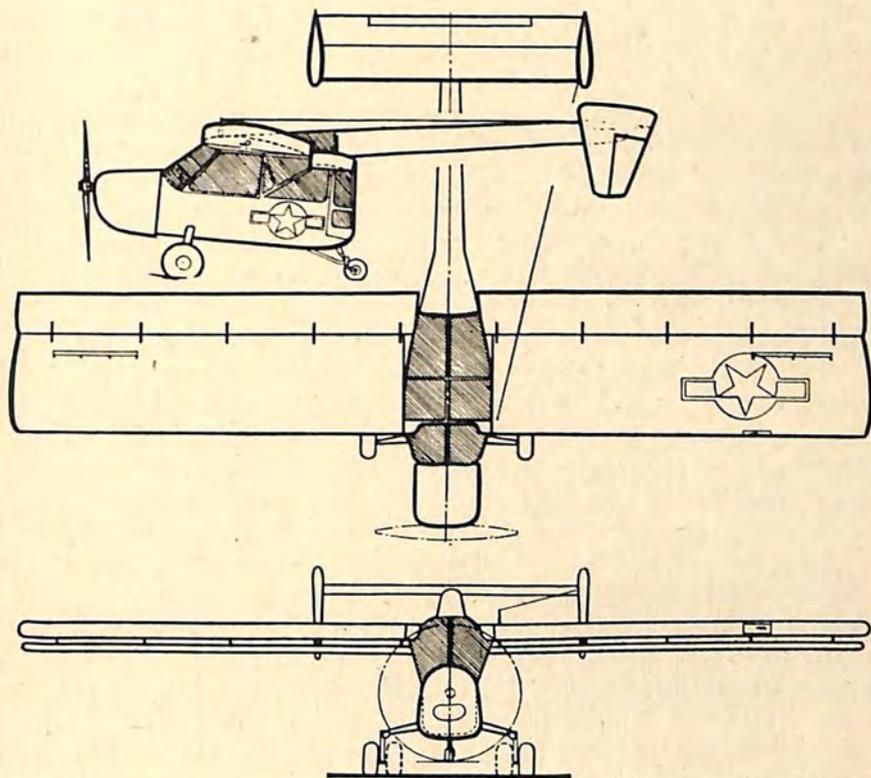
BOEING STRATOCRUISER

wing span was 40 ft. and overall height 8 ft. 8½ in. The airplane had a gross weight of 2,050 lbs., useful load of 541 lbs., a service ceiling of 16,400 ft. and a maximum speed of 112 m.p.h.

The Army Air Forces continued to call on Boeing for experimental as well as production contracts. A Boeing-AAF development project for a ground-to-air-pilotless missiles—GAPA. Pencil-slim rockets, 10 ft. long, were being developed to seek out and destroy enemy aircraft over this country should such defense be necessary. Boeing was given responsibility for all phases of the project, which included designing, developing and testing the new rockets. The missiles were being

tested at Wendover, Utah, far out on the Great Salt Desert. First models were powered by standard Aerojet rocket units which propelled the aerial destroyers at supersonic speeds.

Other Boeing experimental projects included the XB-47, a multi-jet bomber, and new type power plants. By the end of 1946, the Navy had accepted 2 of the 3 XF8B-1 fighters designed and built by Boeing during the latter months of the war. The third airplane was at the factory for modification. Known as the five-in-one because of its adaptability as a fighter, interceptor, torpedo or dive bomber or attack plane, the 8-ton fighter was powered by a single 3,500 h.p. Pratt & Whitney Wasp Major with counter-rotating propellers. During 1946 the Army evidenced interest in the XF8B-1, testing 2 of the airplanes at Wright and Eglin fields. Although the war had been over for more than a year, Boeing B-29 Superfortresses continued to make records in



BOEING L-15A LIAISON

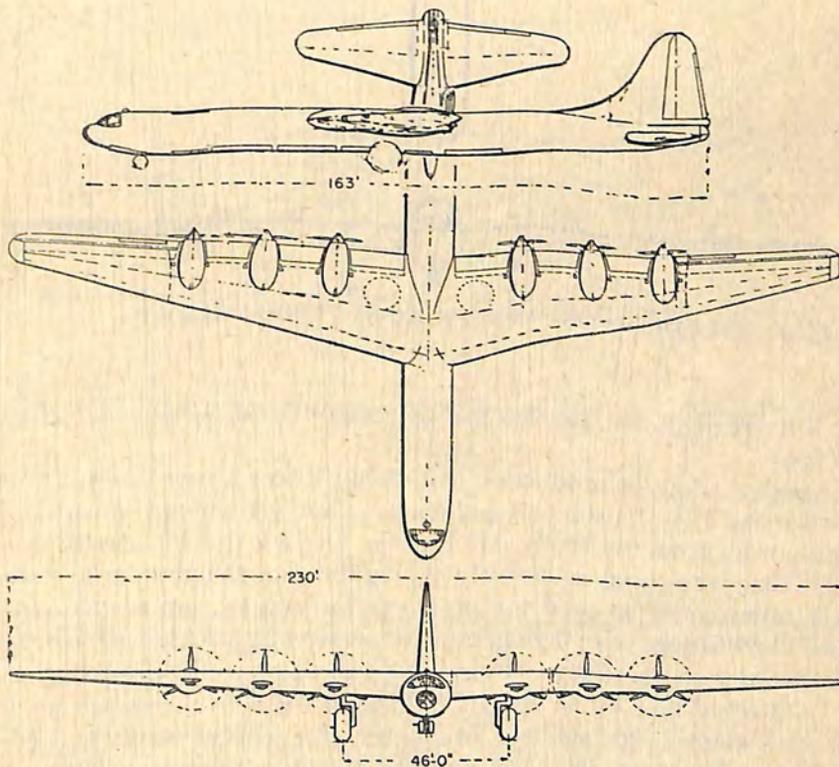
1946. Flying a stripped-down B-29-B, Col. C. S. Irvine and a hand-picked crew of 9 men raced non-stop from Pearl Harbor to Cairo, Egypt, on an over-the-top-of-the-world flight in 39 hrs. 36 min. Averaging 276 m.p.h. on the 9,500 mi. trip, Irvine set a new world speed-for-distance record as well as contributing new data on the performance of standard equipment in polar regions. At Wright Field and in the Marianas, the Army Air Forces flew B-29's for national and international speed-and-distance-with-load, and altitude-with-load records, smashing or establishing a total of 20 during the year. At Guam, where Col. Irvine headed the altitude record project, crack crews of the Pacific Air Command piloted the big Boeing bombers to 6 new records. Lt. Edward M. Grabowski and Capt. John D. Bartlett, command pilots for the Strategic Air Command, broke a total of 8 speed-and-distance-with-load records. The Air Materiel Command and Proving Ground Command established 6 other miscellaneous records with Superfortresses. Although one of the 20 records was broken later in the year by another AAF airplane, the 19 official records held by B-29's was nearly two-thirds of the 30 established by the AAF in 1946.

Consolidated Vultee Corporation, San Diego, Calif., had undergoing flight tests or nearing completion at the beginning of 1947 seven commercial, military and personal airplanes designed by the company. Convair had a backlog of approximately \$333,000,000 for military, commercial and personal aircraft. It operated 4 aircraft manufacturing plants at San Diego and Downey, Calif.; Fort Worth, Texas; and Wayne, Mich., and a general manufacturing center at Nashville, Tenn. Employment at the five plants was approximately 22,500.

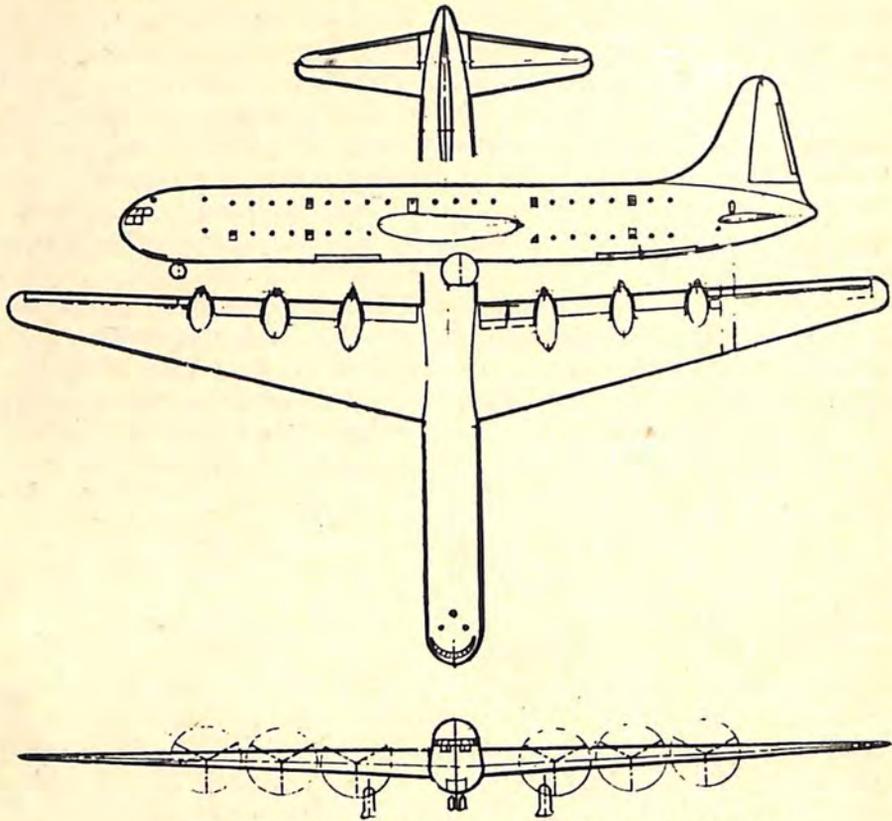
Production of 40-passenger, 300 m.p.h. air-conditioned and pressurized Convair-240 airliners moved steadily ahead in the company's San Diego plant. The first Convair-240 was expected to make its initial flight test in the spring of 1947. Deliveries to domestic and foreign airlines were to begin a few months later. Convair had orders for the twin-engine, pressurized transports from the American Airlines, Western Air Lines, Pan American World Airways, Continental Air Lines, KLM Royal Dutch Airlines, and Trans-Australia Airlines. In addition to those orders, there was a substantial number of options. The Convair-240 featured a self-contained stairway, with optional locations forward on the right side or beneath the tail. It was the first commercial plane to utilize Convair's jet exhaust augmentation principle. Exhaust gases were led aft over the wing and directed through nozzles. The jet action, which resulted in greater speed, also was utilized to cool the engines by drawing air around the cylinders. Gross

weight of the Convair-240 was 39,500 lbs., and its maximum payload 10,000 lbs. Its length was 74 ft. 8 in., wingspan 91 ft. 9 in., height 26 ft. 11 in., maximum range at 300 m.p.h. 1,120 mi. Cabins of the plane were pressurized, assuring complete comfort to passengers while the plane was climbing, cruising or descending. Air-conditioning equipment maintained uniform temperatures inside the cabin regardless of outside weather or the altitude. Special soundproofing, radiant wall heating, large windows and comfortable seats with plenty of leg room were other features.

Convair's San Diego division was building the AAF 6-engine XC-99 troop transport and cargo plane, world's largest land-based airplane. The giant transport had a wingspan of 230 ft., length 182½ ft., and height 57½ ft. The initial flight was scheduled during the summer of 1947. The double-deck XC-99 was designed to carry 400 troops, or



CONSOLIDATED VULTEE B-36 BOMBER



CONSOLIDATED VULTEE XC-99 TROOP CARRIER

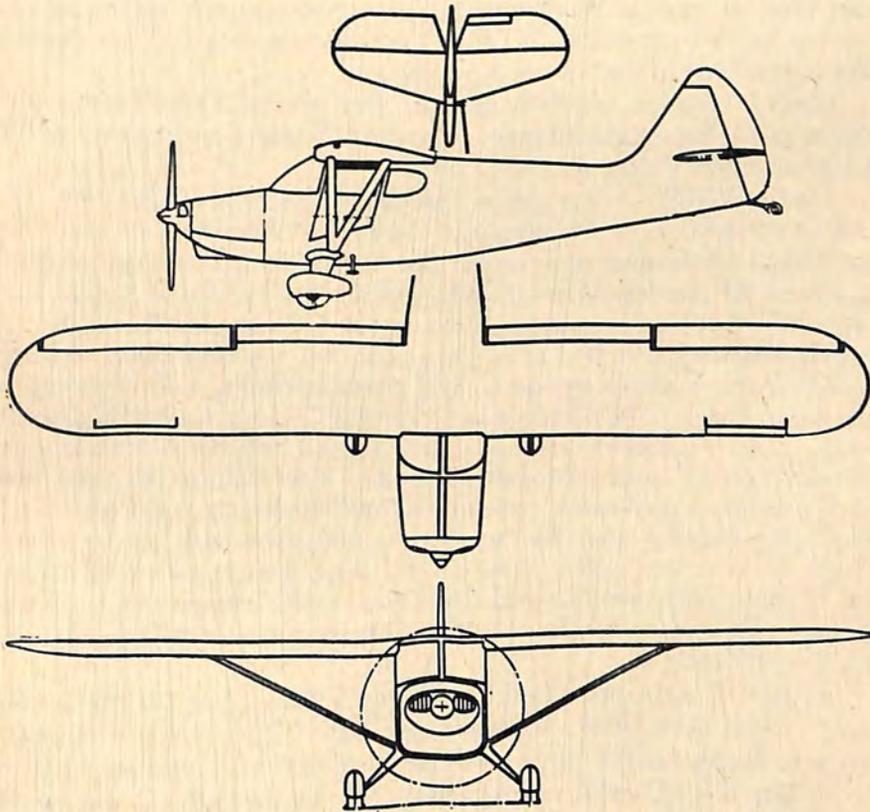
335 litter patients, or 100,000 lbs. of cargo. Gross weight was 265,000 lbs.

Another plane in production at Convair's San Diego division was the all-metal L-13 liaison and ambulance plane for which Convair had a large order from the Army Air Forces. Designed to replace Stinson L-5 Flying Jeeps used extensively during the war, the new aerial jack-of-all-trades could be used for photographic service, ambulance purposes, observation, wire laying, courier service, light cargo movement and special radio activities. Powered by a 245-h.p. Franklin engine, the L-13 could take off in 230 ft., a distance equal to the wingspan of Convair's giant B-36 bomber. Equipped with folding wings and adjustable landing gear, the L-13 could be towed by military vehicles or hauled in a truck. Length was 31 ft. 9 in., wingspan 40 ft. 5.5 in., and

height, 8 ft. 5 in. Gross weight was 2,900 lbs. At a cruising speed of 92 m.p.h. the L-13 had a range of 368 mi.

Included in experimental projects under development by Convair was the powerful XB-46 jet bomber. This 4-jet bomber, being built in San Diego, was expected to fly in 1947. Its maximum speed was over 500 m.p.h.

The 139-ton B-36, world's largest bomber, underwent extensive flight tests at Convair's Fort Worth, Texas, division, where the huge planes were in production for the Army Air Forces. Initial flight test of the XB-36 was on August 8, 1946, in Fort Worth, Texas. The B-36 carried 10,000 lbs. of bombs for 10,000 mi., or its maximum bomb load of 72,000 lbs. for a shorter range. The 6 Pratt and Whitney Wasp Major pusher-type engines, developing a total of 18,000



STINSON VOYAGER

h.p., drove the world's largest production propellers—19-ft. Curtiss reversible-pitch. Gross weight of the B-36 was 278,000 lbs., length 163 ft., wingspan 230 ft. and height 46 ft. 7 in. It was equipped with 2 pressurized compartments for a crew of 12 plus a 4-man relief crew.

The company's Vultee Field division at Downey, Calif., was building 2 experimental XP-81 jet fighters for the Army Air Forces. Designed as a long-range escort fighter, the XP-81 was powered by 2 engines which developed as much power as most 4-engine bombers. A gas turbine engine in the nose drove a propeller, and a separate jet engine operated in the tail. The experimental fighter had a maximum speed of over 500 m.p.h.

Convair's Stinson division at Wayne, Mich., had 2 1947 models in production, the 4-place Voyager 150 and the Flying Station Wagon. The Voyager 150 was equipped with a 150 h.p. Franklin engine, and cruised at 125 m.p.h. The Stinson Flying Station Wagon was a Voyager type which could be converted to a general utility plane by removing the 2 back seats. It carried 600 lbs. of cargo. Performance was comparable to that of the Voyager 150.

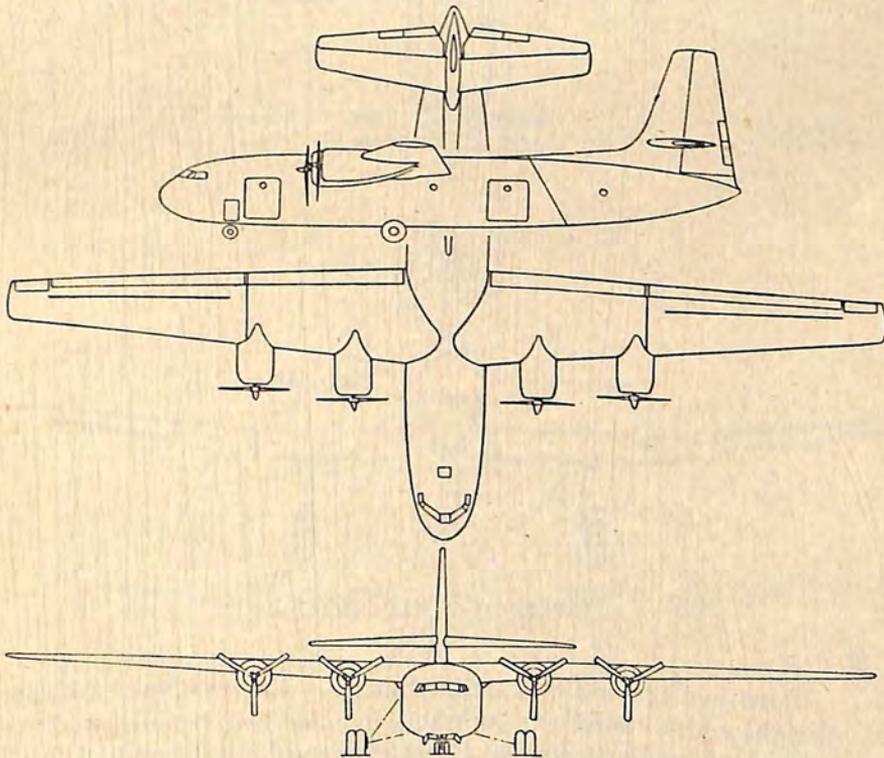
Guided missiles, pilotless aircraft and several experimental airplanes in the secret classification also were under development at the 4 Consolidated Vultee plants.

Curtiss-Wright Corporation Airplane Division, Columbus, O., had in production or development a number of aircraft projects for the armed forces and commercial operations, including experimental contracts on pilotless aircraft and guided missiles. Construction had begun on the Curtiss all-cargo transport CW-32, an 80,000-lb. 4-engine freighter designed to carry 25,000 lbs. 1,500 mi. at a cruising speed of 270 m.p.h. at 25,000 ft. at a direct operating cost of 5 cents a ton mile. It was to be powered by 4 Wright Cyclone R-1820 1,525 h.p. engines and Curtiss electric reversible propellers with automatic synchronization of engine-propeller speeds. The CW-32 stripped and empty weighed 40,000 lbs.; useful load was 40,800 lbs. payload 26,195 lbs., wing loading 57.6 lbs./sq. ft. Its wingspan was 130 ft. 2 in., length 86 ft. 2 in., height 32 ft. 4.5 in., wing area 1,400 sq. ft. Maximum speed with takeoff weight was 304 m.p.h., service ceiling 32,000 ft. range at 20,000 ft. with maximum cruising power 2,445 mi., stalling speed 88 m.p.h.

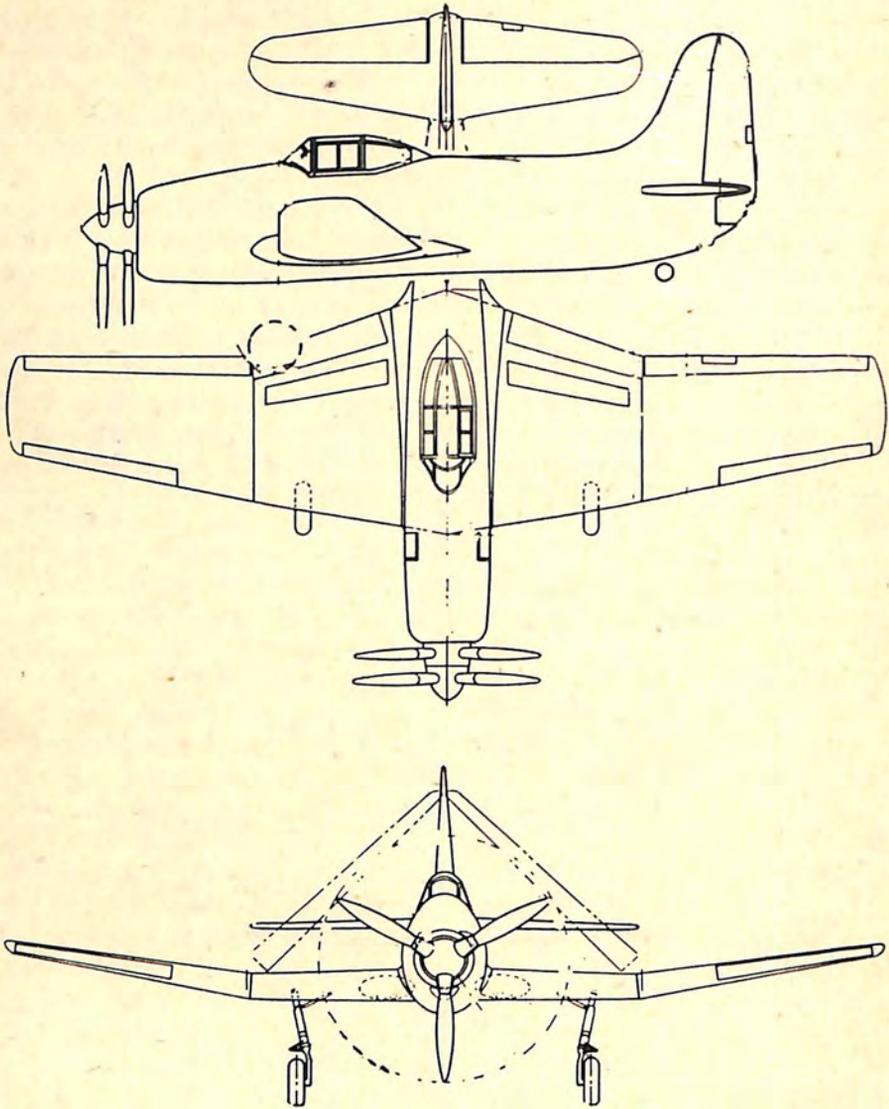
Curtiss-Wright was developing a new fighter plane XP-87 for the AAF. The plant produced a number of XBT2C-1 and 2 bomber-torpedo planes for the Navy carriers. The XBT2C-1 was powered by a Wright R-3350-24W, 18-cyl. 2,500 h.p. for takeoff. It was 38 ft. 3½ in. long, 16 ft. 6 in. in height and had a wingspan of 47 ft. 7¼ in.

Its gross weight empty was 12,210 lbs., useful load 4,777 lbs. with a 1,000-lb. bomb, or useful load 5,955 lbs. with an aerial torpedo. The XBTC-2 was powered by a Pratt & Whitney 28-cyl. XR-4360-80 engine, had a span of 50 ft., length 38 ft. 6.8 in. and height 16 ft. 6 in., with useful load of 3,060 lbs., high speed over 350 m.p.h., service ceiling over 29,000 ft. and range over 800 mi.

Curtiss-Wright also produced for the Navy the XF15C-1, an experimental high speed carrier-based fighter with a turbo-jet engine in addition to the conventional engine-propeller plant and a T tail for improved stability and control. It had a span of 48 ft., length 43 ft. 9.4 in., height 15 ft. 3 in., high speed over 450 m.p.h., stalling at 100 m.p.h. service ceiling over 38,000 ft. and range over 1,200 mi. Its gross weight was 16,775 lbs., empty weight 13,084 lbs., useful load 3,671 lbs. It was powered by a Pratt & Whitney 18-cyl. R-2800-34W radial and a DeHavilland-Allis-Chalmers Type H1 turbo-jet. The propeller was a Curtiss electric 4-blade, 13 ft. in diam.



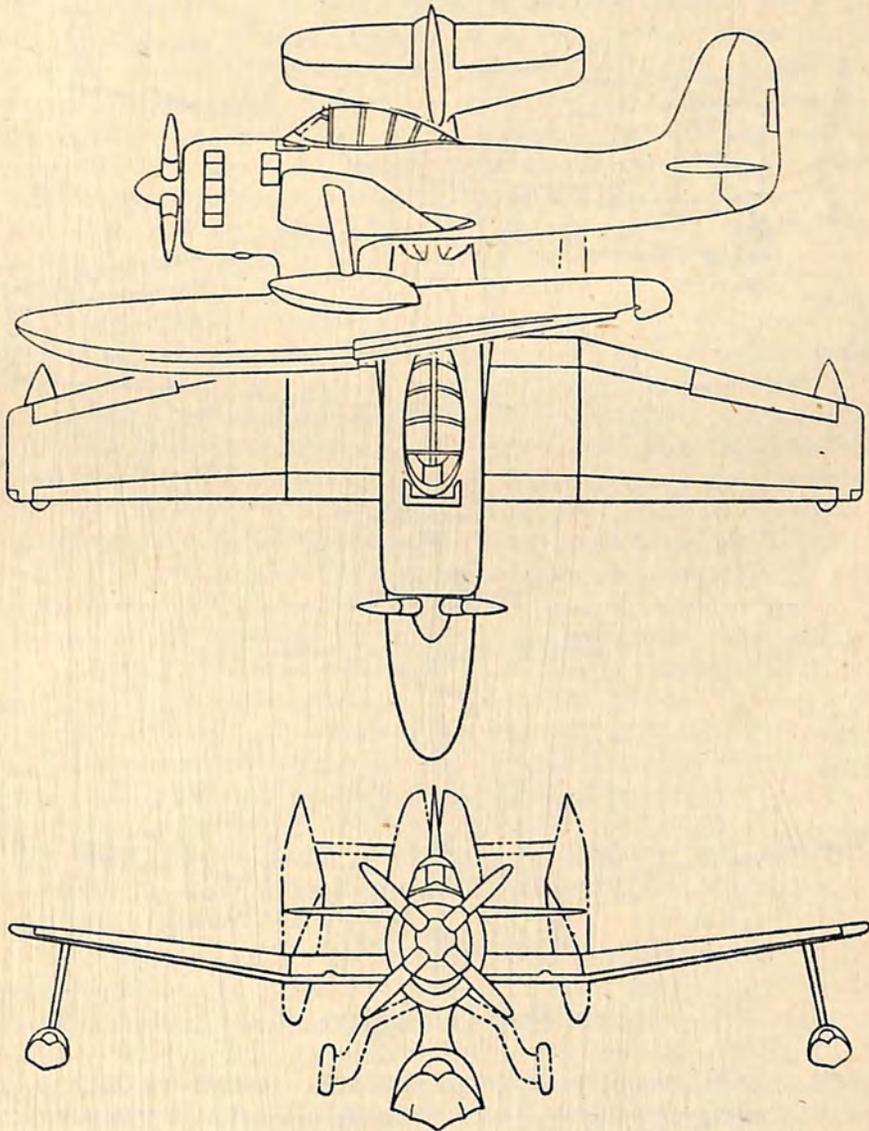
CURTISS-WRIGHT CW-32



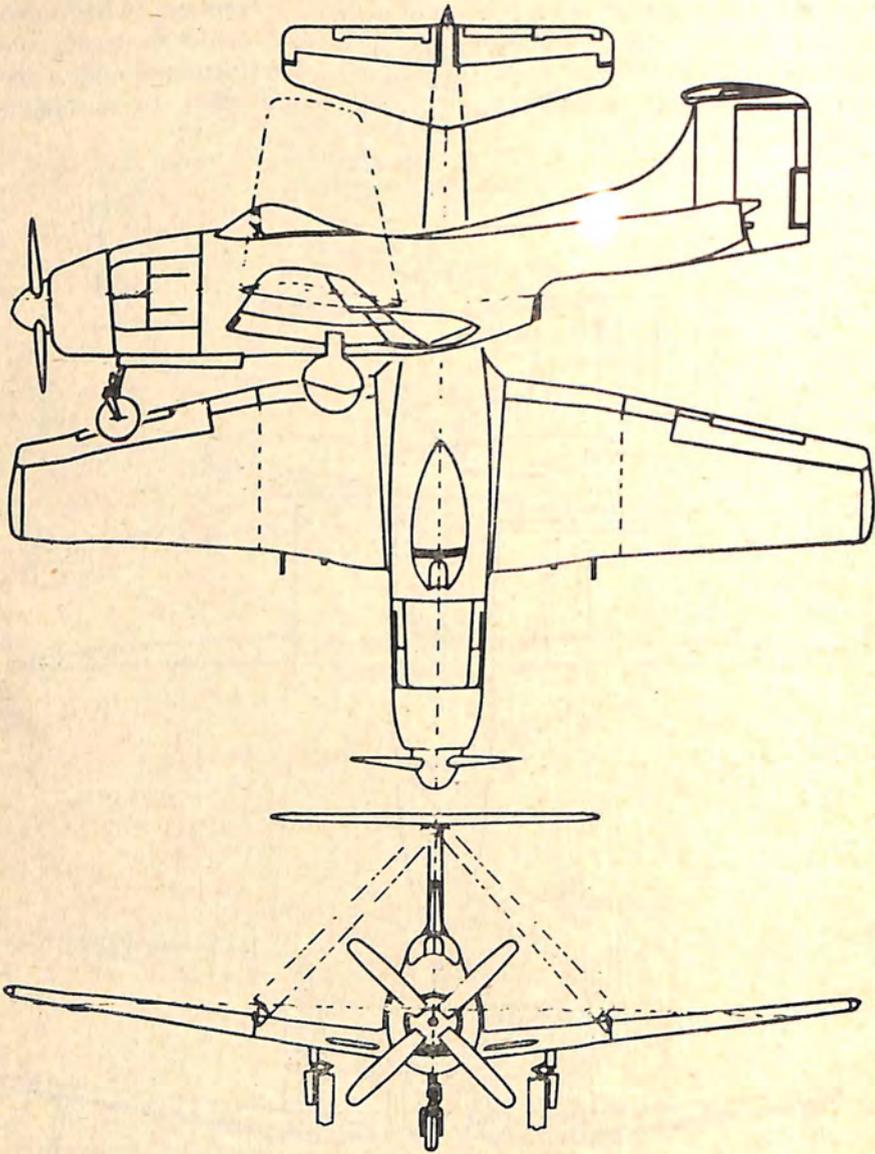
CURTISS-WRIGHT XBTC-2

1946 marked the end of wartime business with the Navy, as Curtiss-Wright ended those war contracts in mid-year, having produced more than 6,700 military combat aircraft for the Navy Bureau of Aeronautics. Some were on carriers used at the Bikini atomic bomb tests.

They were the late model SB2C Helldiver dive bombers, which also were on the new carrier Valley Forge. The SC-2 model Seahawk was put in production early in 1946, with improved performance and wider utility for scouting. It had a span of 41 ft., length 38 ft. 1.2 in. height



CURTISS NAVY SC SEAHAWK

CURTISS-WRIGHT XF<sub>15</sub>C-1

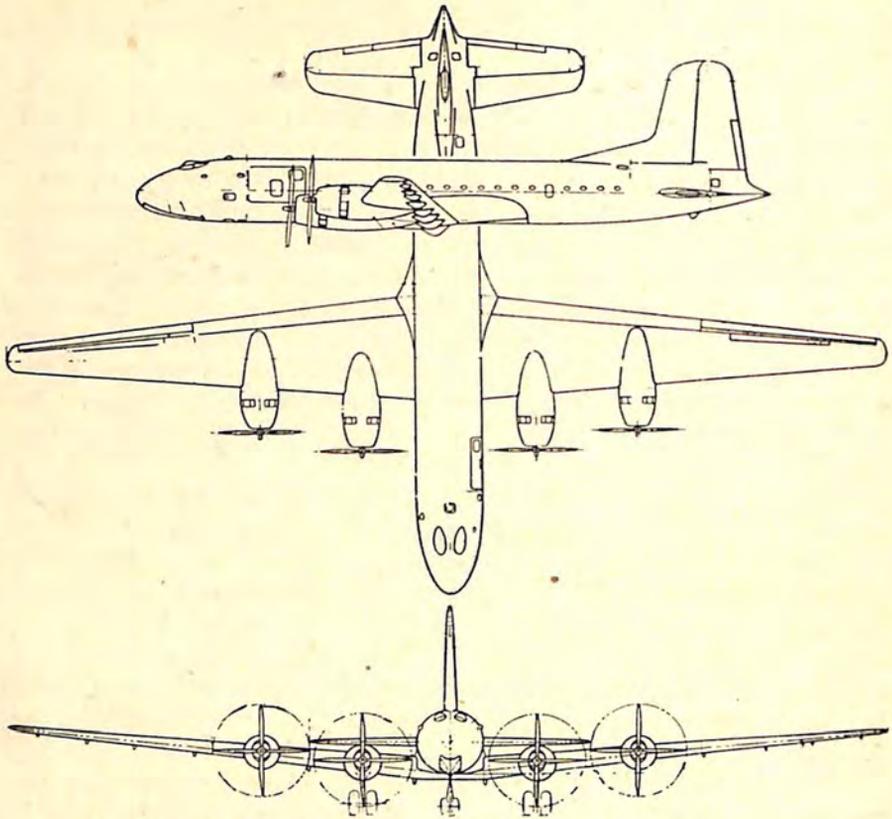
16 ft. 10.2 in., max. speed over 250 m.p.h., cruising at 150 m.p.h., service ceiling over 28,000 ft. and range over 670 mi. It was powered by a Wright R-1820-76 9-cyl. radial and a 4-blade Curtiss propeller.

Its weight empty was 6,451 lbs., normal weight 7,785 lbs., wing loading 27.6 lbs./sq. ft.

Curtiss-Wright was beginning on a long-term contract with the Army Air Forces to obtain engineering data to help in the design of future aircraft through remodification of 10 B-17 airplanes for ditching or landing-on water tests. With emphasis on research, the engineering staff was greatly expanded as special technical studies were begun on missiles, pilotless aircraft and other projectiles. A developmental laboratory was set aside in a section of the Columbus plant for this work in aeronautical science and allied techniques. A shielded radio room of copper was built and put in use, simulating the most perfect possible radio reception conditions. Also developed was a new spot weld analyzer, and radiography equipment was installed for latest testing methods. Other devices were set up for work on confidential projects.

Douglas Aircraft Company, Santa Monica, Calif., had completed reconversion from its record wartime output of 29,385 aircraft and was in full-scale production on a \$200,000,000 backlog of commercial and military plane orders. The parent plant at Santa Monica was occupied principally with manufacture of 150 new four-engine DC-6 luxury liners for domestic and foreign airlines. Newest, fastest and most luxurious of the DC series of commercial transports, the DC-6 was a post-war development from the thoroughly tested and war-proven C-54 and DC-4 Skymasters. The DC-6 combined the latest engineering and scientific developments with the utmost in styling, comfort and convenience for air travelers. It carried 52 passengers as a dayplane or 26 in berths as a sleeper aircraft. Other interior arrangements permitted up to 68 passengers in addition to the normal crew of five, including two cabin attendants. Passengers and crew of a DC-6 rode in a cabin pressurized, sound-insulated and fully air conditioned. With these comfort features was the cruising speed of 300 m.p.h. The DC-6 had a wing span of 117 ft. 6 in., length 100 ft. 7 in., height 28 ft. 5 in., wing area 1,457 sq. ft. including 81 sq. ft. of aileron. It was powered by four Pratt & Whitney 2,100 h.p. Double Wasp engines driving 13-ft. reversible propellers.

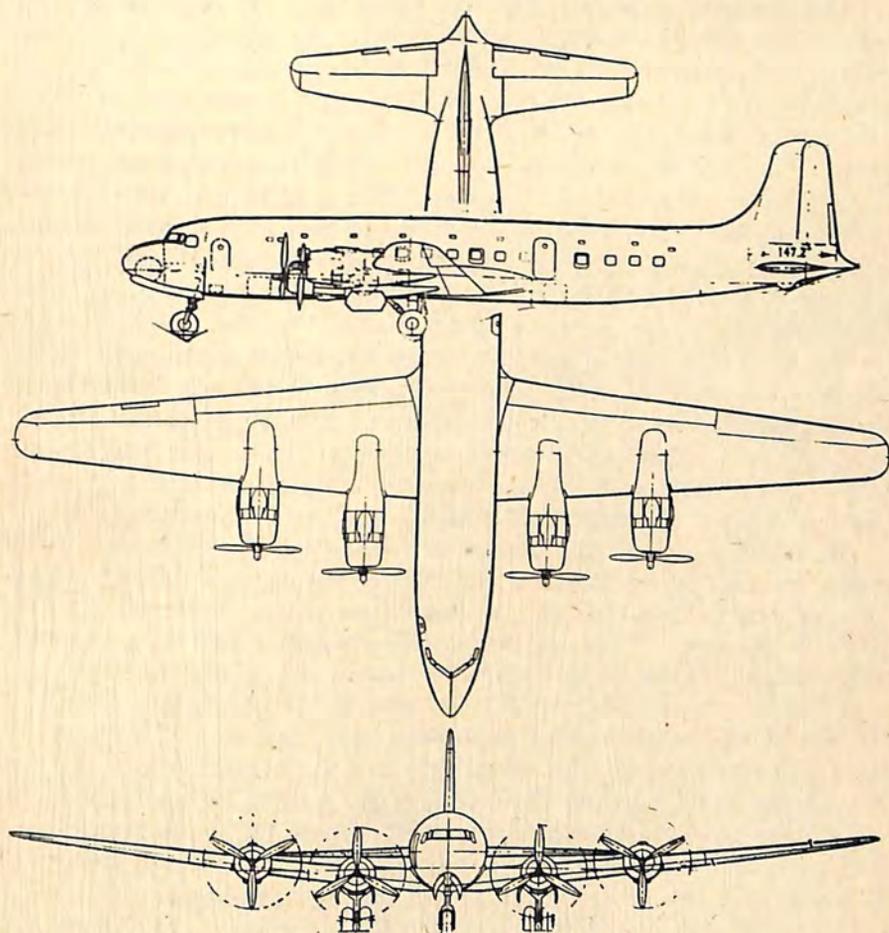
Two years of study were represented in the design of the DC-6 sleeper interior. In attaining their goal of style, comfort and utility, Douglas designers had the initial advantage of an unusually spacious cabin—7 ft. from floor to ceiling, nearly 10 ft. wide at seat level, and more than 67 ft. long. The entrance and service section containing buffet, cloak room and attendants' office was located near the center and divided the main cabin into two sections. The forward section



DOUGLAS C-74 MILITARY TRANSPORT

seated 36 passengers in the dayplane and had 18 berths as a sleeper. Sixteen additional seats or 8 berths were located in the aft section. Artful use of color and fabric created a restful and spacious effect throughout. All fabrics, including floor and wall covering, upholstery, curtains and ceiling fabric were flame and mildew proofed. In this comfortable interior were special sleeper chairs developed after months of research and engineering. Seats were approximately 20 in. wide, and were cushioned with soft sponge rubber. Chair backs reclined easily and smoothly to any desired position by a Douglas developed hydraulic mechanism. An adjustable table could be attached to either arm of the chair for dining, writing or playing cards. Ingenious design permitted the DC-6 chairs to be converted into berths in 30 seconds. Lower berths were 76 in. long and 42 in. wide, and uppers

were only 6 inches narrower. Uppers were concealed in the ceiling and could be swung down, ready for occupancy, with a single motion requiring as little as 10 seconds. Both berths afforded ample head room for passengers to sit up. Both had windows, reading lamps, call buttons, clothes hangers and cold air jets. Inside berth compartments were cabinets containing adjustable mirrors and make-up kits for women and shaving kits for men. Additional accessory cabinets also were provided for valuables, waste disposal and ash trays. The spacious and well-equipped women's lounge in the aft end of the fuselage contained a full-length mirror, full-sized sofa, and two dressing tables



DOUGLAS DC-6 AIRLINER

equipped with adjustable, self-lighted mirrors. A separate section contained a wash basin and dental bowl with built-in accessories, special lighting and a large mirror. The men's lounge, in the forward section, contained three wash basins, a dental bowl, three large mirrors, shoeshine stand, two lounge seats and a toilet compartment. The entire cabin was engineered to be exceptionally quiet. Automatic air conditioning maintained ideal temperature and humidity in flight or on the ground. Sea-level pressure was maintained automatically in the DC-6 cabin up to 9,000 ft. altitude. At higher altitudes, cabin conditions gradually approached a maximum of 8,000 ft., while the aircraft actually flew as high as 20,000 ft.

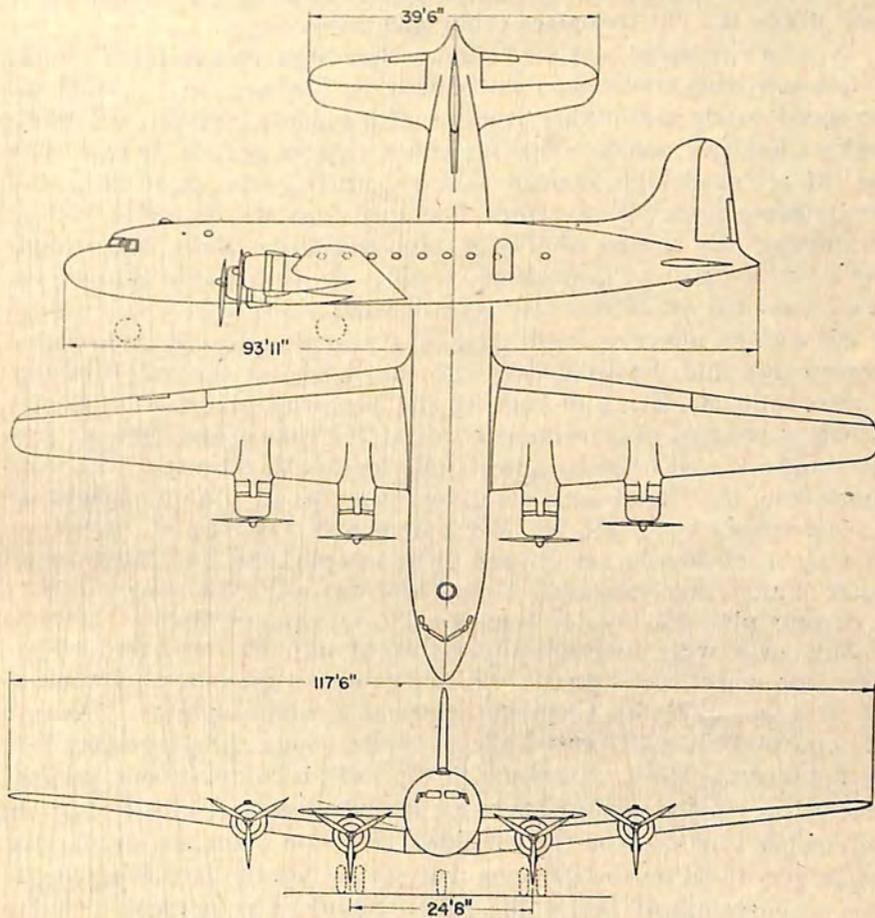
The Douglas company also was filling a U. S. Navy order for \$50,000,000 worth of single-engine attack and dive-bombers. Formerly designated the BT2D-1, this long range aircraft was redesignated the AD-1 (attack, Douglas, model 1) and named the Skyraider. The carrier-based plane could mount 12 five-in. rockets and two 12-in. Tiny Tims, largest carried by aircraft. With this rocket armament, the Skyraider packed more firepower than a light cruiser. Capable of flying farther, more than 50 m.p.h. faster and with a greater munitions load than any other of its type in service, the Douglas AD-1 was one of the most versatile aircraft in the Navy's postwar air fleet. In addition to 20mm. machine guns mounted in the wings, it could carry a 6,000-lb. load of bombs, torpedoes, fire bombs, radar units, rockets or extra fuel tanks without changing armament installations. With a range of more than 1,500 miles, it had a wing span of slightly over 50 ft., a wing-fold to 24 ft., length 39 ft., weight 10,470 lbs., minus useful load, and was powered by a single Wright 2,500 h.p. Cyclone engine. Fuselage dive brakes were a unique feature.

In addition to production of new models, Douglas was filling orders for new DC-4 airliners and converting surplus military C-54s into both cargo and deluxe passenger transports. Powered by four Pratt & Whitney 2SD13-G engines developing 1,450 h.p., commercial versions of the C-54 Skymaster had a maximum speed of 243 m.p.h. using only 60 per cent of rated power. At 10,000 feet, the DC-4 cruised at 224 m.p.h. with a gross load of 65,000 lbs. Wing span of the DC-4 was 117 feet 6 in., length 93 ft. 5 in., height 27 ft. 7 in., and wing area totaled 1,457 sq. ft. including 93,55 sq. ft. of aileron.

During 1946 the company produced 66 new DC-4s and completed 86 C-54-to-DC-4 conversions, bringing the total of new and converted DC-4s to 210 in service on airlines of the United States.

Douglas also completed an order for 14 giant C-74 Army Air Forces transports, produced in the Long Beach, Calif., plant. De-

signed to carry 125 military personnel with full equipment, the C-74 weighed 145,000 lbs. fully loaded. Because its maximum range of 7,800 miles enabled it to circle the earth with only two stops, the transport was named the Globemaster. It had a wing span of 173 ft., length 124 ft., and height of 43 ft. The C-74's four 28 cyl. Pratt & Whitney 3,650 h.p. Wasp Major R-360 engines gave it a speed in excess of 300 m.p.h. Among advanced design and construction features were full span flaps, reversible propellers, thermal anti-icing, built-in cargo elevator and traveling crane. Douglas did not plan to produce a commercial version of the Army transport.



DOUGLAS C-54 COMMERCIAL TRANSPORT

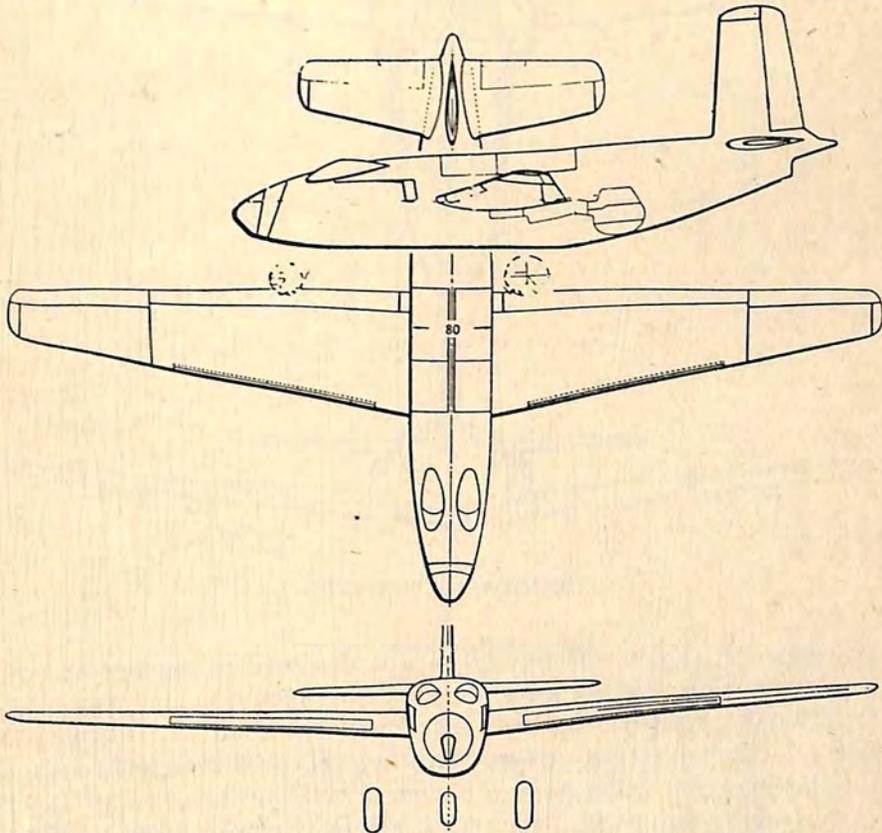
A new military plane produced during 1946 by Douglas was the XB-43, America's first jet-propelled bomber. Closely resembling the unconventional Douglas XB-42 in design and structure, the XB-43 was a mid-wing, tricycle gear monoplane. Jet engines occupied the same position within the fuselage, just aft of the cockpit, as the Allison liquid-cooled engines did in the XB-42. Twin jet exhausts replaced the XB-42s coaxial counter-rotating propellers aft of the fuselage. Both planes had a wing span of 71 ft. 2 in. and measured 51½ ft. from nose to tail. Powered by two T.G. 180 jet engines supplying 8,000 lbs. of static thrust, the XB-43 attained speeds in excess of 500 m.p.h. soon after its initial test flight on May 17, 1946. The Douglas jet bomber had a range of more than 1,400 mi. and a service ceiling of over 38,000 ft. The two-place cabin was pressurized.

Newest aircraft to bear the Douglas name was the five-place Cloudster, a low-wing monoplane introduced in January 1947. With all the speed, safety and luxury features of a modern airliner, the twin-engine Cloudster was intended for either charter service or executive use. It achieved high performance by utilizing the same advanced aerodynamic principle of center line thrust as the Douglas XB-42 Mixmaster. By means of a gear box and drive shaft, the Cloudster's two E-250 h.p. Continental engines drove a single 8-foot propeller mounted aft of the rear control surfaces. Either engine could be cut without affecting flight control, giving the aircraft twin-engine performance and dependability with single-engine ease of handling. Unconventional placing of engines and propeller increased efficiency of wings, reduced drag, eliminated propeller turbulence from all surfaces and reduced noise to a negligible level. An all-metal, low-wing monoplane, the Cloudster's wing span was 39 ft. 9¾ in., height 12 ft., and length 35 ft. 4½ in. Wing area was 235.2 sq. ft., including 14.4 sq. ft. of aileron. It cruised at 200 m.p.h. and had a maximum range of more than 1,000 mi. Useful load was 1,885 lbs. It could carry 5 persons plus 250 lbs. of baggage 950 mi. at 200 m.p.h. Tricycle landing gear were hydraulically retracted into the nose and wings. The nose wheel was steerable. A low center of gravity, plus tread of 15 ft. 3 in., gave the Cloudster extreme ground stability. Because the entire cabin was located ahead of the wings, all passengers had exceptional visibility. Entrance to the deluxe compartment, comparable in size and appointments to the finest limousines, was through an automobile type door on the left side. The wide cabin permitted three passengers to sit on the spacious rear seat, while the fourth passenger had a separate seat beside the pilot. Standard equipment included electric starters; cabin heating and cooling system; dual controls;

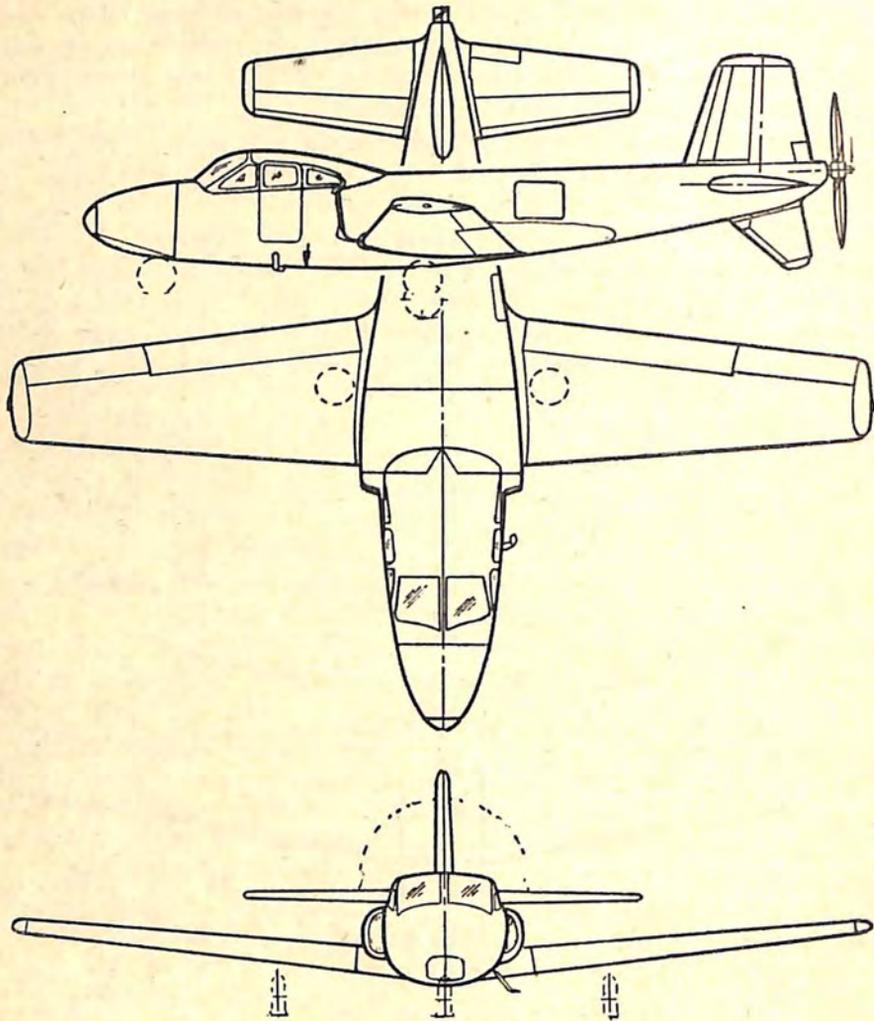
transport-type instrument panel; hydraulic landing gear, flaps and brakes; two-way radio with broadcast receiver; night-flying instruments; ash trays, cigarette lighters, glove compartment, cabin dome light, landing lights and navigation lights.

Douglas Aircraft Company also was engaged in research on guided missiles, supersonic aircraft and other technological projects of a secret nature for the U. S. Government.

First public showing of the Douglas D-558 Skystreak, a trans-sonic research airplane developed for the U. S. Navy, was held at the Douglas El Segundo plant on February 5, 1947. It was a slender, low-wing monoplane of advanced design but with performance characteristics of a normal airplane. Propelled by a General Electric TG-



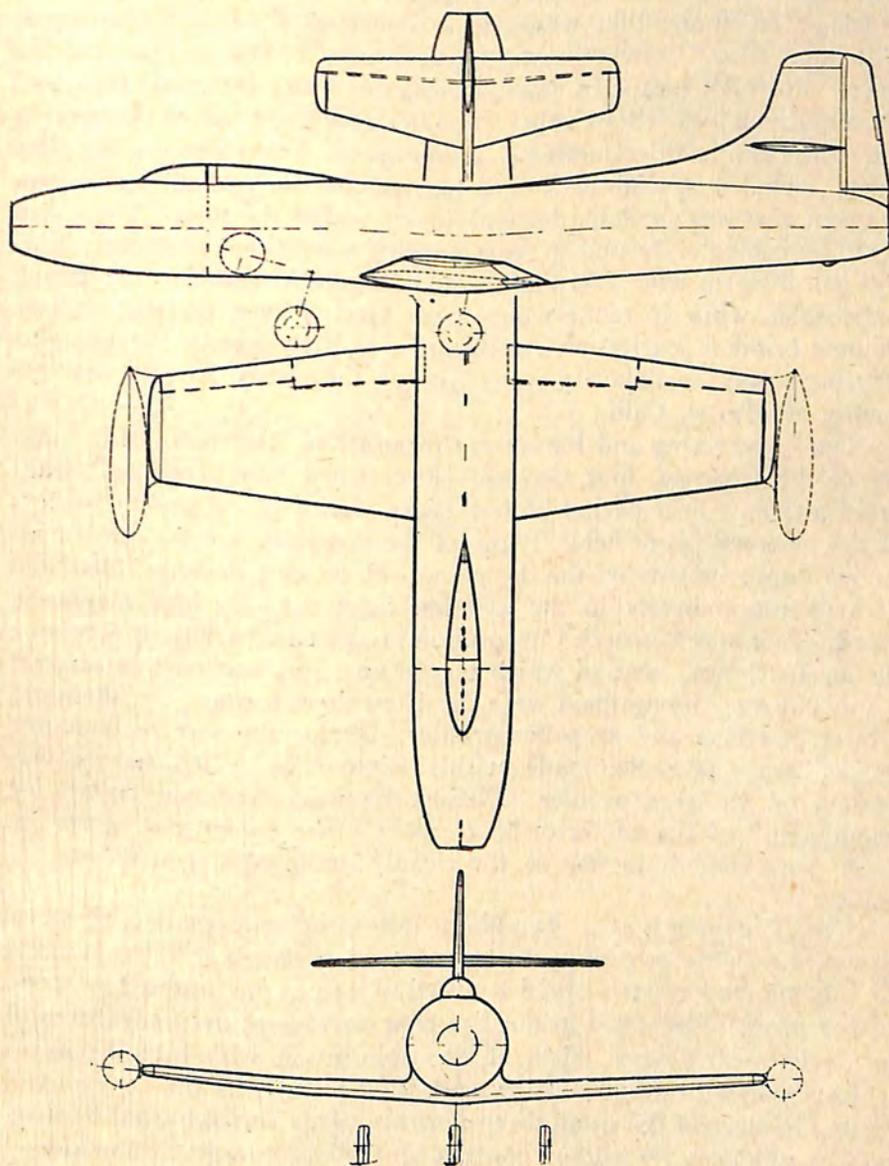
DOUGLAS XB-43 BOMBER



DOUGLAS CLOUDSTER

180 turbo-jet engine, the Skystreak was designed to explore aerodynamic phenomena in the transonic range between 600 and 700 m.p.h. It differed from previous high speed research craft in its ability to take off, climb to service ceiling, perform level speed runs and return to the starting point under its own power. The Skystreak was 35 ft., 1½ in. in length, span 25 ft., height 12 ft. 1½ in. It had a gross weight of 9,750 lbs. including the pilot, 500 lbs. of recording instruments and

fuel. Wing area was 150 sq. ft. A strictly research aircraft, the D-558 did not carry armament. The massive jet unit occupied the major portion of the tubular fuselage. Air entered through the nose,



DOUGLAS D-558

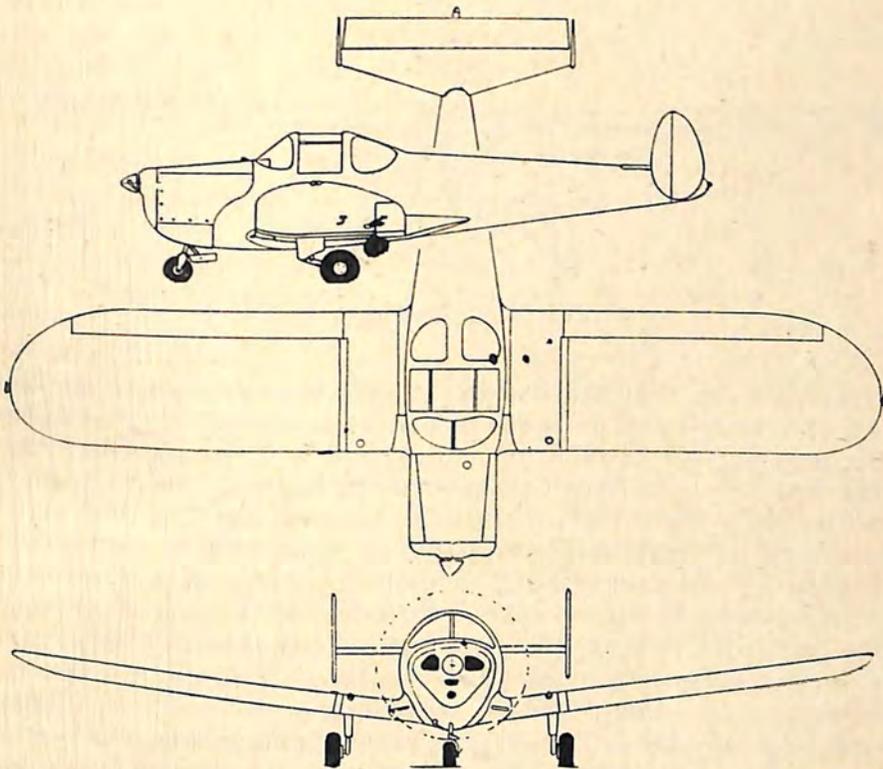
flowed in separate ducts around the cockpit and emerged as a propulsive exhaust from the tail. To withstand excessive turbulence encountered at the speed of sound, the Skystreak was at least 60 per cent stronger in construction than current combat aircraft. The fuselage was a long, smooth tube of magnesium alloy with no internal bracing. Its short, thin wings were constructed of 75S, strongest aluminum alloy. Conventional alloy was used in the cockpit and air ducts. For pilot escape in emergencies, the entire forward section of the Skystreak was jettisonable. The pilot could bail out of the section after the cabin had decelerated to a safe speed. Other devices for pilot safety included special pads and harness in the pressurized cabin. Oxygen also was available for emergency use of the pilot. The cabin could be cooled or heated to meet varying conditions of flight. Two 230 gal. integral wing fuel tanks could be supplemented with 50 gal. jettisonable wing-tip tanks which were ejected by a powder charge. Painted brilliant scarlet for identification at high speeds, the Douglas Skystreak was to make its speed runs at the Army Air Forces test facility at Muroc, Calif.

The Engineering and Research Corporation, Riverdale, Md., makers of the Ercoupe, first Government-certified spin-proof and stall-proof airplane, in a period of few years won a place among leaders in the personal plane field. Plans of the company for the future included improvements on the design as well as new designs calculated to keep the company in the aviation forefront. Besides airplanes, Engineering and Research Corporation produced a variety of precision tooling machines, some of which played an important part in aircraft manufacture. Among them were the Erco sheet former, the shrinker, riveter, stretcher and propeller profiler. During the war, as a matter of fact, every propeller made in this country for Allied service was ground on an Erco profiler. During the war Erco had suspended manufacture of aircraft in order to make other equipment. Early in 1946, however, production of the cleanly designed Ercoupe was resumed.

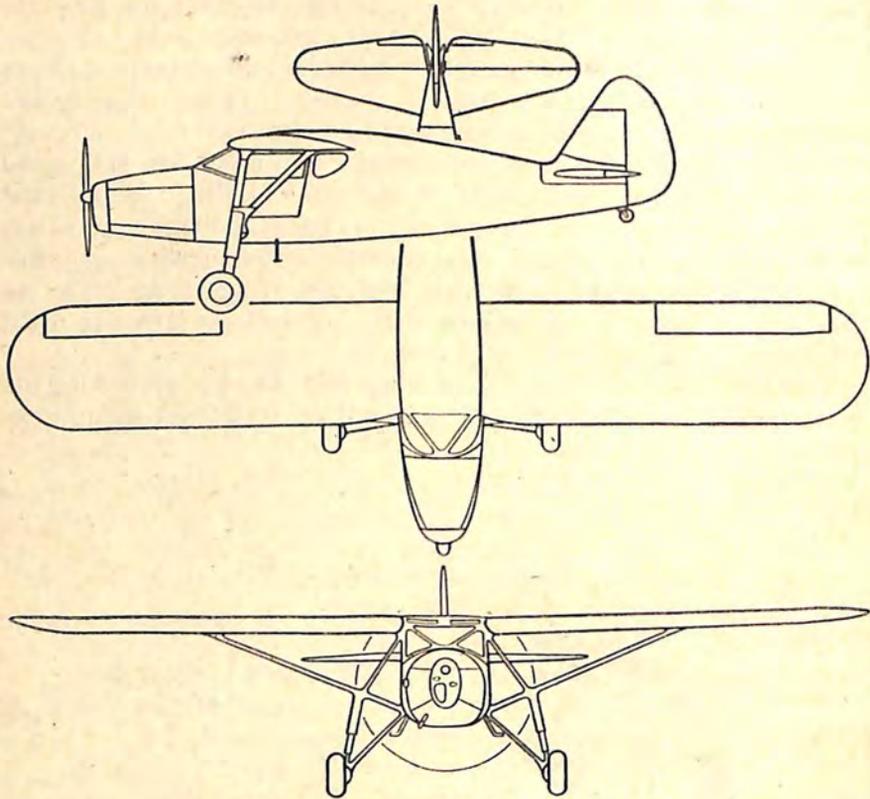
The Ercoupe was a two-place low-wing monoplane, all-metal except for fabric covering on its outer wing panels. A Continental 75 h.p. engine gave it a cruising speed of 110 m.p.h. and a top speed of 127 m.p.h. Embodied in the Ercoupe were three major features of unconventional design. First, it was spin-proof, with lateral control which remained effective at low speeds. Second was the two-control system in place of the usual three controls. This was achieved by linking the rudder to the aileron controls so they automatically functioned together. Thus the rudder pedals were eliminated. Third was the

tricycle landing gear, a novelty for personal planes at the time the Ercoupe was designed. With this gear the airplane could be landed at any speed up to twice its minimum landing speed without tendency to leave the ground after first impact. Danger of ground-looping was eliminated and cross-wind landings could be made easily. So effective were the features which made the Ercoupe spin-proof and stall-proof that the CAA, through a series of tests, found that average time needed to solo this plane was only 53 per cent of that required for conventional personal planes. The tests were conducted among students of all types and backgrounds, ranging in age from 18 to 45 years and having in common only that they had no previous flight training.

Fairchild Aircraft Division of Fairchild Engine and Airplane Corporation, Hagerstown, Md., was in full production on its military



ERCOUPE



FAIRCHILD F-24 PERSONAL PLANE

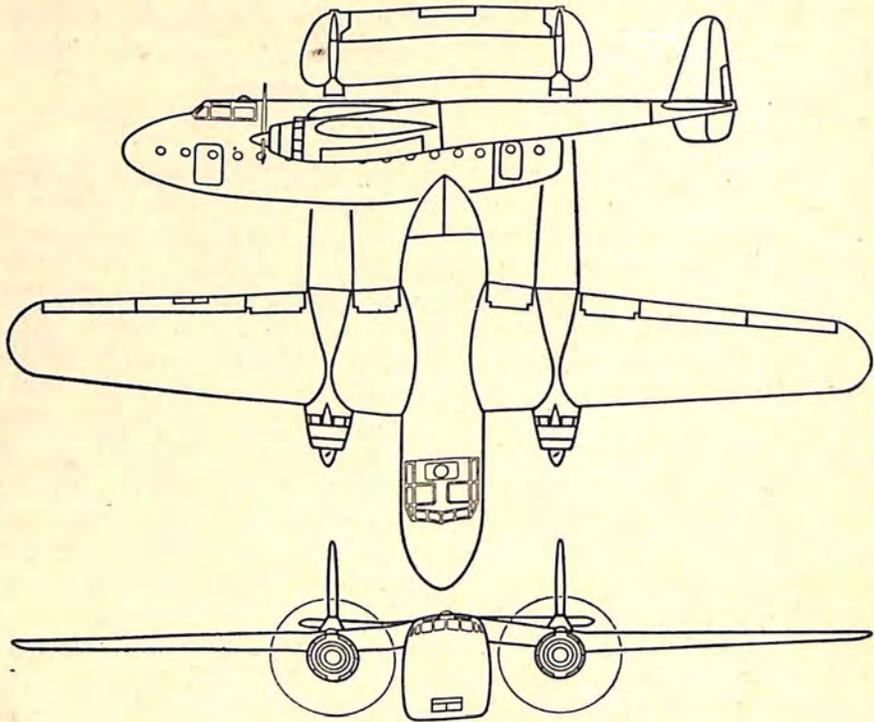
transport plane, the C-82 Packet. With a total production for the year of 1,960,000 airframe pounds, Fairchild delivered 79 Packets to the Army Air Forces to be put into service by Troop Carrier units. Although designed primarily as a transport for heavy military cargo such as jeeps, trucks, light tanks, and field guns, the C-82 had many advantages as a paratroop transport that threatened to overshadow its basic use as a cargo carrier. It could carry 42 paratroopers with full equipment. Two jump doors were located in the rear of the fuselage (not at the side), and the men could bail out two at a time, with no danger of striking against the plane's tail and also eliminating propwash shock because they did not jump into the terrific wind blast behind the propellers. The advantage of dropping two men at a time instead of one was obvious. The paratroopers landed closer together and were thus able to concentrate their strength in a smaller land

area, with fewer casualties. Paracans containing equipment and supplies for the troops were dropped simultaneously by automatic release through two small doors in the belly of the fuselage.

As a cargo carrier, the C-82 could carry a maximum payload of 9 tons on flights up to 500 mi., and  $6\frac{1}{2}$  tons for 1,500 mi. The Packet's immense cargo hold, with 93 per cent as much cubic capacity as a railroad freight car, was long and square-sided like a boxcar. It loaded from the rear end, eliminating the usual slow and cumbersome methods used in stowing heavy cargo aboard a plane. Huge double doors in the rear of the fuselage opened like a clamshell to the full width of the cargo compartment. There was plenty of room, 14 ft., under the high twin-boom tail for a large truck to back up to unload cargo directly into the plane. Transfer of cargo was simplified by the fact that the Packet's floor was level and at truckbed height. The C-82 had a range of 4,000 mi. and a cruising speed of more than 200 m.p.h. It had two 2,100 h.p. Pratt and Whitney engines, tricycle landing gear, and was designed to operate from small, rough airfields requiring short takeoff runs. The Packet could take off, fully loaded at 42,000 lbs. gross weight, in the remarkably short space of 800 ft. It carried a military crew of five.

Although the C-82 went into production too late to see action in World War II, the big twin-engine plane was adopted in 1946 as the standard troop carrier aircraft and late in the year, the famous 36th Squadron of the 316th Troop Carrier Group, based at Pope Field, N. C., became the first postwar AAF unit to be completely equipped with the new flying boxcars. During 1946, the routine work of the 36th was highlighted by outstanding records. In late May, 36th Squadron aircraft participated in Operation Meteor, the transcontinental mass flight of jet planes. The C-82 Packets, carrying engines and other equipment, followed the speedy fighters to service them throughout their flight. They proved conclusively their versatility in high speed, long-range operations. On the return flight from the West Coast to Pope Field, one of the C-82s set an unofficial cross-country record for twin-engine cargo planes of 9 hrs., 14 min., 5 sec. And on December 9, Lt. Col. William Mandt and a crew of six set their C-82 down at Pope Field after a six-months, 25,000 mi. tour of Europe in which they tested and demonstrated the plane before thousands of occupation GI's and civilians. In Prague alone, 400,000 persons gathered at the municipal airport to see the flying boxcar go through its paces. Col. Mandt estimated that more than 1,000 paratroopers overseas made exhibition jumps from his C-82.

Perhaps the most dramatic operation undertaken by the Packet



FAIRCHILD C-82 PACKET

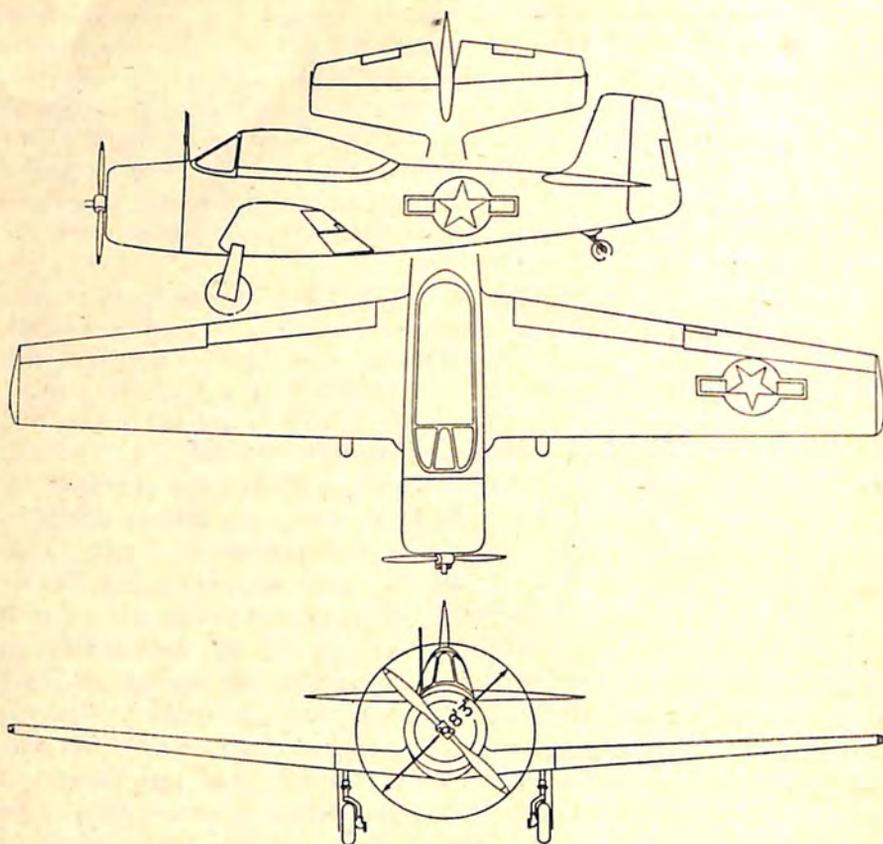
was its several rescue and search assignments. In November, 1946, when 12 Americans crash-landed in the Swiss Alps, the Air Transport Command dispatched a C-82 on a 4,000 mi. rescue mission to Switzerland with a complete R-5 helicopter stowed inside its cavernous hold. The plane was turned back at the Azores after Swiss rescuers had reached the marooned group, but only a few weeks later, another C-82 swallowed a helicopter and set out to aid in the search for a missing transport plane in the snow-covered mountains of northern Washington.

In March, 1946, following the inspection of a C-82 by Post Office Department officials, Fairchild designed a flying mailcar equipped with unique facilities for sorting and storing mail in flight. This all-mail Packet was a modification of the Army's flying boxcar and was capable of carrying up to 7 tons of airmail. Installed in the squared interior of the plane were such postal equipment as a sorting table, letter rack, chutes, and bag racks. The equipment, lighter than that

used in railroad mail-cars, was more compact and more efficient. This new kind of mail plane was put to the test on October 1 when a C-82, rigged with the special postal equipment, made a demonstration flight from New York to San Francisco to mark the inauguration of 5-cent airmail service in the United States. The initial flight of the flying mailcar was conducted by United Air Lines for the Post Office Department, and stops were made at principal cities to discharge and take on airmail. Three railway mail clerks were aboard to work the mail while the plane was in flight.

In October, 1946, Fairchild flew its XNQ-1, a new Navy trainer embodying many major advancements in primary training aircraft. The XNQ-1 was a low-wing, all-metal, two-place monoplane with tandem seating arrangement. It was powered by a Lycoming 9-cyl. engine rated at 320 h.p., the installation of which utilized a new and improved power package principle developed by Fairchild. The airplane was equipped with flaps, and had an electrically operated retractable landing gear. It also was the first primary trainer equipped with a Hamilton Standard controllable pitch propeller. Another outstanding feature of the XNQ-1 was the new functional safety cockpit design which the Bureau of Aeronautics sponsored to provide a standard for all its carrier-based aircraft. The cockpit was enclosed by an unobstructed one-piece bubble canopy, offering all-around visibility to both instructor and student, a feature expected to reduce collisions. The XNQ-1 had a gross weight of 3,700 lbs. Its rate of climb was more than 1,000 ft. per min. and its maximum speed was about 170 m.p.h. Adequate stall characteristics were incorporated into the design of the trainer. Emphasis had been placed on stability and control, so important for carrier-based aircraft. The airplane had a wing span of 41 ft., 5 in. Its over-all length was 27 ft., 11 in., height was 9 ft., 10 in.

Among the experimental projects Fairchild had underway was the development of a new type of landing gear, on which the wheel was free to turn in the same manner as a furniture caster. Flight tests were made on a PT-19 trainer equipped with this swivel gear. Primary purpose was to permit planes to make cross wind landings, holding the plane at an angle to the runway while the wheels adjusted to actual forward direction of the plane. Possibility of ground-looping was greatly reduced because a pilot could keep the plane cocked into the wind without having to coordinate to keep it on the runway. Fairchild's work on the swivel wheel installation was coordinated with other manufacturers, and with the personal flying development office of CAA, which initiated the project to improve the utility of smaller



FAIRCHILD XNQ-1 TRAINER

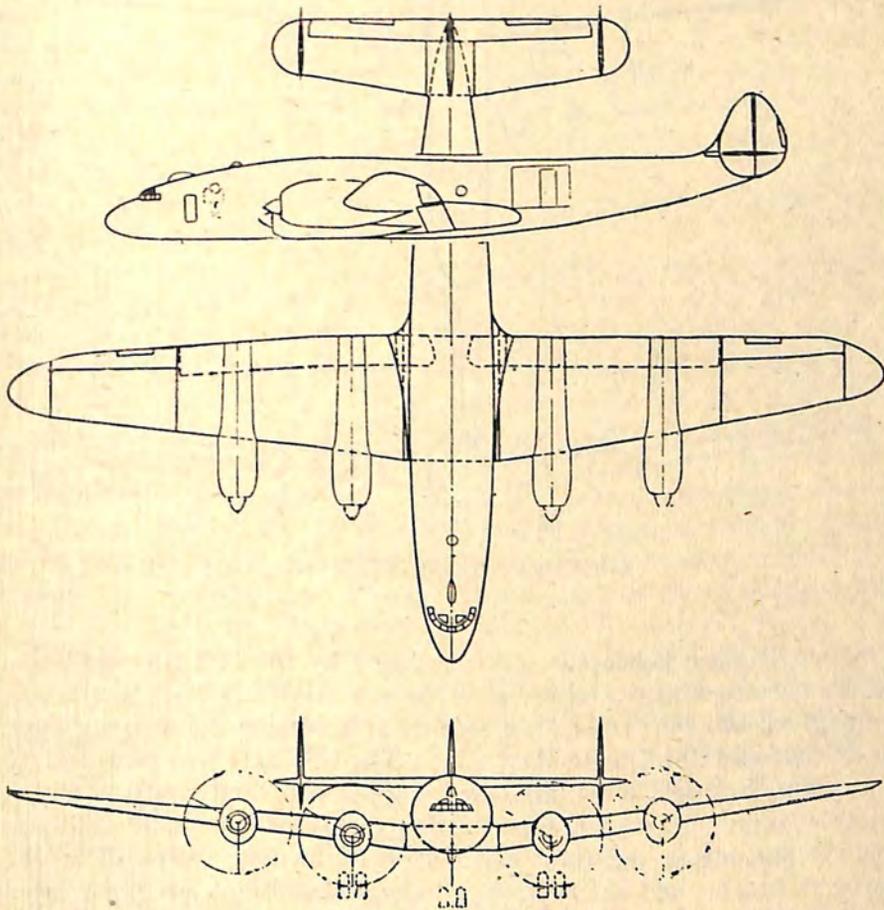
planes unable to use one way airstrips during pronounced cross winds.

Fairchild Engine and Airplane Corporation Personal Planes Division established a large factory and service center with hangars and other facilities at Strother Field, Winfield, Kans. The new plant, expected to employ about 400 persons, served as the main Fairchild base for service, maintenance and repair work on the F-24, PT-19, and all other Fairchild airplanes used by private owners. During 1947 a newly designed 4-place family airplane, the Fairchild F-47, was to be manufactured at Strother Field. The new low-wing, all-metal plane was to have retractable tricycle landing gear and a roomy cabin for 4 or 5, with full instrumentation for all-weather flying. The Fairchild F-24, a deluxe version of the prewar model, was tempo-

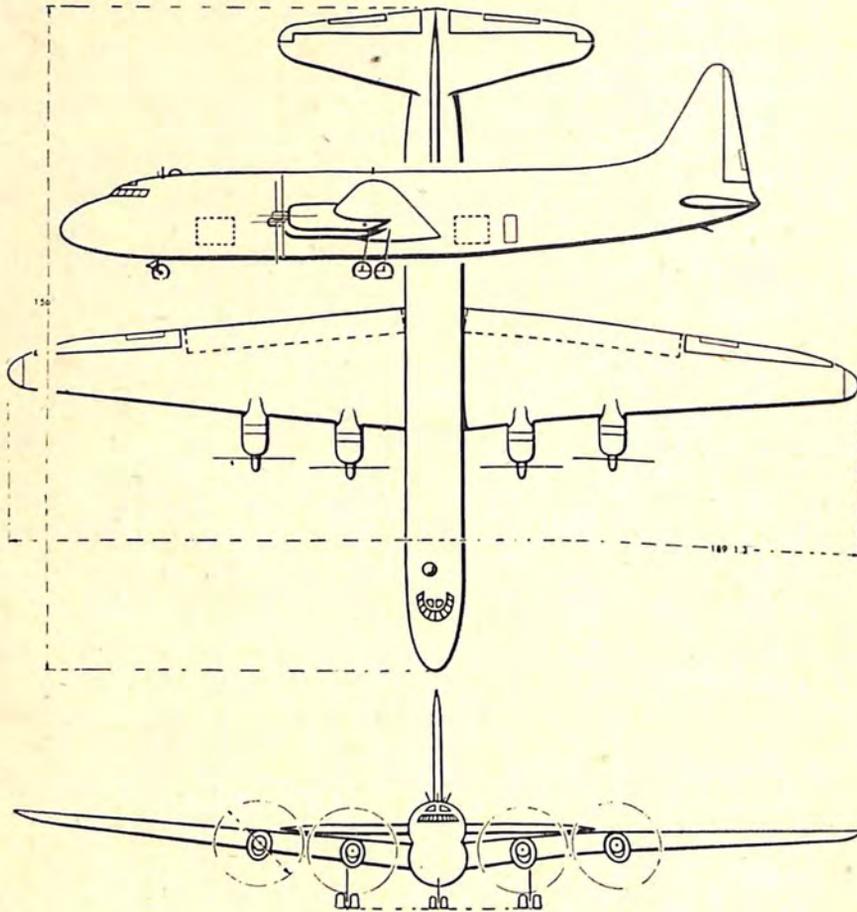
rarily manufactured under contract by Texas Engineering and Manufacturing Company, Dallas, Texas. Deliveries of this 4-place cabin monoplane began in March, 1946. The F-24 was offered with a choice of 2 different aircooled engines, a Ranger 175 h.p. 6-cyl. inline inverted, or a Warner 165 h.p. 7-cyl. radial.

The Pilotless Plane Division of Fairchild, located at Farmingdale, N. Y., was building pilotless aircraft of the guided missile type for the U. S. Navy.

The Firestone Aircraft Company, Willow Grove, Pa., formerly G & A Aircraft, and originally the Pitcairn Autogiro Company, developed the XR-9 light-weight helicopter for the Army Air Forces.



LOCKHEED CONSTELLATION



LOCKHEED CONSTITUTION

This single-place helicopter was succeeded by the XR-9B, a 2-place tandem arrangement aircraft, also for the AAF. The XR-9B was redesigned into the GA-45D, a side-by-side seating commercial type model introduced in September, 1946. The GA-45D was powered by a 175 h.p. Franklin 6-cyl. aircooled engine, had dual controls and a tricycle landing gear. The three-blade main rotor was 30 ft. in diam. and the anti-torque tail rotor was 6 ft. 6 in. in diam. Overall height was 8 ft. 6½ in., and length 27 ft. 7 in., while width at landing wheels was 9 ft. The helicopter cruised at 90 m.p.h., had a top speed of 115

m.p.h. and climbed at a rate of 1,250 ft. per min. Its service ceiling was 13,000 ft. and fuel capacity 25 gal. providing a range of 225 mi. The lucite enclosed cabin gave clear vision through a range of 270 degrees. The rotor blades were constructed of step-tapered heat-treated steel tube spars to which 7/32 five-ply poplar plywood ribs were attached by stainless steel collars. The fuselage was of welded steel tubing with a nose section of transparent plastic. Fuselage fairing was aluminum alloy. The boom had a balsa core with alclad outside skin.

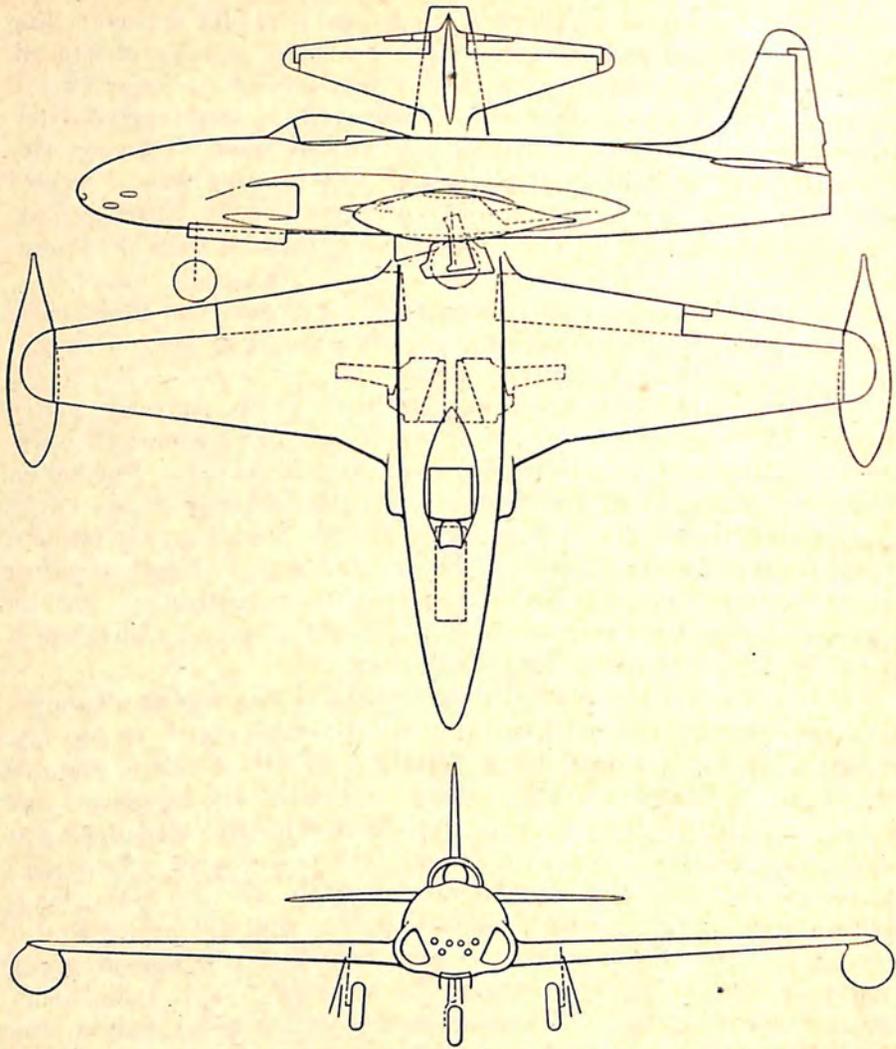
The postwar commercial helicopter GA-45D was test flown early in 1946. The Firestone Aircraft Company planned its next helicopter model to be a 4-place family type sedan.

Lockheed Aircraft Corporation, Burbank, Calif., delivered \$114,000,000 worth of aircraft to the armed forces and commercial operators in 1946, and at the beginning of 1947 reported a backlog of orders amounting to \$156,000,000. The 1946 deliveries embraced 57 Constellation transports for 8 airlines, 398 P-80 Shooting Star jet-propelled fighters for the Army Air Forces and 2 P2V Neptune patrol planes for the Navy. A larger transport, the Constitution, for the Navy, was completed and flown in 1946, and a second Constitution was to be completed in the Summer of 1947.

The Lockheed Constellation, models 649 and 749, was an all-range, high performance transport carrying 64 passengers and 13,500 lbs. of cargo. It was powered by 4 Wright C18-BD1 Cyclone engines with Pratt & Whitney Double Wasps optional. Its wingspan was 123 ft., overall length 95 ft. 1 in., top speed with full load over 350 m.p.h., top cruising speed with 60 per cent power over 300 m.p.h., range non-stop 4,800 mi. maximum and 2,000 mi. with 9-ton load. Its transport operating weight, including crew and all service equipment, was from 58,500 to 61,500 lbs. Its maximum takeoff gross weight was 92,000 lbs. with 100,000 lbs. as model 749 with additional fuel in outer wing tanks. The maximum landing gross weight was 82,500 lbs., with useful load over 18 tons.

The Lockheed Constitution, model 89, Navy model XR60-1, was a transocean passenger transport land monoplane with capacity for 180 passengers. It was powered by 4 Pratt & Whitney Wasp Major TSB1-G aircooled engines. It was 156 ft. 1 in. long, with a wingspan of 189 ft. 1 in. Its high speed was 303 m.p.h., cruising at 286 m.p.h., maximum range 6,300 mi. Its basic weight empty was 11,575 lbs., maximum gross weight for takeoff 184,000 lbs., maximum gross weight landing 160,000 lbs., useful load 69,425 lbs.

The P2V-2 Neptune was a Navy land-based day and night armed

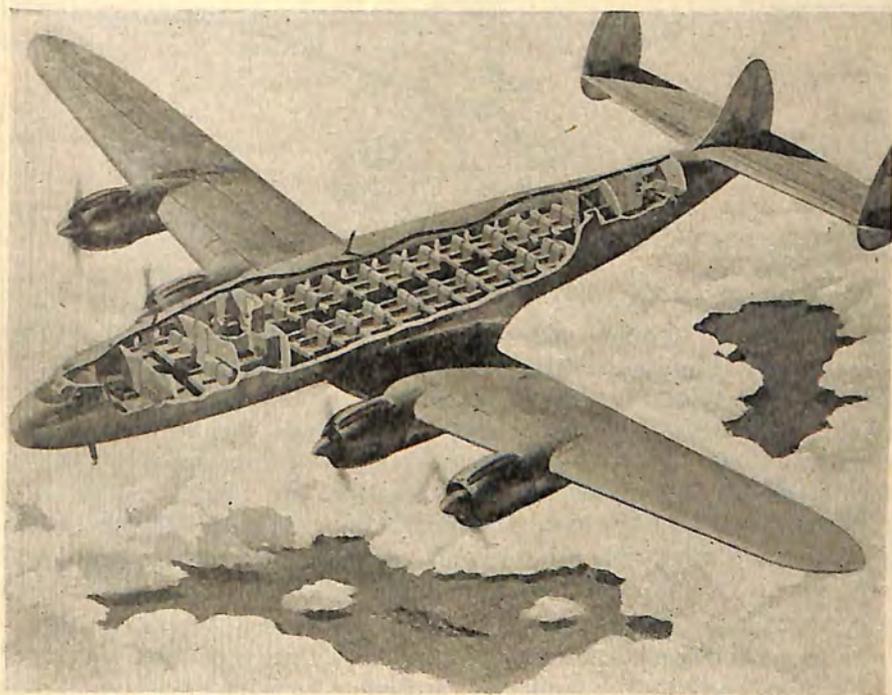


LOCKHEED ARMY P-80 SHOOTING STAR

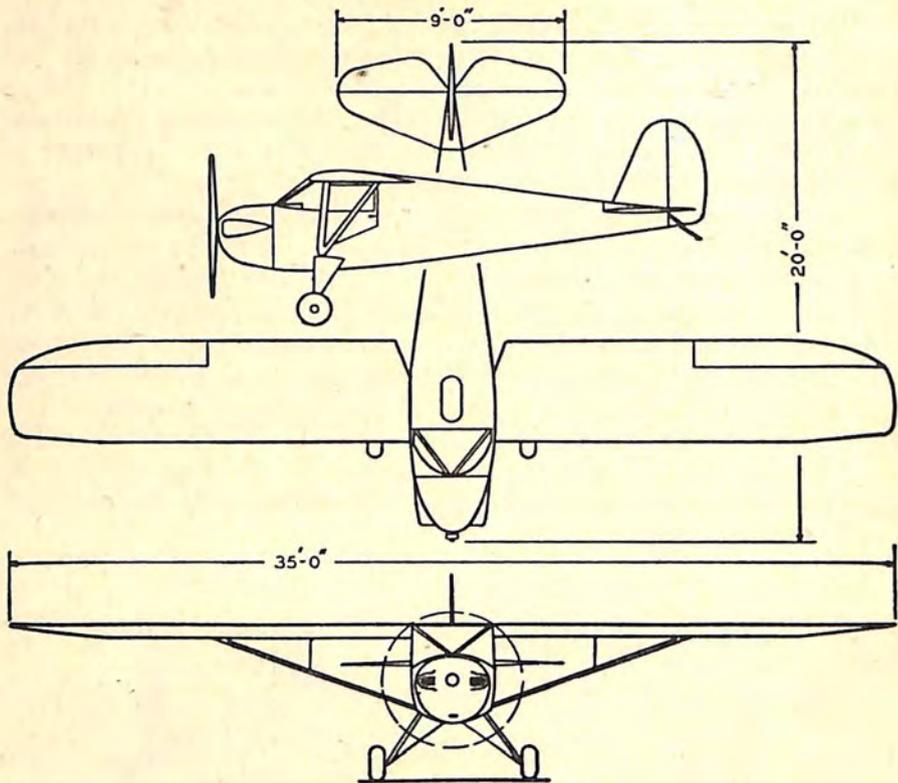
patrol plane carrying a crew of 7. It was powered by 2 Wright Duplex Cyclone R-3350 aircooled engines. Its wingspan was 100 ft., length 75 ft. 6 in. Its top speed was more than 300 m.p.h., cruising speed 170 m.p.h., range with patrol load more than 3,500 mi. Its weight empty was 32,957 lbs. and maximum gross takeoff weight 58,000 lbs.

The Shooting Star, P-80A, was a jet-propelled, low wing, all-metal, single place fighter or reconnaissance plane powered by one General Electric super jet propulsion turbine engine. The plane's weight empty was approximately 8,000 lbs., its maximum operational weight about 14,000 lbs. Its wing span was 38 ft. 10½ in., length 34 ft. 6 in. Its top speed was more than 550 m.p.h.

Lockheed planes set many flight records in 1946. The Constellation held the NAA transcontinental transport record of 7 hrs. 27 min. on a 2,500 mi. flight between Burbank and New York. An AAF Shooting Star crossed the United States in 4 hrs. 13 min. A Navy Neptune held the world non-stop distance record. From September 29 to October 1, 1946, a P2V-2 Neptune flew from Perth, Western Australia, to Columbus, O., by way of the Pacific, a distance of 11,235.6 statute miles, non-stop, in 55 hrs. 15 min. The four Navy pilots were Cmdrs. T. D. Davies, E. P. Rankin, W. S. Reid and R. H. Tabeling. They had named their plane "The Truculent Turtle."



LOCKHEED 649 CONSTELLATION INTERIOR



LUSCOMBE SILVAIRE

The Lockheed Neptune on that record flight had been designed for a gross load of about 58,500 lbs., but it left Australia with 85,000 lbs. Four Jato units assisted the takeoff, adding about 4,000 lbs. of thrust to the 16,000 lbs. thrust of the two 2,300 h.p. Wright Duplex Cyclone engines. The plane fought headwinds, heavy rain, dense clouds and icing conditions at various stages of the long flight across the Pacific. Its crew took it across the American coastline about 100 miles north of San Francisco; then they headed for Ogden, Utah, fighting icing weather and headwinds which cut down their speed and reduced the fuel supply. Near Columbus, O., the fuel gauges warned them to land.

Luscombe Airplane Corporation, Dallas, Texas, in 1946 increased production 10 times the number of airplanes produced in the previous year. Deliveries totaled approximately \$6,000,000. Early in 1945

Luscombe acquired 700 acres of land at Dallas for a new plant site. During 1945 plans were made for a modern 100,000 sq. ft. plant, the ground was broken, and by the end of the year the Trenton, N. J. plant was closed and production was up to three planes a day in the Dallas plant. In 1946 Luscombe moved up from sixth to fourth place among lightplane producers; it declared the first dividend in its 12-year history; and recruited a working force of 1,200 men and women.

Also, the year 1946 saw the production of the Silvaire standard model 8-A, and the tooling up for and production of the Silvaire DeLuxe model 8-E. The completely all-metal wing, one of the most important improvements in the lightplane field, was brought out by Luscombe in June. The wing was constructed around two extruded aluminum spars, had a metal stressed skin, a single metal strut, and retained the replaceable wing tip.

The Luscombe standard model 8-A was a 2-place, side-by-side completely all-metal, high-wing monoplane powered by a 65 h.p. Continental aircooled engine. It had a cruising speed of 105 m.p.h., a top speed of 115 m.p.h., and a landing speed of 39 m.p.h. With two persons and 55 lbs. of baggage, the plane carried fuel for a cruising range of 350 mi. Rate of climb with a full load was approximately 900 ft. per min. with a service ceiling of 15,000 ft.

The DeLuxe Silvaire 8-E also was a 2-place, side-by-side, completely all-metal, high-wing monoplane, and was powered by an 85 h.p. Continental aircooled engine. It had a top speed of 125 m.p.h., cruising speed of 112 m.p.h., and a landing speed of 48 m.p.h. With two persons and 75 lbs. of baggage, the cruising range was approximately 650 mi. Standard equipment of the model 8-E included a tachometer, oil pressure and temperature gauges, direct reading gas gauges, starter, generator, battery, ammeter, compass, air speed indicator, altimeter, cabin heater, cabin ventilator, foot brakes, parking brakes, individual seat belts, vernier type trim tab, position lights, indirect instrument panel lights, landing lights, ash tray, cigarette lighter, wheel pants, and shielded engine.

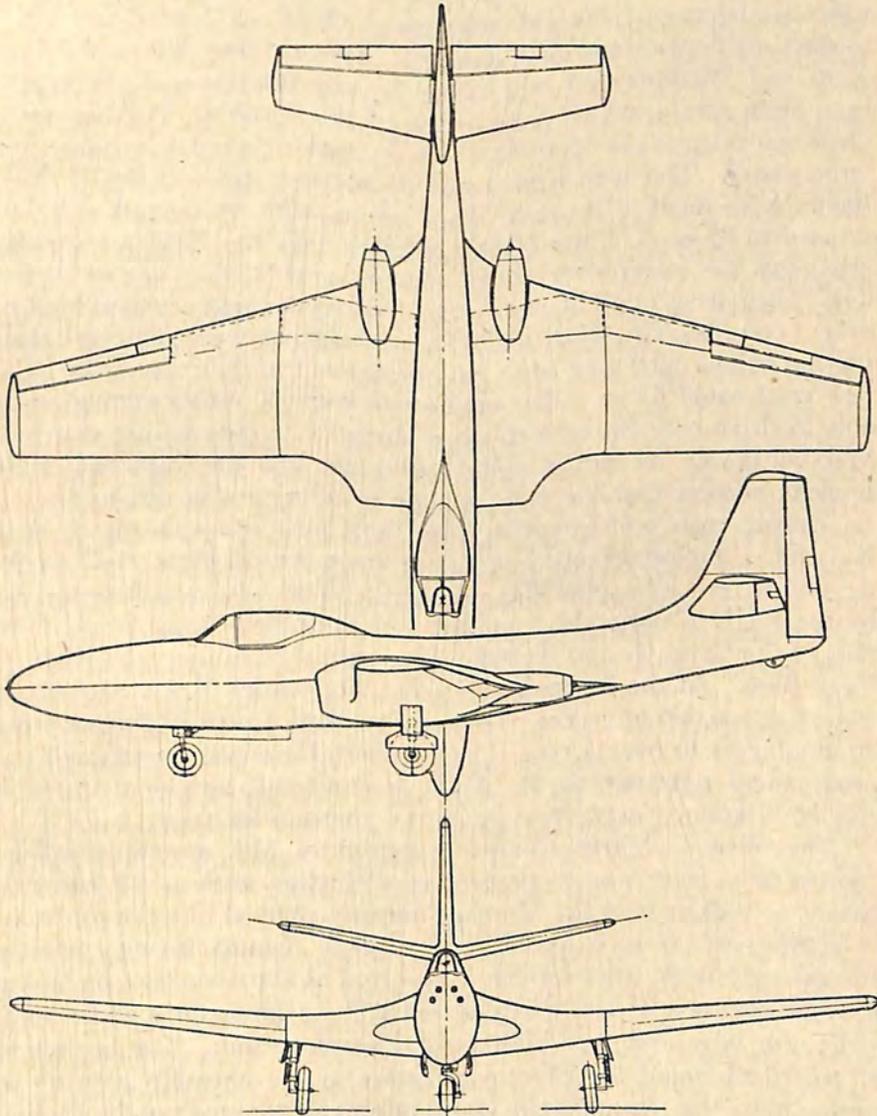
During 1946 Luscombe's experimental department was engaged in designing several new models, one of which was built and successfully flown late in the year. Work was reported progressing favorably on the other new models, of which at least one was expected to undergo flight tests during 1947.

McDonnell Aircraft Corporation, St. Louis, Mo., produced under Navy contracts the XFD-1 Phantom, the FD-1 Phantom, the XF2D-1 Banshee, all jet fighters, and the XHJD-1 twin-engine helicopter. Starting in 1943 with the conception that jet engines could be tailored

to fit the plane, McDonnell engineers had concluded that 2 engines, built into the wing roots, formed the best possible aerodynamic arrangement. Accordingly, the XFD-1, powered by Westinghouse 19-inch turbo-jet engines, made its initial flight in January, 1945. The Phantom had a service ceiling of 37,500 ft. and a range (operating on one engine) of over 1,000 mi. With a top speed of over 500 m.p.h. and after local tests, the XFD-1 went to the Patuxent Naval Air Station for further powerplant, stability, control and performance trials, including simulated carrier operations. In July, 1946, the 8,800 lbs. Phantom was declared ready for actual trials at sea. Considerable interest was centered in this dress rehearsal, as the principal problem of jet-type carrier fighter design was not one of short takeoff characteristics, but a problem of stability and control at slow speeds. The Navy had made exhaustive tests with jet planes, but they were not carrier tests. The XFD-1 went out to sea aboard the carrier Franklin D. Roosevelt. On the first trial the plane took off after a run of only 400 ft., one-third of the length of the carrier's deck. Five successful takeoffs and landings convinced experts that jet fighters were practical in carrier operations. Aside from becoming airborne in one-third of the carrier deck, the Phantom displayed ability to take a wave off in stride. Rate of climb performance during wave off tests exceeded expectations. Only about 1,280 lbs. thrust from each engine was used in the tests to keep the turbine temperatures within completely safe limits, although the engines were designed to operate up to 1,360 lbs. Turbines were operated at 15-18,000 r.p.m. in flight, with temperatures as high as 1200 deg. F. at the turbine buckets.

Also christened Phantom, the FD-1 was redesigned throughout to simplify streamlining and increase internal fuel capacity. The 19-in. turbo-jet engines also were redesigned to include more compression stages, and thereby develop more power. With some 60 of the new planes on order, deliveries were being made to the Navy from the McDonnell plant. The Phantom's aluminum alloy fuselage was flush-riveted and polished to a mirror-like luster. A bubble canopy and completely retracting tricycle landing gear gave the plane a sleek, compact appearance while in flight. Of conventional monocoque design, the 40 ft. 9 in. wings folded to a compact 16 ft. for stowage aboard the flight deck of a carrier. Rocket devices and auxiliary belly fuel tanks could be dropped in flight. Armament consisted of standard fighter equipment, mounted in the nose and accessible through easily-opened side panels. The pilot, sitting well ahead of the engines, enjoyed a sweeping view of the terrain during flight and takeoff or landing operations.

Completion of the world's largest and first twin-engine helicopter, a sensational step forward in the development of rotary wing aircraft, was announced in August, 1946. Designed by the McDonnell helicopter division in collaboration with the Navy, the XHJD-1 under-



McDONNELL NAVY FD-1 PHANTOM

went extensive flight tests at the Lambert-St. Louis Municipal Airport. The Navy pointed out that the first twin-engine craft of its type gave the Navy greater insight into the problem of helicopter design. It also stated that variations of rotor diameter, blade chord, rotor-engine gear ratio, gross weight and control sensitivity were possible on the helicopter. These variations were to be tested under every worthwhile arrangement. The new helicopter took off and landed vertically, hovered motionless and flew forward, backward and sideward. Two Pratt and Whitney 450 h.p. Wasp Jr. engines powered the craft's two lifting rotors, which were arranged side by side. The big 40-ft. blade rotors turned in opposite directions, making a tail or torque rotor unnecessary. The span from rotor tip to rotor tip was 81 ft. Test flights were made with 46-ft. diam. rotors with an overall span increased to 87 ft. The use of twin engines gave the XHJD-1 greater reliability for safety over rough terrain, populated areas or water. The helicopter cruised at more than 100 m.p.h. with a useful load of over 3,000 lbs. The Pratt and Whitney engines were mounted midway on pylons extending from the fuselage out to the rotor hubs. The new craft could fly on either of the two engines, either engine being able to drive both rotors through a system of over-running clutches. Without power, the rotors would autorotate, and the ship could glide to earth in somewhat the same manner as a fixed wing airplane.

During 1946, and extending into 1947, production on the KDD-1 Katydid, a radio-controlled target drone powered by a McDonnell-developed reso-jet engine was extended. Work also was progressing on the KUD-1 Gargoyle, a guided and controlled flying bomb. Details of the Gargoyle and Katydid were published in the 1946 Aircraft Year Book. At the beginning of 1947, McDonnell had a backlog of some \$34,000,000 in orders. The company had grown in 7 years from 20 employees to over 3,100. The Lambert Field plant contained approximately 1,200,000 sq. ft. Many new aircraft developments, still clothed in military secrecy, were on the program for 1947.

The Glenn L. Martin Company, Baltimore, Md., accomplished the reconversion from war to peacetime production with speed and efficiency, so that in 1946 the Martin Company stepped into the forefront of commercial as well as military airplane manufacturing. Martin started 1947 with orders which it reported at \$201,000,000, including postwar commercial airliner sales, but still predominantly made up of orders for advanced type military and naval aircraft. The beginning of 1946 had found the Martin company in the enviable position of having more than \$24,000,000 worth of orders from four of the leading airlines for the new 40 passenger luxury airliner, the Martin 2-O-2;

orders amounting to \$13,500,000 from eight domestic and foreign airlines for conversion of C-54s to civilian use; and a backlog of more than \$92,000,000 in orders from the Army and Navy. In addition, the Martin company was building several different items of airport ground handling equipment designed to increase safety, ease of maintenance and passenger comfort.

The Martin 2-O-2, passenger airliner, which was designed to meet the airlines' requirements for a twin-engine plane with economical medium range operational characteristics, was scheduled to appear in operations throughout on all the commercial airports of the Western Hemisphere in 1947. Orders had been placed by Capital (PCA), Eastern, Chicago and Southern, Braniff International, Northwest, Delta, Cruzeiro do Sul (Brazil), Aeroposta (Argentina), and Linea Aerea Nacional (Chile). The Martin 2-O-2 incorporated the latest refinements of modern commercial aircraft, including an entirely new system of heating and ventilating the plane's cabin to temperatures either warmer or cooler than outside air; the use of new high strength alloys and low-wing construction, which by trimming down weight contributed to speed and economy of operation; service doors accessible from the ground without use of ladders or ground equipment, which were installed under the plane to permit the servicing of radio, hydraulic and other accessory systems without having to enter the cabin or interfere with loading. It was powered by two Pratt and Whitney R-2800 series engines. So powerful were these engines that they gave the Martin 2-O-2 exceptionally good single-engine performance. New-type square blade Hamilton Standard propellers with reversible pitch made possible easier ground handling, especially on shorter landing distances or icy runways. Martin 2-O-2s were specifically equipped for flights up to 700 mi. at 270 to 280 m.p.h., with landing and takeoff times, as well as necessary maintenance and ground-handling times, cut to a minimum. Low drag laminar air foils, developed by Martin, maintained cruising efficiency of the 2-O-2, and assured safe single-engine performance. The 2-O-2 had a normal gross weight of 38,000 lbs., with a payload in excess of 9,000 lbs. The plane climbed at a rate of 1,425 ft. per min., and required a runway of only 3,500 ft. in length. Another new feature was the hydraulically operated passenger loading ramp which swung down from the underside of the tail when the stewardess pushed a button, thus eliminating ground-handled steps and speeding up loading of the plane. Other passengers boarded the plane through a second entrance near the front. Passengers in the 2-O-2 sat two abreast on both sides of the aisle, in deeply upholstered adjustable seats of a new design. Advance

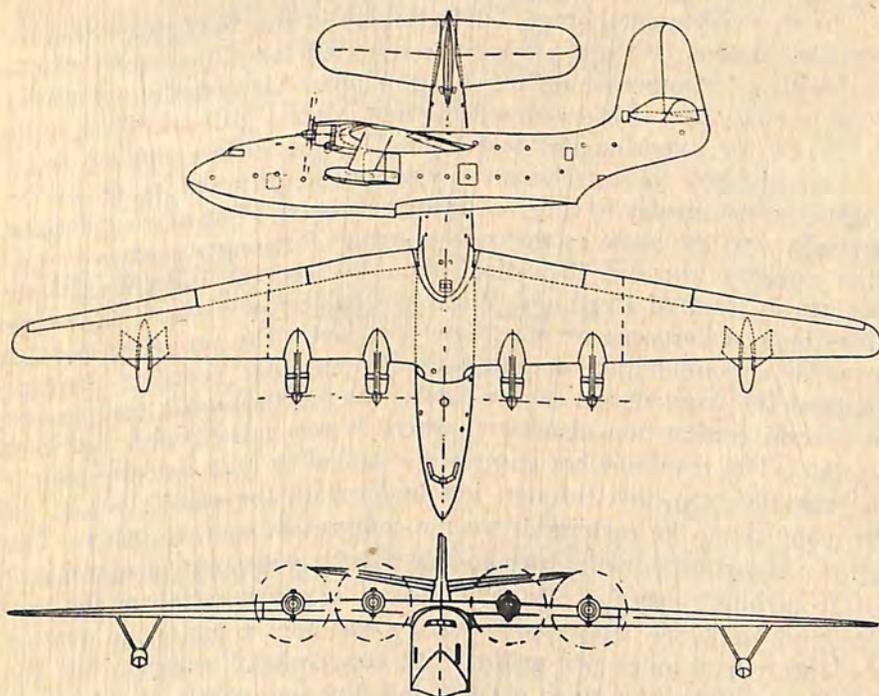
soundproofing and indirect lighting further eliminated travel fatigue. The 2-O-2 carried a crew of three—pilot, co-pilot and hostess. A specially designed pilot's compartment, roomy and simplified, with all instruments and controls within easy reach, was based on suggestions from pilots themselves as to what they desired for their convenience and comfort.

A cargo version of the Martin 2-O-2 was under construction, and orders for these new planes had been placed by operators of air cargo service, including Willis Air Service; National Skyways Air Freight (Flying Tigers); U. S. Airlines; Mutual Aviation, Inc., and Air Borne Cargo Lines, Inc.

The Martin 2-O-2 cargo transport had a wing span of 92 ft. 9 in., a length of 71 ft. 4 in. and height of 28 ft. 5 in. It was equipped with tricycle-type landing gear with dual wheels on each main gear and a steerable nose gear for convenience of operation on small airports. Without sacrificing any of its construction refinements, speed or stamina, the Martin 2-O-2 airliner was adapted to a cargo model by stripping the passenger cabin to allow for a cargo area 7 ft. high, 9 ft. wide and 50 ft. 5 in. long. It carried a useful load of over 9 tons and had a gross weight of 40,745 lbs. Powered by two Pratt and Whitney engines, with Hamilton Standard three-blade reversible pitch propellers, the Martin 2-O-2 cargo plane had a cruising speed of 270 to 280 m.p.h. and a takeoff power of 4,800 h.p. Because of the varying sizes, shapes and weights of cargo carried by the various airlines, Martin engineers designed a number of optional installations for bins, shelves and other type cargo compartments in the planes. Included was a refrigerated compartment for carrying flowers, medicinal supplies, meats and other perishable items. The cargo section, or cabin of the Martin 2-O-2 cargo version fuselage, which was isolated from the cockpit by a bulkhead, was carefully insulated and had automatic temperature control to provide varying degrees of regulation so that fresh produce could be kept cool to avoid spoilage, and other items kept warm to prevent freezing at high altitudes. Additional protection was provided by the latest fiber-glass thermal insulation. Total floor area in the new cargo transport, without aisle, was 367 sq. ft. and total volume, without aisle, was 2,250 cu. ft. A large cargo door, 6 by 8 ft. located in the rear, gave ease and speed in loading larger packages and cartons. It was dimensioned in such a manner that cargo items as large as 35 ft. long by 2 ft. thick (such as a telephone pole), up to 11 ft. long by 5 ft. thick (an automobile, for instance) could be loaded.

The world's first fleet of 300 m.p.h. twin-engine planes having pressurized cabins for low altitude comfort at high altitudes was to

go into service when the Martin Company completed orders for the new Martin 3-O-3 from several airlines in domestic and foreign operation. Among the new features were jet thrust augmentation for extra speed, heat de-icing for the wings and tail, and electronic pilots for use in automatic instrument landings, as well as in regular airway operations. The Martin 3-O-3 cruised at 5 mi. a min. while carrying 36 to 40 passengers, their baggage and 2,000 lbs. of cargo. It had tricycle-type landing gear, with a steerable nose wheel, and with dual wheels on each main gear. Hamilton Standard three-blade reversible pitch propellers permitted backing the plane up to airline terminal docks, and gave the plane absolute braking power, important on icy runways, or small landing fields. Gross weight of the 3-O-3 was over 35,000 lbs., payload over 9,500 lbs. The cabin was 45 ft. long, 9 ft. wide, and nearly 7 ft. from floor to ceiling, with 8 rows of reclining double seats on either side of the aisle. A semi-circular lounge in the rear of the cabin seated 6 passengers. Two large windows on either side of this lounge offered an excellent panorama view. The cabin



MARTIN JRM MARS

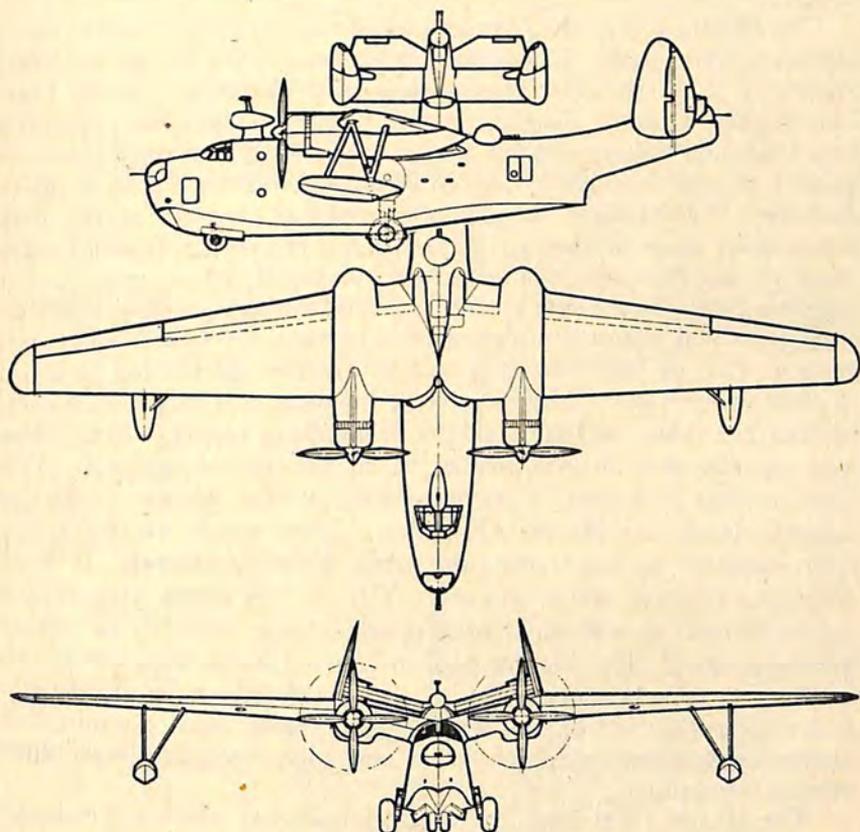
also provided thermostatically-controlled warm-well radiant cabin heating, indirect lighting, men's and women's lavatories, and large cabin windows for greater visibility. A buffet for hot meals was located in the fore section of the cabin. Air conditioning systems within the cabin assured comfortable temperatures for passengers in winter and summer alike, with humidity controlled within comfort limits.

Optional loading facilities were provided for the 3-O-3 by which passengers boarded the plane through both front and rear doors to speed up loading. An integral loading ramp swung down from the rear door, eliminating the use of ground-handled ramps. Loading was further speeded by four baggage bins hinged into the underside of the fuselage and easily available to ground personnel. The 3-O-3 had a crew of two pilots and two stewardesses. The plane was powered by two 18-cyl. Pratt and Whitney engines of 2,100 h.p. each. The plane was designed to maintain a cruising altitude of 13,500 ft. on one engine. The 3-O-3 also was equipped with the latest in travel conveniences. A drop leaf table and other facilities in the lounge were provided for recreation or work, with indirect lighting and individual reading lamps above each chair.

In an experimental stage, but definitely in the 1947 cargo picture was the Martin 3-O-4, a gas turbine-powered cargo passenger transport with speed approaching 400 m.p.h. United Air Lines announced in March, 1946, that it had ordered the new Martin 3-O-4 airliner to be delivered for experimental test flights by the airline during 1947. United planned to test the prototype turbine-powered plane on its coast-to-coast airway in cargo carrying schedules. The new type plane basically was the same as the 3-O-3, except for longer, narrower engine nacelles and for the substitution of General Electric turbine engines in place of Pratt and Whitney double-row Wasps. The turbines burned kerosene or other low cost fuel. The propeller and jet propulsion combination operated as follows: Air entering through vents at the front of the engine cowls was fed through a compressor to several combustion chambers, where it was mixed with fuel and ignited. The resultant hot gases were passed at high velocity over a turbine, then expelled through jets underneath the plane's wing. At the same time, the turbine drove the compressor and propeller. The latter was geared down to turn at only about 1,300 r.p.m. as contrasted to the turbine's speed of 13,000 r.p.m. Fuel consumption of the turbine and jet plane was approximately one mile a gallon as against one and a half miles per gallon with conventional engines, but the speed promised to be much greater and fuel cost substantially lower. Takeoff weight was 39,000 lbs. as against 35,000 lbs. in the conven-

tional type; landing weight 34,000 lbs. or about the same as the Martin 3-O-3; and payload approximately 11,500 lbs. in an all-cargo type of plane, or about the same as in the conventional type.

Late in 1945, the Martin XPBM-5A, world's largest amphibian, made its first flight. It was a development of the Martin PBM Mariner, which proved itself during the war in both Atlantic and Pacific theaters. At the close of 1946, the Martin Company had an order from the Navy for 24 of these amphibians. The XPBM-5A, which was nearly twice the size of any other amphibian ever to get beyond the design stage, was flown to Cleveland in November, 1946, and gave demonstrations of JATO, jet assisted takeoff. Landing gear on the Martin amphibian retracted into wells in the hull and nose of the big 30-ton ship. The amphibian was to be the current standard combat



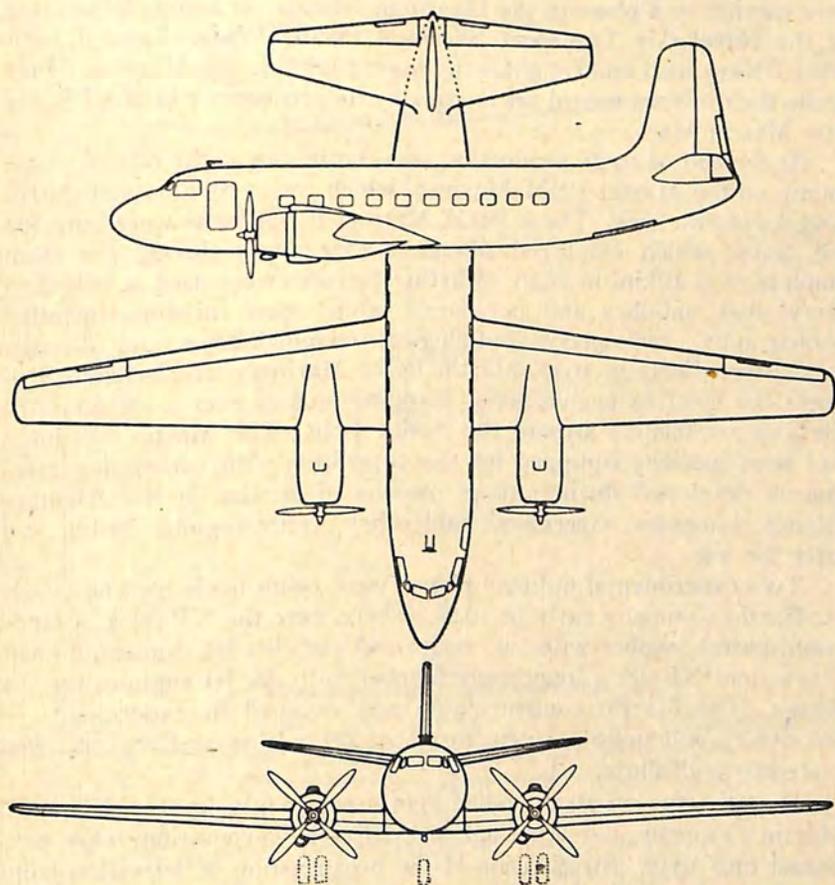
MARTIN XPBM-5A

PBM-5 flying boat, with armament, turrets, bomb bays and all other war equipment, including radar; the only major change being the installation of retractable tricycle landing gear. Weight of the new airplane was slightly over 60,000 lbs., about 4,500 lbs. heavier than the PBM-5. The new fleet of amphibians provided the Navy with a type of aircraft never before possessed by any armed service. It could land or take off on either conventional runways or water. The main wheels of the amphibian turned in a 180-degree arc and folded into wells in the sides of the hull while the ship was in flight or in the water. A nose wheel retracted into a special bay in the forward hold of the hull. Interior equipment, except for such changes as required for the wheel wells were the same as in the standard Martin Mariner. The amphibian Mariners were designed for patrolling, air-sea work, Coast Guard rescue tasks, and land and water operations in the Far North.

The Martin AM-1 Mauler was a powerful Navy single-seater dive-bomber torpedo plane. It was designed especially for use on the huge Midway type carriers, being larger than other planes of a similar type. The Mauler, a heavy, long-range, multi-purpose plane, was powered by a Pratt and Whitney Wasp Major engine with a military rating of 3,000 h.p., and four-blade Curtiss Electric propeller 14 ft. 8 in. in diameter. In level flight, the AM-1's speed was over 350 m.p.h., with a maximum range of over 1,700 mi. As a dive-bomber, it could withstand vertical dive speeds of more than 500 m.p.h. An unusual feature was its intermeshing finger-type dive brakes which opened in less than five seconds at extremely high speeds to slow the plane down in a vertical dive to less than 350 m.p.h., thereby permitting a lower altitude pull-out and therefore greater bombing accuracy. As a dive-bomber, the AM-1 carried 4,000 lbs. of bombs or rockets. In an alternate capacity as a torpedo bomber, it carried one torpedo with additional rockets or bombs. It mounted four 20 mm. cannon. With one 2,000 lb. bomb, the Martin AM-1 had a gross weight of 19,500 lbs., approximately 3,000 lbs. more than that of similar aircraft. It had a wing span of 50 ft. and length of 41 ft. 8 in. The wings were of box-type construction, with outer wing panels folding vertically for carrier accommodation. The Mauler had no internal bomb bay, but carried its bombs, rockets and torpedoes suspended externally in shackles under the center section and wings. The fuselage was of semi-monocoque construction, fabricated from new high-strength alloys, flush-riveted throughout.

The Martin JRM Mars, 72½-ton flying boats which the company was building for the Navy, were intended for several kinds of opera-

tions with the Naval Air Transport Service. They could be equipped to be transformed from one use to another in a minimum of time. In commercial use, the design of the Martin JRM Mars also was readily adaptable for passengers, cargo and mail. As a troop carrier, the JRM's carried 133 fully equipped troops in canvas bench type seats with web backs and safety belts. The seats could be quickly converted into 27 bunks. Flying wounded back from the Pacific theaters of operations, the JRM flying boats were equipped to carry 84 litter cases, with additional seating capacity for 25, including ambulatory cases and attendants. A complete compact electric galley and refrig-



GLENN L. MARTIN 202 AIRLINER

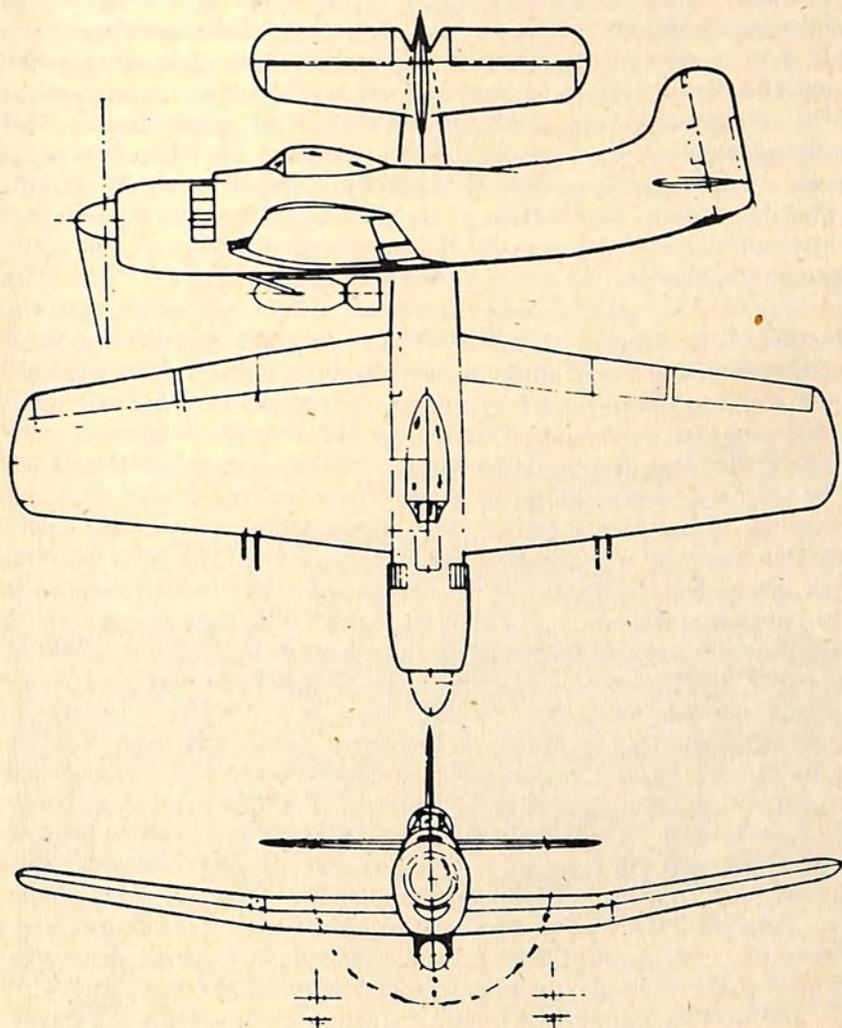
erator located forward on the lower deck provided hot meals aloft. The JRM was a veritable flying warehouse with wide open cargo spaces and cargo doors large enough to load with ease such bulky items as 20-ton tanks or jeeps. It carried its own beaching gear, and could carry almost as much cargo and freight as a standard freight car. A high-wing flying boat, the JRM was versatile in its adaptability to various kinds of cargo and personnel transportation. Two complete decks extended almost the full length of the great hull. Water-tight bulkheads were incorporated, and below the lower deck they divided the hull into 6 integral fuel tanks. The Marshall Mars, while on her second shakedown flight between Honolulu and Alameda in 1946, set a record by carrying the largest air transport payload ever carried by a plane to the Hawaiian Islands. It accomplished this in the Naval Air Transport Service's Pacific Wing. Loaded with official Navy mail and freight weighing 27,427 lbs., the Marshall Mars broke the previous record set in 1944 by its predecessor in NATS, the first Martin Mars.

At the end of 1946, production was continuing at the rate of two a month on the Martin PBM Mariner, which was a rough-water patrol boat during the war. These PBM Mariner flying boats were built for the Navy, which employed Mariners extensively during the atom bomb tests at Bikini in 1946. Martin Mariners were used at Bikini to carry mail, supplies and personnel, while other missions included photography, radiometry, radiological reconnaissance and damage estimation. Early in 1947, Martin PBM Mariners were scheduled to begin the most extensive aerial mapping survey ever undertaken of the vast wastelands around the South Pole. The Martin Mariners had been specially equipped for the expedition with winterizing safeguards developed during many months of service in the Aleutian Islands, Labrador, Greenland, and other Arctic regions during and after the war.

Two experimental military planes were being made by The Glenn L. Martin Company early in 1947. There were the XP4M-1, a land-based patrol bomber with two reciprocal and two jet engines, for the Navy; and XB-48, a long-range bomber with six jet engines, for the Army. The Martin company also was engaged in experiments in electronics and missiles; new forms of propulsion and rockets; and materials and alloys.

Experiments on stratovision, sponsored jointly by The Glenn L. Martin Company and Westinghouse Electric Corporation, were continued into 1947. Stratovision is the broadcasting of television from the stratosphere, the transmitters being located in planes flying high

above the earth and transmitting the program to receiving sets on the ground, at the same time relaying the program from plane to plane on a special beam. Several programs of each type can be handled at one time by each plane. At the chosen height of 30,000 ft., the planes will be above all normal storm areas so that they can circle slowly in their



GLENN L. MARTIN NAVY AM-1 MAULER

prescribed circle. The necessity for slow speeds presented Martin engineers with a new problem, which was totally different from those aviation had been facing from the beginning, where the desire constantly had been for more speed. In this case, Martin engineers were developing a type of slow-speed plane required for stratovision purposes. Such a plane is more economical to operate than a speedier ship, and can fly in a tighter circle, which will make for less likelihood of trouble. Each Stratovision plane, flying 6 mi. in the air, would cover approximately 103,000 sq. mi. in a great circle more than 400 mi. in diameter. Eight such planes, in addition to broadcasting to the respective areas over which they cruised, would form a coast-to-coast high-altitude radio relay network. Addition of six more planes would make possible program service for 78 per cent of the nation's population. At each station two planes would be in the air at all times, with two others on the ground being serviced and the equipment checked. Only one plane would actually be broadcasting, however, the other standing by ready to take over instantly in case of trouble.

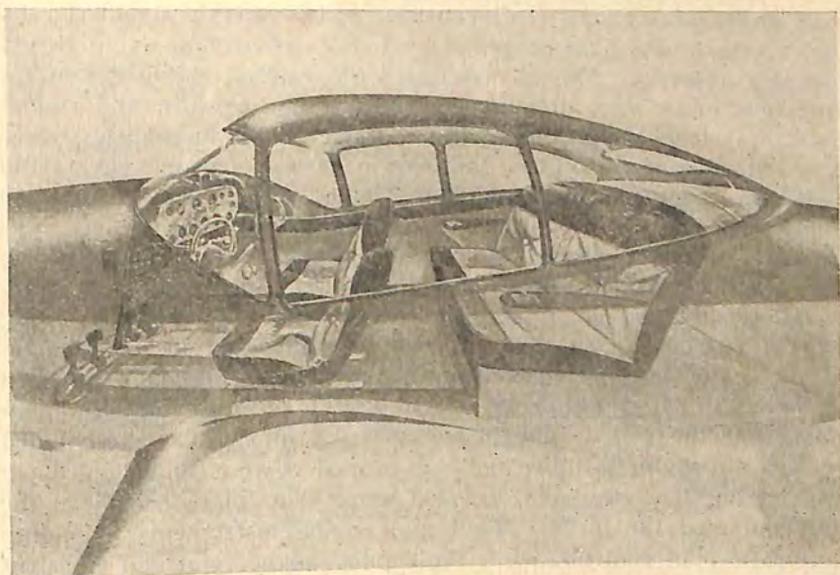
Meyers Aircraft Company, Tecumseh, Mich., planned 1947 production of the Meyers MAC-125-C, a 2-place, side-by-side low-wing cantilever monoplane of all-metal construction. The ship was powered by a 125 h.p. Continental 6-cyl. opposed type engine. A fixed pitch wood propeller was standard equipment but controllable pitch or constant speed propellers could be had as optional equipment, if desired. The ship was a true all-metal type. There was no fabric or wood covering on any part of the airplane. Retractable, hydraulically operated landing gear was standard equipment. A small plexiglas window was inserted in each wing, enabling the pilot to visually determine the position of the landing gear at all times. The plane was equipped with slotted mechanically operated flaps to provide a landing speed of 45 m.p.h. Cruising range was 500 mi., high speed 142 m.p.h., cruising speed 120 m.p.h.

North American Aviation, Los Angeles, Calif., was in production of its personal plane, Navion, and had under way in various stages of design and production a number of models for the Army and Navy air forces. The company had received about \$130,000,000 worth of orders in 1946. All company operations, including engineering, production and research, were being conducted in the main plant at the Los Angeles Municipal Airport. The oldest major structure comprised 1,071,000 sq. ft. of floor area. Other company-owned structures at or near the main plant contained an additional 714,000 sq. ft.

The various experimental and production contracts for the Army and Navy included a new type, the XFJ-1 Navy jet fighter, which was

test flown during the year. Other advanced aircraft models were scheduled for initial flight in 1947. The company held 8 experimental or production contracts for 6 different military types. Among them was the AAF P-82 Twin Mustang fighters. Designed for ultra long range duty, the P-82 had a top speed of more than 475 m.p.h. and could easily cover the vast Pacific stretch between the West Coast and Pearl Harbor. Tactical versatility of the unique plane fitted into long range peacetime work, for it incorporated the newest and latest design features developed by North American's continued engineering and research efforts to constantly improve American aircraft.

A radical departure from the conventional single fuselage airplane, the Twin Mustang was formed by two fuselages joined by wing and horizontal stabilizer. With a pilot in each fuselage and automatic pilot in the main cockpit, it reduced to a minimum the problem of pilot fatigue on ultra long range missions. Culminating five years' development, the Twin Mustang was designed to fulfill Army Air Forces requirements for super range and tactical versatility without sacrificing any of the speed and altitude which made the P-51 one of the top-rated fighters of World War II. The Twin Mustang had a combat range of over 2,500 mi. carrying full armament. A wing section with refine-



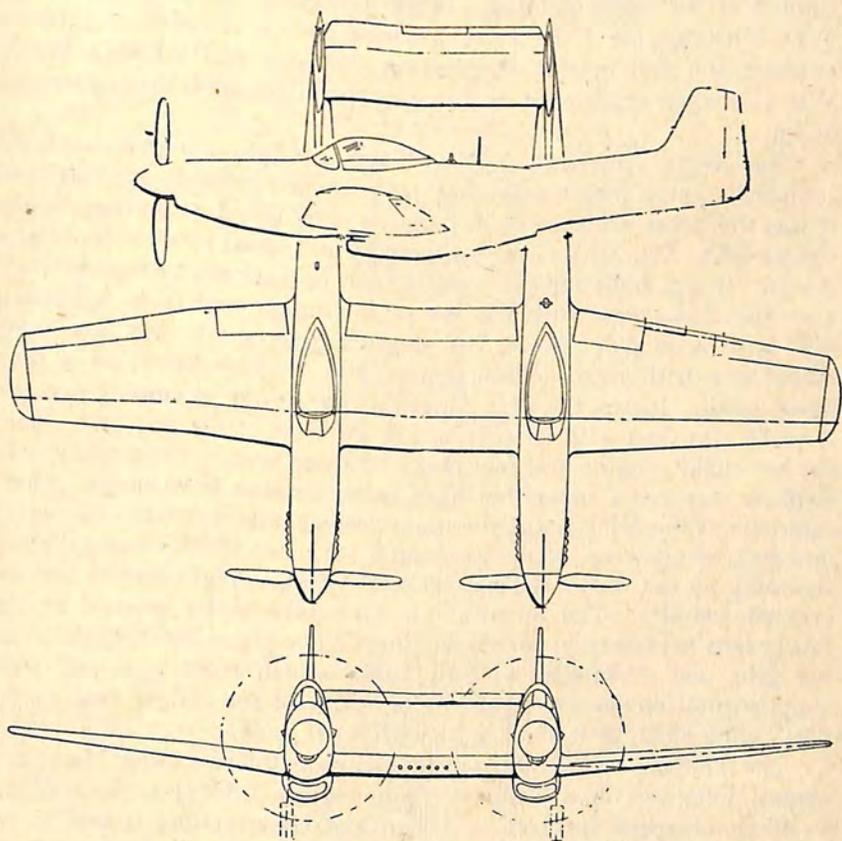
INTERIOR OF NORTH AMERICAN NAVION

ments to the basic N.A.C.A. laminar flow series and other aerodynamic improvements were major factors in the plane's high speed performance. Powered by two Packard-built 12-cyl. V-1650 Rolls Royce engines each generating 2,200 h.p., the Twin Mustang operated efficiently up to 45,000 ft. The powerplants were equipped with a two-speed, two-stage aftercooled supercharger on each fuselage, and each engine had a manifold pressure regulator and water injection system. The plane utilized two opposite-rotating, full feathering four-blade Aero-products propellers. The two fuselages were carried on the center wing section, which was fitted with a single, slotted-type wing flap and with provisions for machine guns and bomb racks. The outer wing sections had removable tips, aileron-type wing flaps and fittings for bomb racks and rocket launchers.

A unique feature of the twin fuselages was the 4-wheel landing gear arrangement, consisting of two main gear assemblies and two steerable tail wheels. The main gear was normally operated by hydraulic pressure from the left cockpit only. Emergency operation through a mechanical system was possible from either cockpit. A cable system extending from each main gear through the fuselage retracted each tail wheel. Steerable through the rudder control system, the tail wheels were free swiveling when the control stick was pushed forward. Each fuselage had a short rear section actually forming a part of the empennage, which consisted of two vertical stabilizers and rudder assemblies linked together by a single horizontal stabilizer and elevator assembly. Dorsal fins faired the vertical stabilizers to the fuselages to improve directional stability. The elevator and rudder control systems included a hydraulic power boost mechanism which automatically cut in to assist the pilot in more violent maneuvers and pull-outs. Each pilot had complete primary and empennage trim tab controls, while the aileron trim tab was controlled from the left cockpit only. Complete elevator and rudder control systems in each fuselage were interconnected through the center wing section, as were complete aileron control systems incorporated in each outer wing panel. The control stick in the copilot's right-hand cockpit was removable, and the rudder pedals in either cockpit could be disconnected in flight and moved out of the way to provide more room for the pilot not flying the plane. The pedals snapped into place when pulled back. Both engine throttles and both propellers were controllable from either cockpit by manually operated levers. The pilot's cockpit at the left contained the normal flight and engine instruments, including automatic pilot controls, while the copilot on the right had sufficient instruments for relief and emergency operation. A simplified cockpit

arrangement was worked out to improve pilot comfort, including a tilting, adjustable seat to reduce fatigue during long flights.

The Twin Mustang's armament consisted of 6 machine guns, 25 rockets and 4 bombs. Six free-firing .50 cal. machine guns were located in the center section with space for 400 rounds of ammunition for each gun. A compensating gun sight was installed in the left cockpit, and a fixed right-and-bead sight in the right cockpit. The plane had 4 bomb racks, one on each outer wing and 2 on the center wing section, each able to carry a 1,000-lb. bomb. Adapters fitted to the center section racks made it possible to carry two 2,000-lb. bombs in that position. Normally, the bomb racks were electrically operated



NORTH AMERICAN P-82 TWIN MUSTANG

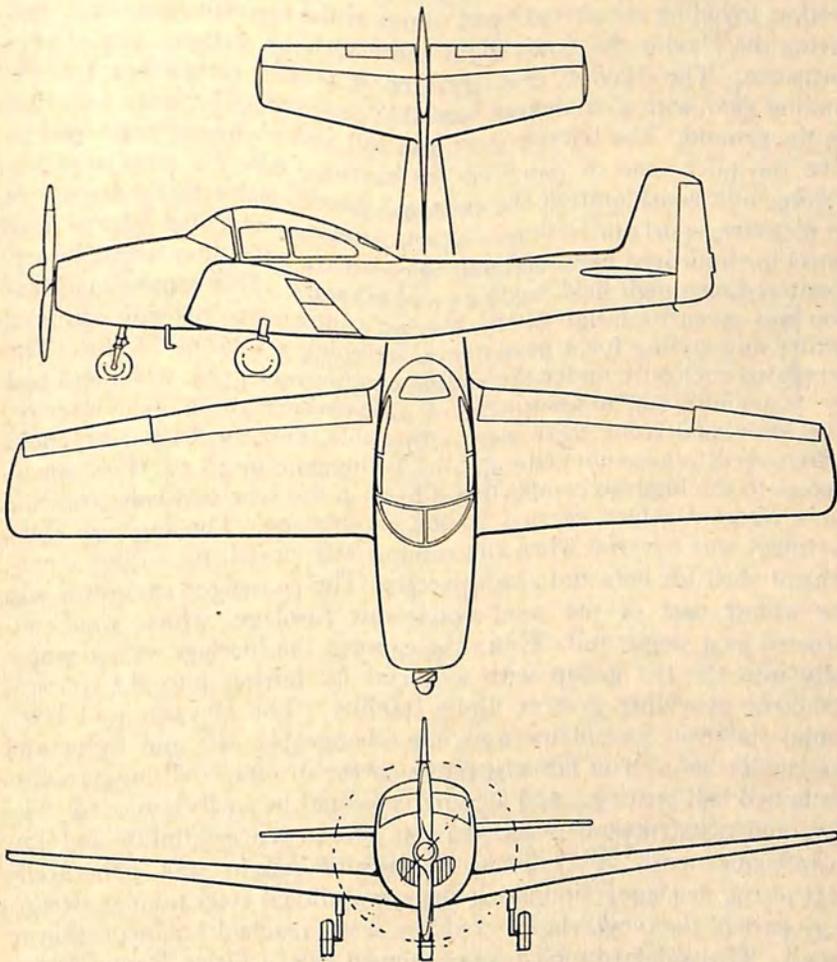
from the left cockpit, but in emergency all bombs could be salvoed by mechanical release from either cockpit. Five rocket-launching racks carrying five rockets each gave the Twin Mustang a firepower equivalent to a light cruiser's full broadside. Two racks were on each outer wing panel and one in the center section. The rockets could be released from either cockpit, and were fired at intervals of a tenth of a second each.

To boost the P-82's range, a special shackle in the center of the center wing section carried a 450-gal. droppable fuel tank. The shackle connection also could boost the firepower by holding a special nacelle carrying eight .50 cal. machine guns. The entire assembly could be jettisoned in an emergency. Adaptations of the 8-gun nacelle provided a camera installation for reconnaissance flights, or radar equipment for night fighting. While reflecting the influence of the P-51 Mustang, the P-82 Twin Mustang was a completely different airplane, the first fighter designed on the basis of America's World War II combat experience, and represented a great advance in aircraft design.

The North American XFJ-1 Navy jet fighter represented the company's entry into the field of jet-propelled military aircraft, and it was the latest evidence of the Navy's shift to jet propulsion in the fighter field. The XFJ-1 was powered by a General Electric jet of new design. It was built for carrier and land operations, taking off from a carrier flight-deck with the aid of a catapult and from a landing field with normal jet power. A single-engine, single-seat, low wing monoplane with short stubby wings, the XFJ-1 resembled a high flying bomb. It was the first American jet fighter to employ a single straight ram duct with its entrance in the nose of the airplane. With the air intake, engine and fuel tanks enclosed within the airplane, the airplane was given super-thin high speed laminar flow wings. Characteristic of the XFJ-1 was the high vertical stabilizer with 10-degree dihedral, or upsweep, of the horizontal surfaces, which placed the tail assembly up out of the wing shock-wave area at high speeds, and increased stability. The dihedral also provided better control at the low speeds necessary in carrier landings. The plane had tricycle landing gear and droppable wing-tip tanks which were equipped with supplemental navigation lights. The height of the XFJ-1 was 14 ft., 6 in., wing span 38 ft., one in., length 33 ft. 7 in.

The company held experimental contracts for two other Navy airplanes. One was the new single engine trainer XSN2J-1. In addition to other advanced features of design and construction, it was to be equipped for dive bombing training and carrier landing and takeoff.

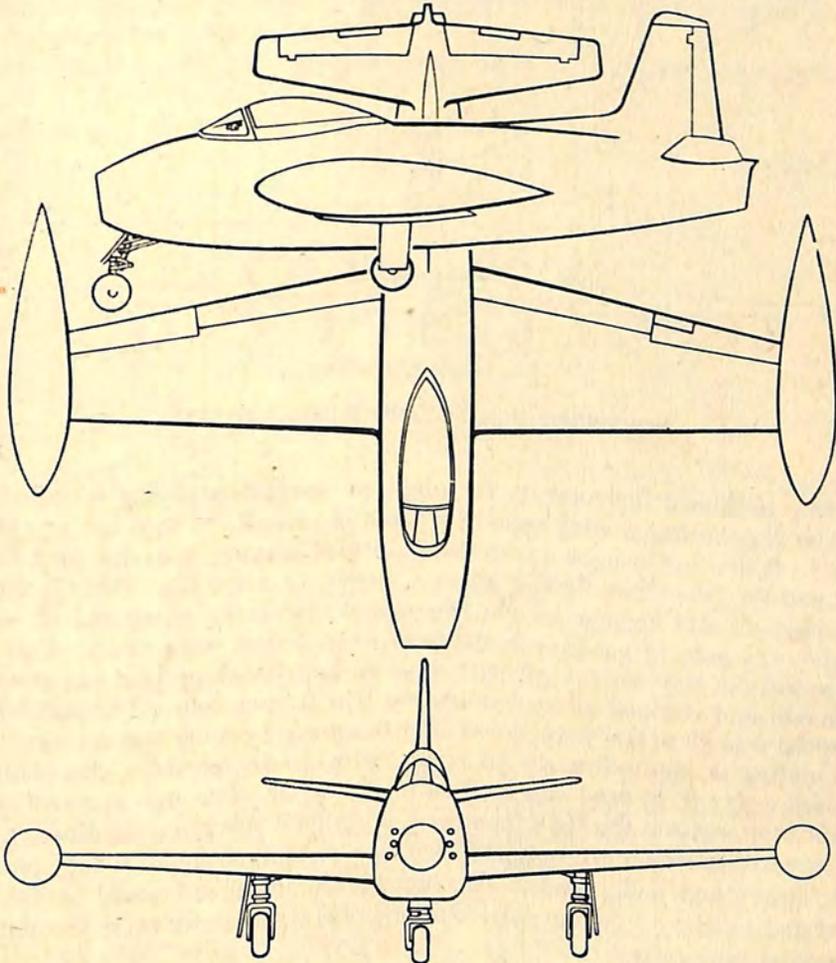
North American entered the personal airplane field in April, 1946, with the Navion, an all-metal, 4-passenger airplane designed for outstanding performance and versatility. The Navion was a low wing, side-by-side dual control airplane featuring unusual flight characteristics with ease, safety and economy of operation to meet the combined demands of pleasure, sport and business flying. Powered by an air-cooled Continental 185 h.p. engine, the Navion had a cruising speed



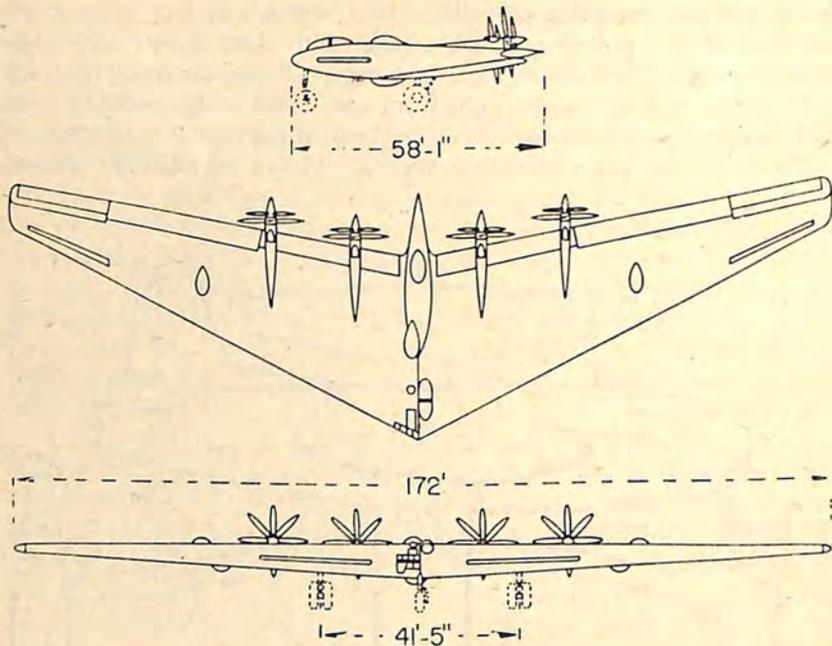
NORTH AMERICAN AVIATION NAVION

of 150 m.p.h., top speed of 157 m.p.h. and maximum range of over 500 mi. It featured a new and specially-designed wing which gave the plane unusual aileron control at low speeds when approaching the stall. The root sections of the Navion's wing were the first to stall, eliminating tendency of the airplane to roll, and maintaining good aileron control up to and through the stall. An up-to-the-middle curvature to the wing tip section further reduced any tendency for the tip sections of the wing to stall first. Through this design, North American achieved a smooth and gradual flow of air over the wing tip section, avoiding the abrupt bend found in the conventional wing, and giving the Navion the finest flight characteristics without loss of performance. The Navion also featured a power retractable tricycle landing gear with a 20-degree steerable nose wheel for easy handling on the ground. The tricycle gear and full vision canopy combined to give the pilot ease of handling for taxiing, takeoffs and landings. Taking into consideration the personal pilot's desire to fly anywhere on pleasure, sports or business, North American installed a large nose wheel for improved handling, and to eliminate difficulties normally encountered on rough field landings and takeoffs. This same consideration was given to design of the Navion's interior to provide comfort, luxury and styling for 4 passengers, weighing a total of 680 lbs. The ventilated enclosure under the sliding canopy was 43 in. wide, and had the roominess and appointment of a luxurious automobile interior. The individual front seats were adjustable, and the back seat could be removed to accommodate 435 lbs. of luggage in 46 cu. ft. of space. Access to the luggage compartment back of the rear seat was from the cabin interior, which carried 80 lbs. of luggage. The luggage compartment was covered when the canopy was closed, providing a convenient shelf for hats and small parcels. The passenger enclosure was the widest part of the semi-monocoque fuselage, which was constructed as a single unit. From the canopy, the fuselage swept gracefully into the tail group with a dorsal fin fairing into the vertical stabilizer providing greater flight stability. The elevator and horizontal stabilizer assemblies were interchangeable, left and right, and the rudder had a trim tab adjustable on the ground. All hinge points contained ball bearings, and all surfaces could be easily removed. Design and construction of the Navion accented accessibility and low maintenance cost. The monocoque engine mount was structurally part of the fuselage, eliminating the conventional steel tubular design. Any part of the 6-cyl. engine could be easily reached for inspection or repair. The standard model was equipped with a Delco-Remy electric starter, navigation lights, flight and engine instruments for contact

flying, and variable pitch propeller. The Navion's surface control system was of the pulley and cable type, with dual wheel and pedal controls for the pilot and copilot. The copilot's controls could be easily and quickly removed so the right front seat could accommodate a non-pilot passenger. The rubber-mounted instrument panel was designed so the basic instrument arrangement would not be radically altered



NORTH AMERICAN XFJ-1



NORTHROP B-35 FLYING WING BOMBER

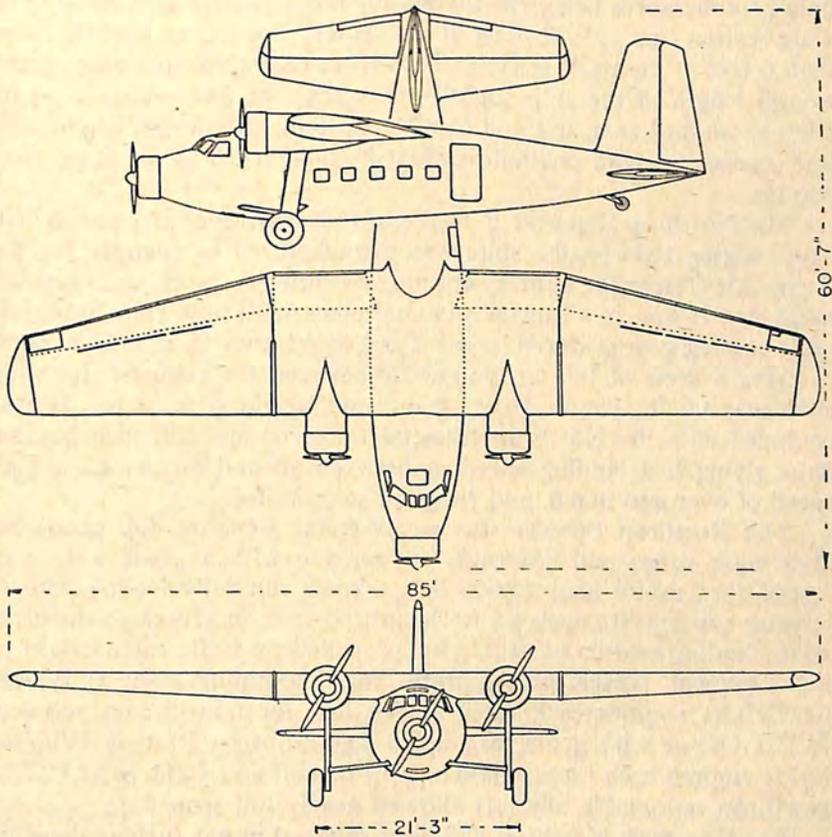
with additional instruments for night or instrument flying installed. The Navion had a wing span of 33 ft. 5 in., length 27 ft. 8 in., height 8 ft. 8 in., and weight 1,660 lbs. empty. Carrying a useful load of 1,016 lbs., the plane flew at a gross weight of 2,676 lbs. Besides the passenger and luggage weight, the useful load included 10 qts. of oil and 39.5 gals. of gasoline in the two pressed steel wing tanks. Fully loaded, the Navion took off with flaps up in a 560-ft. ground run at 10 m.p.h. and climbed at approximately 800 ft. per min. The stalling speed was 58 m.p.h. flaps down, and the service ceiling was 14,000 ft. Landing at approximately 58 m.p.h. with 40-degree flaps, the plane used a 333-ft. ground run in a 10 m.p.h. wind. Through removal of the rear seat and the right front seat, additional space was obtained for farmers, salesmen or sportsmen wishing to confine most of the space to heavy and bulky loads. The luggage compartment could be converted to carry photographic equipment for aerial surveys, or other special equipment.

North American also was active in advanced research programs for the Army and Navy in the fields of rocket propulsion, supersonic

aerodynamics, and development of guided missiles. A newly created aerophysics section of the engineering division was handling a majority of those projects.

Northrop Aircraft, Inc., Hawthorne, Calif., produced the huge flying wing experimental bomber XB-35 and the F-15 Reporter photo reconnaissance plane for the Army Air Forces; and developed the Northrop Pioneer for feeder line and other commercial operations using relatively short runways. The XB-35 flying wing took to the air in 1946, and commenced an exhaustive series of tests under the supervision of AAF experts.

Northrop had an AAF contract for 15 of the big flying wing bomb-



NORTHROP PIONEER

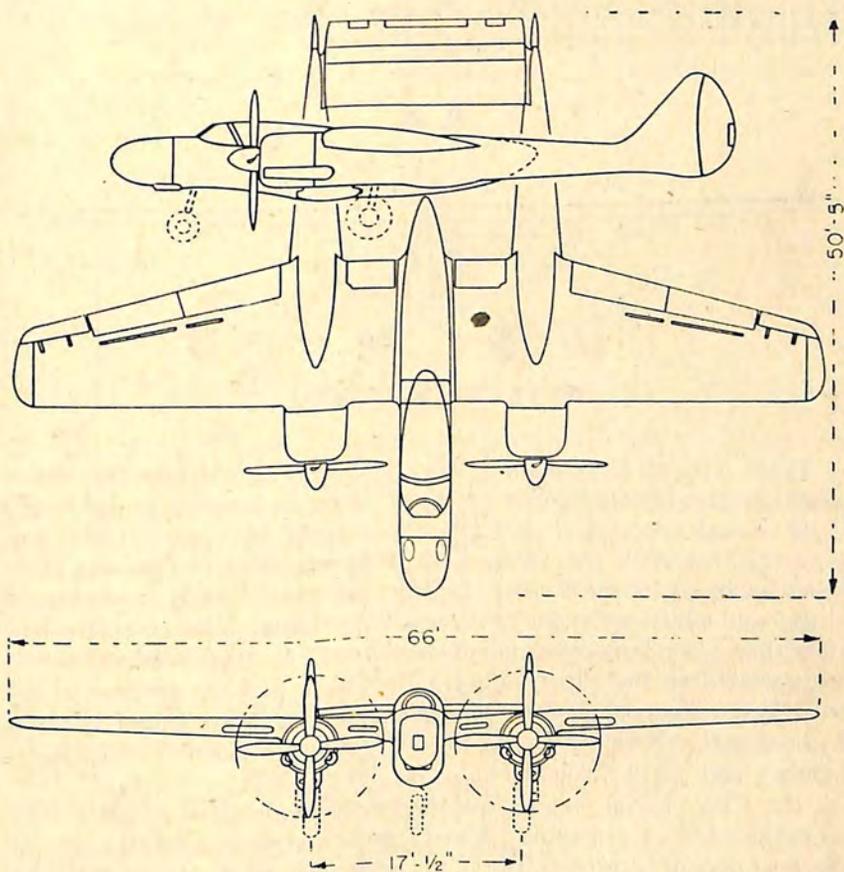
ers, including a jet-powered version. The B-35 represented 23 years of research and millions of engineering hours. It had a span of 172 feet. Its area was 4,000 sq. ft. It was designed to operate under overloading conditions at a gross weight of 209,000 lbs., more than 104 tons. It was powered by 4 Pratt & Whitney Wasp Major engines turning four eight-blade Hamilton Standard coaxial pusher propellers, designed to give a total of 12,000 h.p. The crew nacelle was pressurized. The B-35 had a gross weight of 209,000 lbs., as compared to the 130,000 lbs. of the B-29 Superfortress, the very heavy bomber of the war. The B-35 carried a crew of 9—pilot, copilot, bombardier, navigator, engineer, radio operator and three gunners. Cabin space was available for 6 additional men to alternate as crew members on long missions. All crew accommodations were in the wing itself, the only protuberances being the turrets for the defensive armament. The wing section was 37½ ft. long at the center, tapering to slightly more than 9 feet at the tips. It swept back from center to tips, making the overall length of the ship slightly more than 53 feet. At rest on its tricycle landing gear, it stood over 20 ft. high. Its design useful load was 73,000 lbs. with possibilities that it could reach as much as 120,000 lbs.

The Northrop Reporter F-15 photo-reconnaissance airplane, a fast, long-ranging twin-engine ship, was manufactured in quantity for the Army Air Forces for military training, weather research and mapping missions. It was an all-metal midwing plane with fully retractable tricycle landing gear powered by two Pratt & Whitney R-2800-C engines, carrying a crew of two in the nacelle between the engines. Its wing span was 66 ft., length 50 ft. 3 in., and height 9 ft. 2 in. It was equipped with the Northrop retractable aileron and full-span landing flaps giving it a landing speed of between 70 and 80 m.p.h., a high speed of over 440 m.p.h. and range of 4,000 miles.

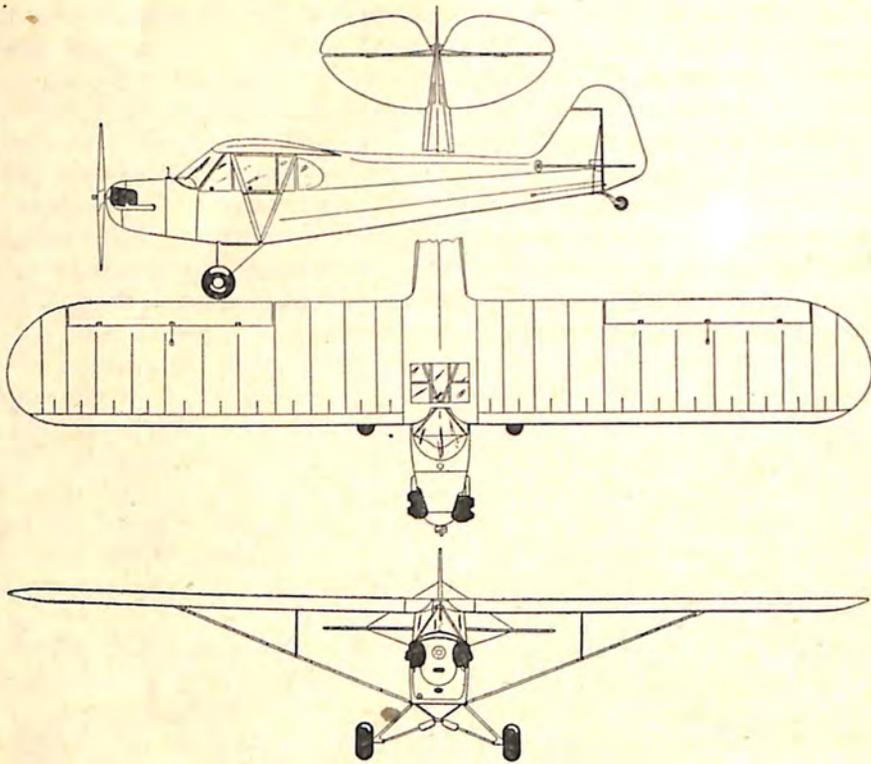
The Northrop Pioneer was an all-metal 3-engine, full cantilever high wing cargo and passenger monoplane with a gross weight of 25,000 lbs., useful load 10,600 lbs., takeoff run fully loaded 700 ft., landing run 750 ft., span 85 ft., length 60 ft. 7 in., fuselage diameter 10 ft., landing gear tread 21 ft. 3 in., propeller arc 12 ft., cabin height 79 in. Optional power plants were, for maximum load 3 Wright 957C7BA1 engines each rated at 800 h.p. for takeoff and 700 h.p. M.E.T.O.; or with gross load up to 24,000 lbs., 3 Pratt & Whitney S3H1 engines each rated at 600 h.p. for takeoff and 550 h.p. M.E.T.O. Northrop retractable ailerons allowed nearly full-span flaps.

For six years, Northrop had been engaged in gas turbine development under restricted Government contracts. This research and de-

velopment was combined with that of Joshua Hendy Iron Works, to supplement the Northrop engineering department and provide adequate production facilities and experience. This resulted in the organization of Northrop-Hendy Co., an affiliate owned jointly by Northrop Aircraft and Joshua Hendy Iron Works. Northrop-Hendy developed gas turbine components having unusually high overall efficiencies, particularly in compressors. Known by their trade name of "Turbodyne," they were designed to power aircraft, the most difficult of all applications, possessing the problems of any other prime-mover requirements, plus those peculiar to aircraft—meticulous weight control, the obtaining of maximum power in minimum space.



NORTHROP F-15 REPORTER



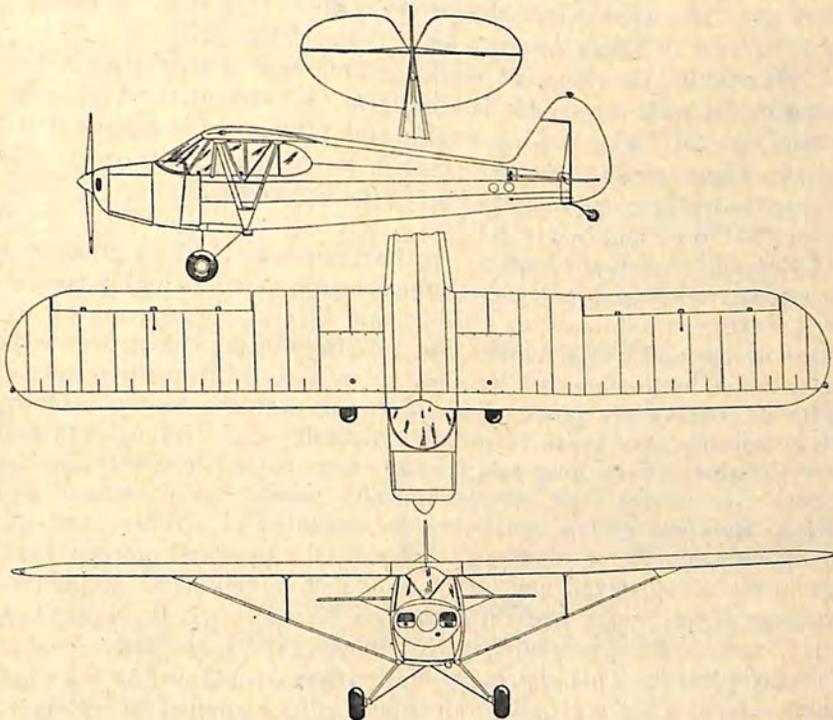
PIPER CUB J3C SPECIAL

Piper Aircraft Corporation, Lock Haven, Pa., continued to maintain its position as the largest producer of personal airplanes by virtue of its record production of 7,780 Piper Cubs in 1946. In building more than twice the number of Cubs it had built in any prewar year, Piper enlarged its main plant facilities at Lock Haven, and opened a new mid-continent plant at Ponca City, Okla. The company had more than 3,000 employees in January, 1947. In 1946 production was concentrated on the Piper Cub J-3 Special, a postwar version of the Army's Grasshopper, and the entirely new Piper Cub Super Cruiser, a passenger personal airplane. Production was divided between 6,667 Specials and 1,413 Cruisers.

The Cub Special was a 2-passenger, tandem-seated airplane with a Continental 65 h.p. engine. It had a gross weight of 1,220 lbs., empty 680 lbs., overall length 22 ft. 4½ in., wingspan 32 ft. 2½ in., height 6 ft. 8 in. While the ship was intended primarily for student instruc-

tion, it was adopted successfully to other industrial and agricultural uses. It was found particularly useful on the farm because of its ability to operate from short rough fields. Farmers used the plane for a variety of purposes, including checking fence lines, coyote hunting, searching for stray cattle, flying to nearby towns for parts and groceries, and visiting neighbors. When especially equipped for crop dusting, the Cub carried 500 lbs. of insecticide. Over 1,000 Cubs were used for that purpose. In Canada a cargo version of the Cub, the Cub Prospector, was widely used by bush pilots for short haul work. In other sections, the ship was used for pipe line and power line patrol. The FAF price was \$2,295 with complete equipment, including dual controls, brakes, compass and tail wheel.

The Piper Super Cruiser went into full production during the latter part of 1946, when it proved an instantaneous success with airport and charter operators, as well as private owners. The ship carried two



PIPER CUB J5C SUPER CRUISER

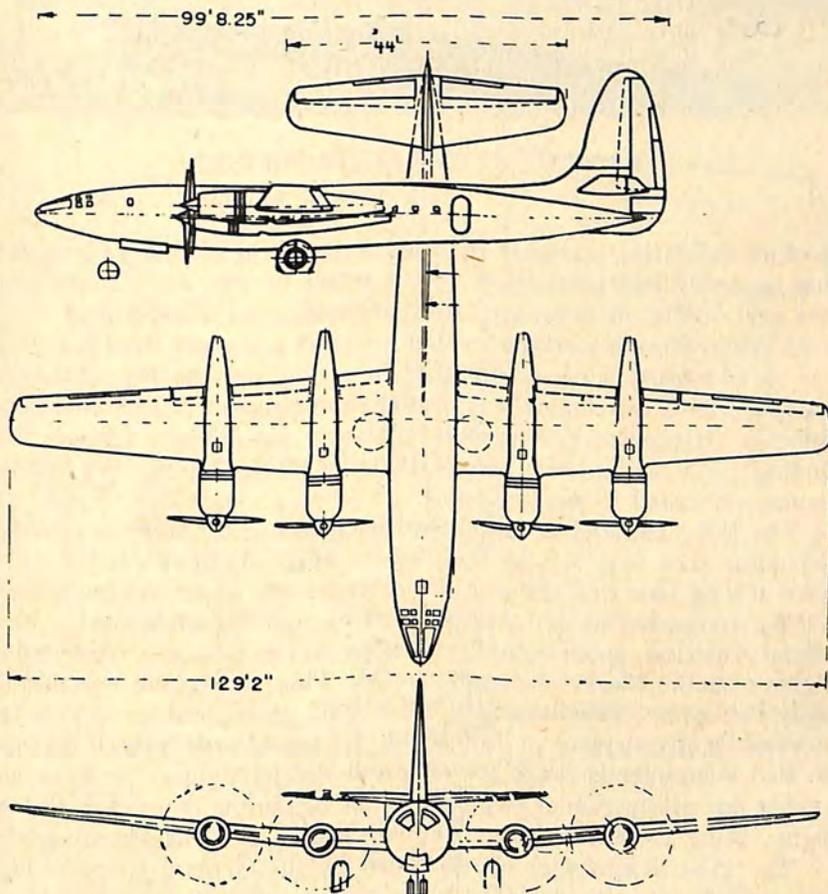
passengers in the rear seat and a pilot forward in the sound-proofed cabin. With dual controls as standard equipment, it also could be used for student instruction. The Super Cruiser was powered by a 4-cyl. 100 h.p. Lycoming engine which gave it a top speed of approximately 120 m.p.h. and a cruising speed in excess of 105 m.p.h. A 38-gal. gas capacity provided the unusual range of over 600 mi. which made the plane popular in foreign countries with long distances to be traversed. Standard equipment included a two-way radio, engine starter, generator and navigation lights. Completely equipped, the Cruiser sold for \$3,295 FAF, Lock Haven. It had a gross weight of 1,750 lbs., empty 1,000 lbs., overall length 22 ft. 6 in., wingspan 35 ft. 5½ in., height 6 ft. 10 in.

The demand for both the Cruiser and the Special necessitated expansion of production facilities, with the result that Piper opened a 163,000 sq. ft. plant at Ponca City, Okla., and concentrated all J-3 production there, permitting increased production of the Super Cruiser at Lock Haven, the rate reaching 35 a day in December, 1946. More than 575 Cubs were exported to every continent, in 1946. A majority of sales were in South America and South Africa.

Meanwhile, development work continued on a new 4-place low-wing model with retractable landing gear. Known as the Piper Skysedan, the ship had a 165 h.p. engine and a top speed in excess of 160 m.p.h. Plans were to have the plane in production by late 1947. The Skysedan had a gross weight of 2,400 lbs., overall length 26 ft., wingspan 34 ft. 8 in. and height 7 ft.

Republic Aviation Corporation, Farmingdale, N. Y., completed a sweeping transition which carried the company from its highly specialized wartime production to a broad and diversified program of airplane design and manufacture. The problems of the changeover were accentuated by the fact that Republic, in making this transition, turned from conventionally powered single-engine fighters to the building of 2 radically new types of military aircraft—P-84 jet fighters and the 4-engine XF-12 long range photo reconnaissance giants for the Army Air Forces—the aerodynamically similar 46 passenger 450 m.p.h. Rainbow global transports for commercial airlines, and the company's equally revolutionary entry in the personal aircraft field, the 4-place, all-metal, pusher-type Seabee amphibian. Republic's working force, which had dropped to a low of 3,700 in November, 1945, continued to grow until in November, 1946, it reached a level of 8,000 employees. This approximate level was maintained as the company entered 1947 with all production facilities applied to its diversified program.

Meanwhile Republic negotiated an agreement with the War Assets Administration to lease for 5 years, with option to buy, the Government owned aircraft plant and airport at Farmingdale. The agreement covered more than 30 buildings, with a floor area of approximately 1,400,000 sq. ft., and the 260 acre airport with paved runways and taxi strips. These facilities, with 14 company-owned buildings, provided Republic with a complete plant for its expanding postwar operations. As was prevalent throughout the aircraft industry, repeated shortages of materials and parts and prolonged delays in delivery of special dies and machine tooling, all the result of production tie-ups



REPUBLIC RC-2 RAINBOW



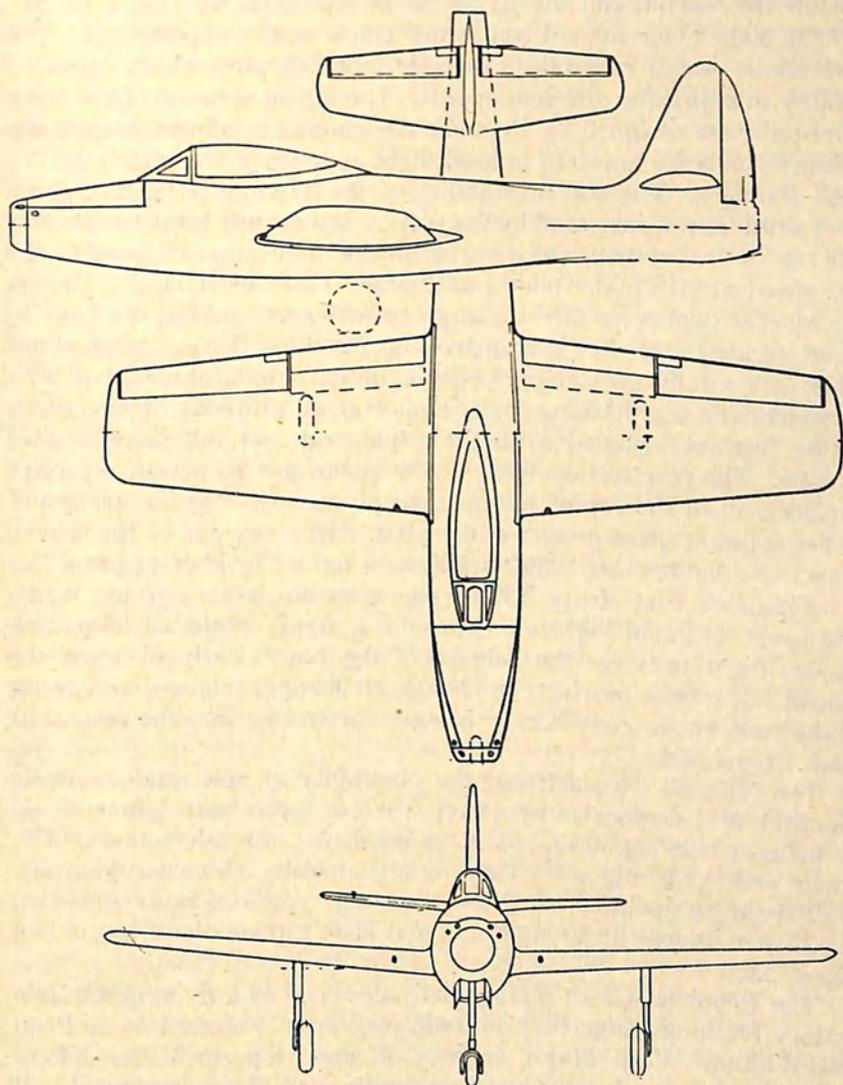
REPUBLIC ARMY P-84 THUNDERJET

in other industries, seriously retarded Republic in getting its program into assembly line production. As a result of this work carry-over and new orders, in February, 1947, Republic had a backlog of more than \$56,000,000 of work under firm contract and more than \$21,000,000 of additional business involved in airline options for additional Rainbows and distributor and dealer commitments for Seabee amphibians. Republic's Government contracts for military aircraft, including AAF orders for 500 of the new P-84 Thunderjet fighter planes, amounted to \$55,500,000.

The P-84 Thunderjet established itself as one of America's fastest airplanes. The first XP-84 had had its initial flight at Muroc Lake AAF testing base in California on February 28, 1946, and the second XP-84, completed in mid-August, had by mid-September set a new official American speed record, averaging 611 m.p.h. on 4 consecutive flights over the Muroc measured course. This same plane was unofficially clocked by official timers at 621 m.p.h., the highest speed thus far attained by any airplane in level flight. Increased orders for P-84 production subsequently were secured, and the jet fighters were in assembly line production at Republic by the beginning of 1947, with test flights being conducted from Republic's own field at Farmingdale.

The P-84 Thunderjet was powered by the General Electric TG-180 axial flow jet engine. The plane's service range was stated to be in excess of 1,000 mi. and its service ceiling above 40,000 ft. Its wing

span was 36 ft. 5 in., overall length 37 ft. 3 in. It was a midwing type of sleek, clean design, with retractable tricycle landing gear. The exterior surfaces were completely free from protruding equipment of any kind. Not only was it flush-riveted and specially treated for skin



REPUBLIC P-84 THUNDERJET

smoothness, but all radio antennae and armament were internally concealed so that even the guns were so mounted that no part of the muzzles show beyond the surface. By the location of the air scoop in the nose, the Thunderjet's fuselage became a giant tube, through which passed the air into the axial flow engine, located behind and below the cockpit, and the jet nozzle sweeping back and out the tail of the plane made for a direct straight flow of the expelled air. The jet nozzle was a controlled, variable exit tail pipe which provided ability to adjust for different speeds. The airfoil sections of the wing and tail were designed by Republic's engineers to almost exactly the same formula for low drag in level flight as those of Republic's XF-12 and Rainbow. The maneuverability of the Thunderjet at all speeds and altitudes was increased by use of an automatically adjusted booster aileron control system which varied in the application of force to the air speed at which the pilot was flying. Thus, even at the highest speeds, the pilot controlled his airplane with ease and did not have to exert unusual pressures in maneuvering the ship. It was equipped not only with a fully pressurized cockpit for extreme altitudes, but with automatic air conditioning for the pilot at all altitudes of operation. Other features included a pilot ejection seat and full-vision bubble canopy. The rear section was quickly removable to permit complete replacement of the engine in less than 50 minutes. Armor plate and bullet-resistant glass protected the pilot. Gross weight of the Thunderjet as a fighter was 12,881.5 lbs., as a fighter-bomber 14,911.5 lbs.

Republic's first Army XF-12 photo reconnaissance plane, which had made its initial flight on February 4, 1946, continued under extensive flight tests for the balance of the year. Early in 1947, the second XF-12 was nearing completion, all changes required as a result of the tests on the first XF-12 being incorporated into the second as work progressed.

The XF-12's demonstrated the possibility of new attainments in the field of 4-engine transport-type planes, even with conventional propeller-driven engines. The plane confirmed the calculation of Republic and AAF engineers that aerodynamically clean 4-engine aircraft could be designed to sustain cruising speeds of more than 400 m.p.h. over ranges up to 4,000 mi. and have top speeds of more than 460 m.p.h.

The Republic XF-12 was specially designed as a flying photo laboratory for long range high altitude missions. Powered by 4 Pratt and Whitney Wasp Major engines of 3,000 h.p. each, the XF-12 cruised at 400 m.p.h. and had top speeds well above 450 m.p.h. It measured 93 ft. 10 in. from nose to tail, had a span of 129 ft. 2 in., and

height, from ground to top of stabilizer, 28 ft. 4 in. The big plane carried a crew of 7 and was equipped with latest aerial cameras and flash bombs for night photography from altitudes up to 44,000 ft.

The XF-12 Army photo reconnaissance giant, which would have its commercial counterpart in the 46-passenger Republic Rainbow transport, gave an unofficial demonstration of speed capabilities on May 24, 1946. The first completed model of the XF-12 flew a routine flight at relatively low altitudes from Wright Field, Dayton, O., to the Republic plant at Farmingdale, L. I., a distance of 576 mi., in 1 hr. 21 min., an average speed of 426.6 m.p.h.

The commercial version, the Rainbow (RC-2), was designed as a fast 4-engine transport, carrying 46 passengers and crew of 7. Its top speed was stated above 450 m.p.h., and maximum range 4,100 mi. Normal gross load was 114,200 lbs. with crew, passengers, luggage and 5,500 gal. of gasoline; maximum gross 116,600 lbs. with 5,900 gals. The Rainbow was powered by 4 Pratt and Whitney Wasp Major engines of 3,500 h.p. each at 2,700 r.p.m. It utilized heated, compressed exhaust gases from reciprocating engines to obtain a jet thrust assist of approximately 200 h.p. per engine. The fuselage was 99 ft. 8 in. long; wing span 129 ft. 2 in. and overall height 31 ft. 4 in. The Rainbow could fly from New York to Paris in 9 hrs. or New York to Fairbanks, Alaska, in 8¼ hrs., under normal conditions. Especially designed for long range transcontinental, transoceanic, and global airline operations, the Rainbow's fully pressurized interior assured passengers and crew of traveling in comfort at altitudes unaffected by weather. Although speed, altitude and range were the Rainbow's dominant characteristics, it possessed unique performance capabilities. With only 3 engines operating, the Rainbow could complete a takeoff and climb to and maintain an altitude of 25,000 ft. It could maintain safe operating altitudes on only 2 engines, and with normal load could climb on 2 engines up to altitudes of 5,000 ft. The Rainbow was an aerodynamic counterpart of the XF-12, even though it required a 90 per cent new engineering design to adapt its potentialities to airline transport purposes. Work on the Rainbow, involving thousands of perfections and refinements, continued throughout 1946 and the beginning of 1947 saw the first of the commercial Rainbows under assembly, although initial deliveries to the airlines were not scheduled until the latter end of the year. Republic had firm orders from American Airlines for 20 and from Pan American World Airways for 6 Rainbows, designed for cruising speeds ranging from approximately 400 m.p.h. over long range routes up to 4,000 miles and 430 m.p.h. over relatively shorter domestic routes. Pan American also held de-

livery options for 12 additional Rainbows. Republic's backlog of Rainbow production on firm order at the beginning of 1947 was \$26,350,000, with other airline contracts under negotiation.

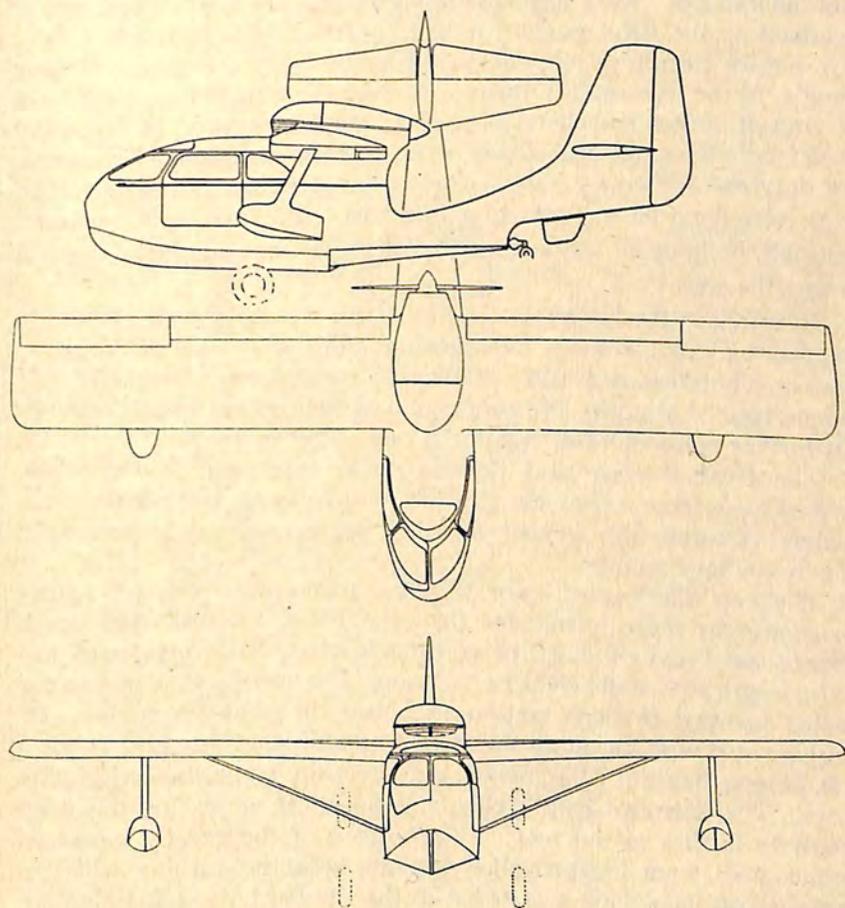
Republic's Seabee amphibian, the company's first venture in the personal plane field, proved popular throughout the United States and Canada and more than a score of foreign countries. With distributor and dealer agreements covering more than 5,000 Seabees, due to repeated production delays, the company at the end of 1946, had not been quite able to average one plane delivery to each of its more than 400 distributors and dealers. The full list of demonstrators was provided during the early weeks of 1947, however, and with the receipt and placement of long awaited permanent tooling, Seabee production was scheduled to level off at 24 planes a day in the Spring of 1947.

The Republic Seabee (RC-3) was a 4-place all-metal amphibian personal or family plane with exceptional roominess, sturdiness and wide range of practical utility for business or pleasure. It had a high speed of 120 m.p.h. and a cruising speed of 103 m.p.h. with range of 560 mi. on 75 gal. of fuel. Powered by a Franklin Aircooled 215 h.p. engine, the Seabee carried 4 adults and baggage in automobile-like comfort, and operated with equal ease off either land or water. Its wing span was 37 ft. 8 in. and overall length 27 ft. 10 $\frac{3}{4}$  in. Standard equipment included 2-way radio, controllable-reversible pitch Hartzell propeller, electric starter, hydraulically operated flaps, dual wheel controls and rudder pedals, retractable landing gear, full component of cross country sensitive flight instruments and standard engine instruments. It featured low, wide doors on both sides and a roomy nose door in the bow for fishing, anchoring or docking. Rearward mounted engine and pusher type propeller accentuated exceptional visibility which was provided pilot and passengers by 7 large lucite windows, also constituting an important safety factor. The takeoff run was 800 ft. from land and 1,000 ft. from water; landing run 400 ft. on land and 700 ft. on water. Simplified design features increased the plane's ruggedness, safety, durability and usefulness. Republic stated that the simplified design enabled it to produce Seabees at a retail price of \$6,000.

In order to assure a source of engines for its Seabees, and carry on in the light plane engine field the simplified design and low cost production policies it had applied to the Seabee, Republic acquired the Aircooled Motors Corporation plant at Syracuse, N. Y., producers of Franklin aircooled engines. At the beginning of 1947 Aircooled Motors had a backlog of more than \$8,000,000 in engine orders of which slightly over \$4,000,000 were Republic orders for Seabee

engines and the balance of \$4,184,000 were contracts for engines for other airplane companies.

The Ryan Aeronautical Company, San Diego, Calif., continued to play an important part in the development and perfection of aircraft and aeronautical equipment of scientific design. Activities of Ryan's airplane division during 1946 consisted primarily of development engineering and manufacturing on contracts with the Army and Navy for new and advanced type combat airplanes and guided missiles. Two new flying laboratory jet planes, both incorporating the jet-plus-propeller combination pioneered by the Ryan Fireball, reached the flight



REPUBLIC SEABEE AMPHIBIAN

stage and underwent extensive research testing for the Navy. The XF2R-1 was the Navy's first plane to be powered by a gas turbine engine both driving the four-blade steel propeller and boosting with jet propulsion. It also had a straight jet engine in the aft fuselage to supplement power of the propeller in giving peak performance for terrific bursts of speed and phenomenal climb.

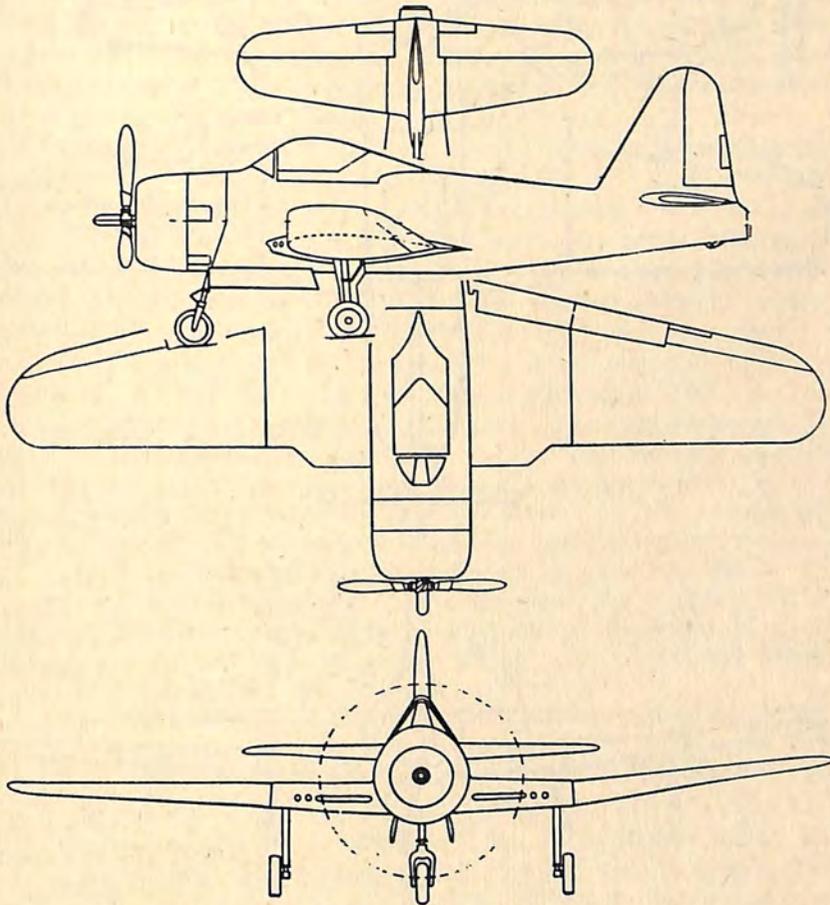
A larger and faster Fireball-type fighter was being developed under Navy contract. Tooling for the experimental manufacture of this most formidable of Ryan fighters was completed and construction of first models was under way early in 1947. Other more advanced projects were under construction in the company's experimental shops and laboratories. Ryan also was doing modification work and major overhaul on the FR-1 model Fireball fighters, which had seen extensive service since they were delivered to the Navy during the closing months of the war against Japan. Modifications included installation of aircraft rocket launchers and other items necessary to place the planes in fully operational service prior to their assignment to regular sea duty as the Navy's VF-1E carrier-based fighter squadron. The work was done on a production line basis, utilizing the large final assembly building in which the Fireballs were in volume production during the war.

Research in the helicopter field by Ryan was on a scale limited to engineering and laboratory experimental work on certain of the problems in connection with rotor blades and control mechanisms for this unique type of aircraft. No production of helicopters was scheduled, but further research work was to be carried on in 1947.

The Ryan Aeronautical Company was interested in the whole field of sonic and supersonic aircraft, both piloted and pilotless, including research into guided missiles, jet propulsion and rockets, largely military secrets.

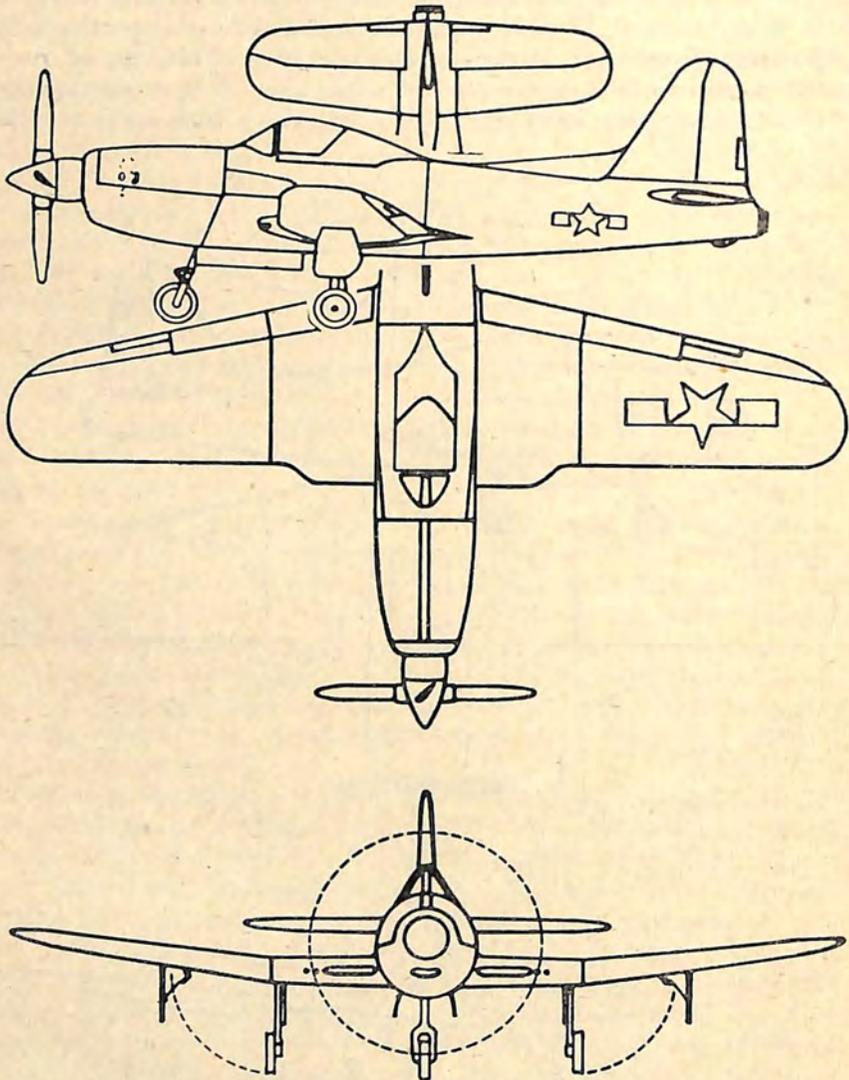
The new shark-nose Ryan XF2R-1 turbo-prop plus jet fighter plane was far more formidable than the FR-1 Fireball, with much greater speed and climb in the 500 m.p.h. class. Its wingspread was 40 ft., length 36 ft. and height 12 ft. 4½ in. The new Fireball had an extended forward fuselage section to house the prop-jet engine. Its long, pointed nose increased the plane's overall length to 36 ft., almost 4 ft. longer than the FR-1 model, and gave the plane its sleek, bullet shape. The extended length also had the effect of placing the wing relatively farther to the rear. To take care of the greatly increased torque, both from the propeller and the spinning turbine wheel, a larger dorsal fin-section was added to the standard FR-1 fuselage-tail structure. The propeller-plus-jet engine combination, as first used in

the Ryan FR-1 Fireball, was demonstrated as highly effective in giving peak performance over a wide range of speeds and altitudes. Although all-jet planes lacked flexibility at low speeds, particularly during takeoff, because of the slow acceleration, that was overcome by the propeller-pulled, jet-pushed combination power arrangement of both Ryan models. The short takeoff characteristic was particularly important, of course, in aircraft carrier operation. This type of composite power resulted in an excellent combination of desirable fighter plane characteristics, including high speed over a wide range of alti-



RYAN NAVY FR-1 FIREBALL

tudes, making both Fireballs all-altitude, rather than just critical altitude high speed craft. In addition, the Ryan composite-powered planes had an extremely high sustained rate of climb at all altitude, short takeoff, extreme maneuverability, slow landing speed, good combat

RYAN NAVY XF<sub>2</sub>R-1

radius and heavy firepower—each with its relative degree of importance to the others.

The forward engine in the dark shark Fireball research plane was a General Electric TG-100 prop-jet which provided two-way harnessing of gas turbine power to drive a propeller and at the same time boost with jet thrust. About three-fourths of the available power was absorbed by the propeller, the remaining one-fourth being supplied by thrust of the jet exhaust stream which nozzled into troughs on either side of the fuselage, just below the cockpit. The engine in the aft fuselage of the XF2R-1 was a General Electric I-16, and was the same thermal jet unit as installed in the earlier FR-1 model. Total power of the two jet engines of the XF2R-1 was considerably in excess of that of the conventional and jet engine combination of the FR-1. That increase in available power was obtained with a proportionately small increase in gross weight.

Schweizer Aircraft Corporation, Elmira, N. Y., was in production on two new model gliders, the SGU 1-19 and SGU 2-22, and at the same time was doing contract work on rudders and ailerons for the Fairchild Packet and development work on control surfaces for the Piper PA-6 Skysedan. The SGU 1-19, a single-place utility glider, was flown cross country 30 miles, reached altitudes of more than 5,000 ft. above takeoff point, and soared for more than 5 hours at a time. Fully approved by the CAA, the SGU 1-19 had an overall length of 20 ft. 7½ in. and a wing span of 36 ft. 8 in. The wing area was 170 sq. ft., weight empty, 320 lbs. max.; gross weight loaded, 550 lbs., normal wing loading, 3.23 lbs. per sq. ft. The two-spar wing was strut-braced and had wooden ribs. The leading edge was covered with aluminum alloy, and the entire wing was fabric covered. The fuselage was welded of chromemoly steel tubing, and was fabric covered. Horizontal tail surfaces were of steel tube construction, fabric covered. The SGU 1-19 placard speeds were level flight high speed, 75 m.p.h., airplane tow speed 75 m.p.h., auto-winch tow speed 60 m.p.h., stalling speed (landing), 28 m.p.h., gliding ratio, 17:1; and sinking speed, 3 ft. per second.

The SGU 2-22 2-place utility sailplane was being used extensively in glider flight schools. The ship had a low rate of sink, a flat glide angle and was highly spin-resistant. It was of all-metal structure, had an overall length of 25 ft. ½ in., and a wing span of 43 ft. The wing area was 210 sq. ft., empty weight 450 lbs., gross weight loaded, 830 lbs., wing loading, solo, 3.05 lbs.; dual, 3.95 lbs., placard speeds, level flight high speed, 80 m.p.h.; airplane tow, 89 m.p.h.; auto-winch tow,

66 m.p.h.; stalling speed (solo), 27 m.p.h.; (dual), 30 m.p.h.; gliding ratio, 18:1; sinking speed (solo), 2.8 ft. per sec.; (dual), 3 ft. per second.

Schweizer also was completing the SGS 1-21 glider, planning for production in 1947. It was to carry several hundred pounds of water ballast to give a cruising speed of 80 m.p.h. The water would be jettisoned at will to let the pilot take advantage of lighter soaring conditions. The glider was to have a span of 51 ft.

Sikorsky Aircraft, division of United Aircraft Corporation, Bridgeport, Conn., put its first postwar helicopter, the four-place S-51, into production in 1946, and unveiled a new all-metal blade, two-passenger helicopter—the S-52. Test flights on the S-51 began in March. Approved Type Certificate was awarded by the CAA in the same month. While production on the S-51 was gaining momentum, helicopter air mail pickup trials using the Army-Sikorsky R-5, the prototype of the S-51, were successfully conducted in the Los Angeles and Chicago areas. In Chicago, the S-51 also flew mail from the Municipal Airport to the roofs of the new Post Office on Van Buren Street and the Merchandise Mart. On August 19, Sikorsky in Bridgeport made the world's first delivery of a commercial helicopter to Helicopter Air Transport, Inc., Camden, N. J. Two other S-51's went to the same operator in September. H.A.T., operating from Central Airport, Camden, found immediate work for its S-51's in aerial photography, package delivery, passenger travel from Philadelphia to the Garden State race track, harbor surveys and other pioneering services. In September, it flew an S-51 into Fenway Park baseball stadium to deliver polo coats to 40 members of the Boston Red Sox baseball squad. At the turn of the year in connection with its 100th anniversary, a Hartford department store used 3 S-51's to deliver packages in 66 Connecticut towns, covering every section of the State. The longest of the 3 routes with 28 stops was finished only 3 minutes behind schedule. The other 2 were on time to the dot.

Greyhound Skyways, another pioneer in helicopter transportation took delivery of two S-51's in September, 1946. These aircraft were put into immediate use to test the possibilities of an integrated air and highway passenger system which Greyhound had under study for a number of years. First demonstration of the facility with which passengers could be exchanged between helicopters and highway bases was made on the super highway near Willow Run, Mich. Later, one of the Greyhound helicopters landed in the stadium in Ann Arbor at the Michigan-Army game to pick up negatives which were flown downtown and lowered to the roof of the Detroit News building.

Late in the year, United Airlines became the first airline operator to purchase a helicopter. It ordered an S-51 for Spring delivery.

The Navy took delivery of 4 standard S-51's in the Fall and immediately assigned them to duty with its Antarctic expedition then getting under way. An outstanding demonstration of the dependability of the Sikorsky design was given by Coast Guard helicopters, an R-6 and an R-4 which were dismantled, flown to Gander, Newfoundland, reassembled and used to rescue 18 survivors of an accident who could have been saved by no other means. Early in 1947, Sikorsky was represented in the New York area airmail pickup and delivery tests by 7 S-51's. Helicopter Air Transport assigned 3 to the Long Island route, Greyhound used two on the New Jersey section and the Sikorsky factory supplied two for the important shuttle runs between LaGuardia Field, N. Y. Post Office and Newark Airport. The first airmail flown from LaGuardia Field to the East 23rd Street Skyport was in an S-51, with Sikorsky Chief Pilot D. D. Viner at the controls and Second Assistant Postmaster General Gael Sullivan as passenger.



SIKORSKY 4-PLACE S-51 HELICOPTER

During the five-day trial, all schedules were flown on time and without incident.

A new Sikorsky model, the two-place S-52, was unveiled in November, the first production helicopter with all-metal blades and a useful load of 650 lbs. in a gross design weight of 1,750 lbs. All-metal blades were specified for the S-52 after a year's flight test of the new blade construction, during which eminently satisfactory performance was obtained. At the beginning of 1947, Sikorsky Aircraft had a considerable backlog of commercial and military orders.

Chance Vought Aircraft Division of United Aircraft Corporation, Stratford, Conn., announced initial flight tests of its first jet-propelled fighter, development of a revolutionary new structural material, a flying wing aircraft of completely radical design, continued production of the F4U-4 and F4U-4B Corsair fighters for the Navy under a peacetime schedule, and acceleration of an extensive program of research and development as highlights of operations in 1946. Established as one of the major suppliers of warplanes for the U. S. Navy, Chance Vought, as the 12 months ended, moved into its 30th year as a designer and builder of military aircraft. This three-decade history, studded with dependable aircraft, stretched back to 1917 when the first Vought airplane, the VE-7 trainer, was built at Long Island City, N. Y. The company was moved to East Hartford in 1930, and transferred to its present site in 1939. During 1946, research and development took on positions of vastly increased importance at Chance Vought. The engineering department, working at full strength, was engaged simultaneously in improving its production aircraft, developing new types to take their place and in the invention of still better aircraft for the future. Much of this experimental work, because it was being done under Navy contract, was secret.

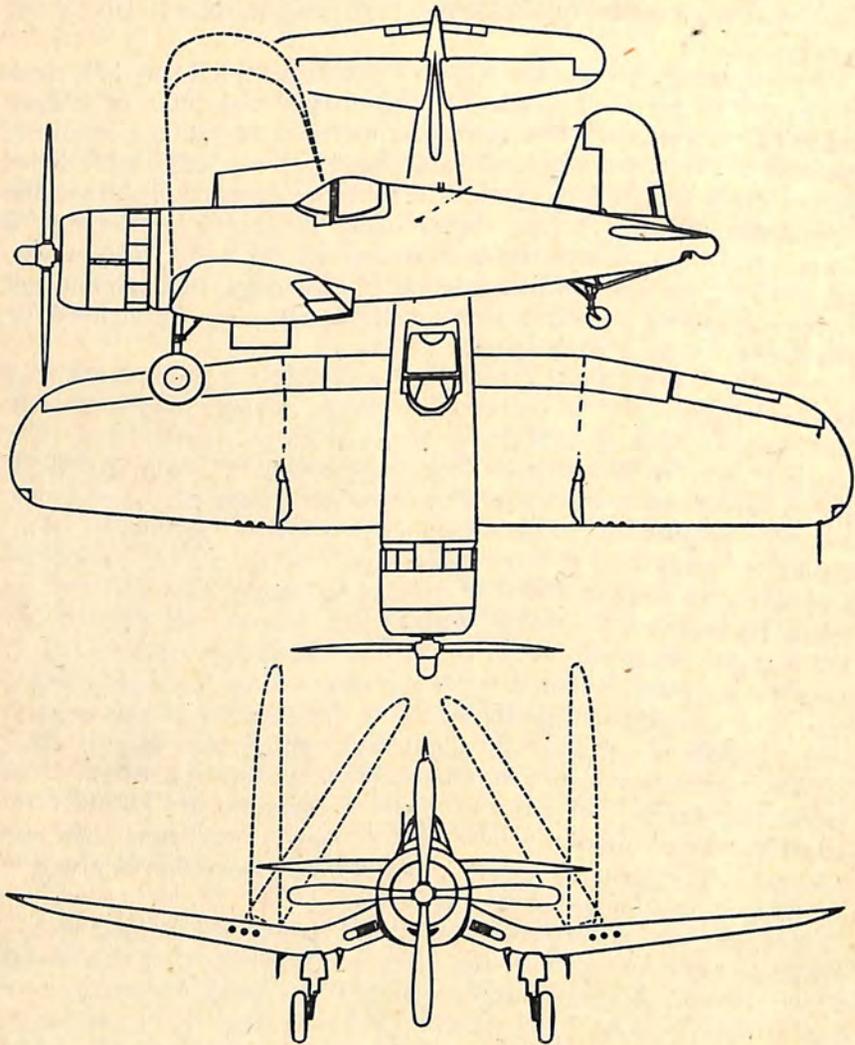
Flight tests of Chance Vought's first jet airplane, the XF6U-1 Pirate, started October 2, 1946, at Muroc Dry Lake, Calif. The new aircraft, an experimental Navy fighter, offered a startling contrast to those who, throughout the war years, had associated Chance Vought with the distinctive outline of the inverted gull-winged Corsair. The XF6U-1 was small and light. Its low mid-wings, extending straight from a slim fuselage, measured a scant 30 ft. 2 in. from tip to tip—almost 12 ft. less than the Corsair's 42 ft. span. Built into that comparatively small package was high performance. There was no announcement of the Pirate's top speed, but the Navy described the plane as being in the "well over 500 miles-an-hour class." The company believed, however, that the XF6U-1, with exceptionally clean lines and a powerful jet engine of newest design, would give carrier-

based aviation a fighter fully capable of matching the best in land-based fighters.

Contributing much to the XF6U-1's small size, light weight, sleek finish and simple design, was the fact that it was built of Chance Vought's revolutionary new structural material, Metalite, a sandwich material of aluminum alloy and balsa wood. It was remarkably light, yet possessed tremendous strength beneath an exterior of mirror-like smoothness. For more than a year many stabilizers for the F4U-4 Corsair had been constructed of Metalite. In the XF6U-1, however, the material was used in construction of the wings, fuselage and tail surfaces, marking Metalite's first practical application throughout the primary structure of an airplane.

Metalite was a logical choice for the XF6U-1 because it afforded the new fighter several advantages which, Vought engineers felt, could not be realized with conventional all-metal construction. For example, skin wrinkling and drag were becoming major problems when conventionally-built airplanes entered the subsonic speed range. Metalite, because of its great inherent rigidity, eliminated skin-wrinkling. Drag was reduced considerably in the XF6U-1, because large Metalite sections could be molded as single units, thereby reducing the number of external joints. But, beyond this was the fact that Metalite provided, for the first time, a surface completely free of even the slightest indentation or waviness—a surface, actually, of plate-glass smoothness, ideally suited to maintenance of the uninterrupted airflow so necessary for flight at extremely high speeds. And, contributing further to this surface smoothness was application of an outstanding finish. Also, through use of Metalite, the XF6U-1 required far fewer internal reinforcements such as stiffeners, ribs and bulkheads. The saving of weight which resulted was reflected in larger fuel capacity and increased combat range.

Metalite was a metal-faced sandwich employing a light-weight core to separate and stabilize the faces, and it consisted of thin sheets of high strength aluminum alloy, separated by a thick, low density core of balsa wood bonded firmly together to form a single light, rigid unit. The grain direction of the balsa core was perpendicular to the metal faces. A core material of greater density than balsa was used in spots where greater strength was desired. The core was relatively thick in comparison to the face plates. The material was constructed by bonding the core and faces together under moderate heat and pressure, all the bonds being ordinarily made in one operation. The bonding operation was done with the parts or assembly in a mold of the desired shape. For flat work, the parts were normally put together on a



VOUGHT F4U-4 CORSAIR

bench and the whole assembly placed in a mold afterward. For curved work, both single and double, several different forming methods were used. Where only gentle curves were required, the work was assembled flat on a bench and the entire assembly placed in a mold and forced

into the desired shape by the application of pressure. Because of the thickness gained by the light core, the bending stiffness of a completed Metalite panel was many times greater than that of a simple sheet of metal of the same weight. Metalite's hard metal faces could not be easily damaged and typical panels could be walked on without injury to the material. Several years of work on methods and techniques of Metalite fabrication had resulted in determination of practical production processes. In addition, both theoretical and experimental studies had been made on design standards for resistance of the metal faces to failure by local wrinkling, resistance of the core to failure by transverse shear loading, and resistance of the Metalite unit to failure by breakage of the bond between the core and metal faces. Investigation had also been made of Metalite's fatigue strength, its resistance to large variations in temperature, and its resistance to moisture and weathering.

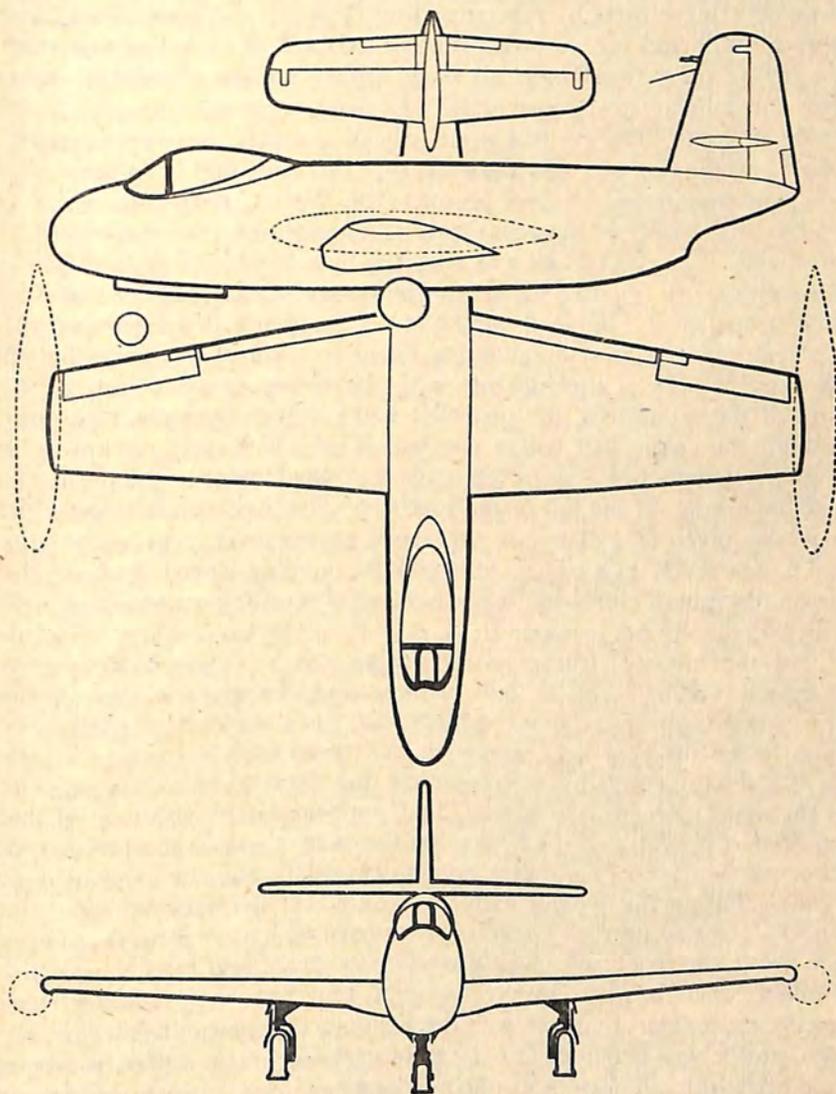
At rest on its tricycle landing gear, the XF6U-1 Pirate appeared to hug the ground, its main landing gear being extremely short with the wheels close to the undersurfaces of the wings. The cockpit, with its clear-vision canopy, was situated well forward, providing the pilot with the best possible visibility. The cockpit interior had many features for increasing safety, efficiency and comfort of the pilot. The Pirate was characterized by a high vertical stabilizer and rudder. The horizontal tail surfaces were installed substantially above the fuselage level so that the entire tail assembly was up out of the wing shock area at high speeds. A Westinghouse jet unit of new design powered the new airplane and was compactly installed in the lower aft portion of the fuselage with the exhaust being ejected out of the center line of the airplane below the tail cone. Air intake scoops were located in the leading edge of the wing on either side of the fuselage. Droppable wing-tip fuel tanks were equipped with supplemental navigation lights. Considerable attention was given to making the engine, armament and other equipment as accessible as possible to speed up maintenance work. For instance, the engine could be removed completely and replaced by another in only a quarter of an hour. This was accomplished without splitting the fuselage or removing the tail from the airplane. The Pirate was built for either carrier or land operation, taking off from a carrier flight deck with the aid of a catapult, and from a landing field with normal jet power. It offered significant evidence of the Navy's shift to jet propulsion in the fighter field.

Production activities at Chance Vought during 1946 centered first on the F4U-4 Corsair (six 50-caliber machine guns), and later on the F4U-4B (four 20-mm. cannon). The Corsair, the design of which

dated back to 1938, still ranked as a Navy first-line fighter and fighter-bomber. It had been possible, throughout the years,\*to effect steady improvements in its performance, combat effectiveness and all-around utility without once altering its basic design. The ease with which it was adapted to varying tactics throughout the war, serving as fighter or bomber either from shore or carrier bases, made it one of the Navy's most formidable warplanes. In 1946, F4U-4 Corsairs were standard equipment aboard U. S. carriers, including the Roosevelt and Midway, the world's largest. Serving as fighters and fighter-bombers, their armament included various combinations of machine guns, cannon, rockets and bombs. Early in 1947, work was progressing on an even faster, more powerful version of this warplane.

Chance Vought Aircraft's radically designed flying wing was developed as a Navy fighter, and designated the XF5U-1. A low-powered, full-scale flying model, was named the V-173. Preliminary flight tests of the V-173 began in 1942, the craft first being flown in that year by Vought experimental test pilot Boone T. Guyton. The basic wing plan of those aircraft was that of a circle, modified only by moving the wing tips forward. The XF5U-1 was expected to maintain flight at speeds ranging from 40 to 425 miles an hour, and, with the addition of water injection, from 20 to 460. It was also estimated that use of a gas turbine would make possible a speed range from 0 (hovering flight), to over 500 miles an hour. The XF5U-1 was developed from a type originally invented in 1933 by Charles H. Zimmerman, a consulting engineer at Vought. Its low aspect ratio wing served not only as a lifting surface but also as a streamline body to house the power plants, fuel tanks and armament. The most unusual feature was the unconventional location of two large-diameter four-blade propellers mounted on nacelles extending forward from each wing tip. A nacelle for the pilot projected from the leading edge of the center of the wing. The pilot's cockpit and accommodations were conventional, but considerable study was made of the prone position for the pilot, to relieve strain and prevent blacking out in violent, high speed maneuvers. Horizontal and vertical stabilizing and control surfaces were attached to the aft portion of the wing to provide functions normally performed by the tail surfaces and ailerons on conventional aircraft. The vertical fin and rudder surfaces were similar to and performed the same functions as those of a conventional airplane. Twin fins and rudders were used to keep them in the slipstream at all times, and thus retain their effectiveness at low speeds. The landing gear was similar to that of conventional aircraft, being designed to retract into the airfoil in flight.

Two Pratt & Whitney R-2000-2 engines mounted within the wing powered the XF5U-1, driving the propellers through a system of gearing and shafting. The propeller blades were made of compressed, impregnated wood attached to steel shanks, and the control mechanism



VOUGHT NAVY XF6U-1

of their hubs was similar to that employed to regulate the pitch of the latest type conventional airplane propellers. The propellers turned at a comparatively low r.p.m. and were free to flap fore and aft, somewhat in the manner of the rotor blades of a helicopter.

The Waco Aircraft Company, Troy, Ohio, in 1946 devoted its manufacturing efforts to subcontracting of parts and components for other aircraft and for its own prewar models, and tooled and started production on a two-wheel, all metal utility trailer of welded sheet steel and tubular steel construction; likewise, as a subcontract article for its designer. During this period the Waco plant was reconverted for line production of a new personal type airplane, and in October the Company announced its new product, the Waco Aristocraft, a novel 4-place, high wing cabin monoplane with simplified two-control characteristics. The Aristocraft was powered by a 215 h.p. Franklin 6AL-500 series 6-cyl. opposed aircooled engine and a Hartzell controllable pitch propeller as standard equipment. The plane possessed several new features, the most outstanding being location of the propeller at the extreme rear of the fuselage with the power plant mounted forward of the cabin area, the propeller being driven by a shaft passing through the cabin well below the seat level and extending upwards angularly from a point aft of the luggage compartment to the propeller shaft mounting on the tail of the fuselage. The Aristocraft's performance was given as 154 m.p.h. top speed at sea level, cruising at 135 m.p.h. sea level, 152 m.p.h. at 5,000 ft., landing speed 57.5 m.p.h. maximum rate of climb 950 ft per min. service ceiling 17,500 ft., range with 60 gal. 657 mi. at 5,000 ft.

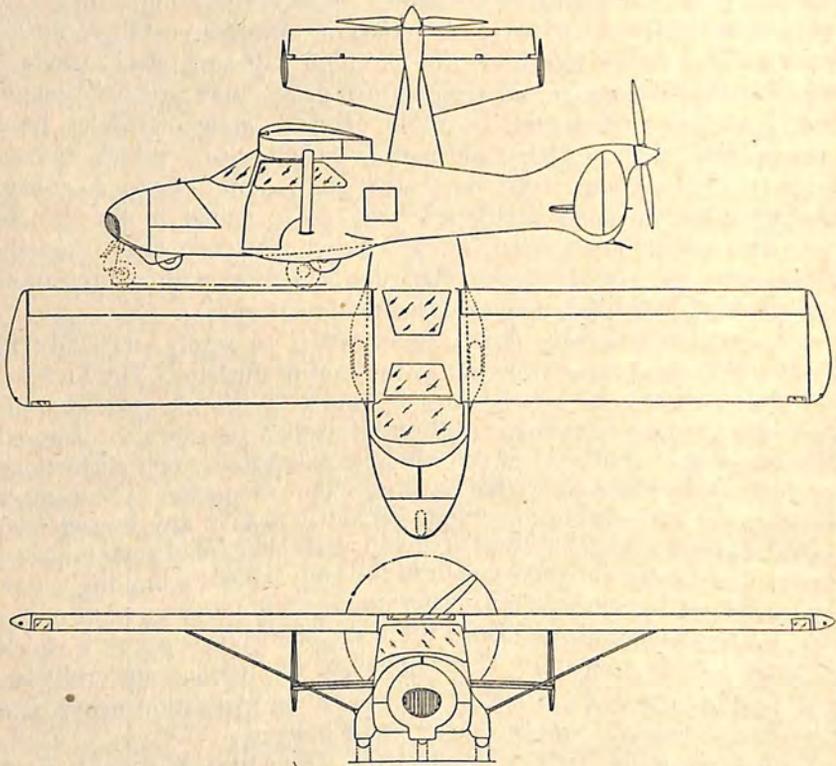
Another unusual feature of the design was a tricycle landing gear on which landings without hull damage could be made in gear-up or gear-down positions. To accomplish this, the tires were partially exposed when the gear was retracted. All three wheels retracted rearward and were cradled in such manner that the loads were transferred to the main fuselage structure. The front wheel thus was held in the true line of travel, and the brakes on the rear wheels could be used in a normal manner. There were no rudder pedals, and the airplane was maneuvered on the ground with the nose wheel steered by the control wheel. Unusual upward visibility was provided by two large windows, one above the front and one above the rear seat; and for hot weather comfort when upward vision was not required, each window was readily curtained. Comfort was the keynote for the cabin interior design, and it was provided for the pilot and copilot as well as the rear seat occupant, all four seats being deep-cushioned and form-fitting. Two broad automobile type doors were provided, and the low cabin

was entered in two steps, each less than 20 in. in height. There was no disturbance from propeller blast. The comfortable seat areas, front and rear, were full 48 in. wide; front seat backs folded forward independently, making it possible for all seat occupants to rotate their positions in flight. Rear seat sides had indented arm rests, increasing the usable width of the seat to lounging proportions. A luggage compartment of 16 cu. ft. capacity was loaded through a side fuselage door at a convenient low level. Luggage was instantly accessible in flight over the top of the back seat. The location of the propeller in the rear materially reduced the cabin noise level, but very complete sound-proofing was used throughout the cabin area and behind it, and the engine was muffled in an all-out effort to provide extreme quiet for the occupants. At its quoted domestic flyaway price of \$9,980, the Aristocraft was equipped for instrument flight certification, with 2-way radio with loudspeaker, airspeed indicator, compass, sensitive altimeter, bank and turn indicator, rate of climb indicator, clock, tachometer, oil pressure gauge, oil temperature gauge, fuel pressure gauge, fuel level gauge, ammeter, manifold pressure gauge, cylinder head temperature gauge, ignition and master switch with key lock, instrument spot lights, dome light, navigation and landing lights. Adequate heating and controlled ventilation were incorporated in the design. The instrument board, likewise, was fitted with two large capacity glove and map compartments. The cabin was fitted with ash receivers and the luggage compartment carried tie down ropes.

The Waco company gave consideration to safety, not only in flight and ground maneuvers but in the case of mishaps. The forward position of the engine offered considerable protection in ground collision; the fuselage of tubular steel structure had its tubes so disposed that in event of collisions of considerable magnitude, their distortions would be least likely to strike or injure the occupants. The control wheels were of form-fitting design, intended to take any impact load over the greatest possible chest area and again, in case of such impacts, the resultant downward movement of the body caused a braking action on the control wheel shaft, permitting the shaft to move forward under a friction load tending to absorb the body energy and act as a shock absorber for the occupant. That portion of the fuselage generally aft of the cabin area was fabric-covered, excluding inspection panels and the rear cowling over the propeller shaft housing.

Wings and empennage were all-metal. The wings were single-strut braced, and the empennage was cantilever. It was of the twin tail type, and its area made it almost impossible for personnel to walk into the revolving propeller disc except directly from the rear where they

would have ample warning from the propeller blast. All window and windshield panels were of acrylic resin except the two door panels which were of safety glass. The forward door panel moved inward and back to provide an open area when required. Fuel tank capacity was 60 U. S. gal. carried in two rubber cell-type tanks, nylon reinforced, one tank located in each wing. No fuel was carried within the fuselage structure, and all fuel valves, primers, and gauges were remotely controlled and well clear of the cabin area. The Firestone design landing gear offered unusually long shock travel,  $9\frac{1}{2}$  in. on the rear wheels and 8 in. on the nose wheel. Coupled with the long wheelbase of 100 in., the airplane taxied or ran for takeoff or landing with extreme comfort and a minimum of "porpoising" on very rough fields.



WACO ARISTOCRAFT

## CHAPTER XI

### AIRCRAFT POWERPLANTS

Improvements in Reciprocating Engines for Giant Transports and Bombers—Jet Engines for Fighters—Progress in Gas Turbine, Turbo-jet and Ram-jet Powerplants—New Propellers.

THE powerplants that sent American aircraft through the skies higher and faster than ever before, and with steadily increasing loads, were becoming as varied as the planes they powered. The old line companies that had provided the reciprocating engines to carry the air forces to victory in the war still were supplying nearly all the power for the machines of the air forces, the airlines and private owners. Yet many of the military planes had jet propulsion. A majority of the engine builders, however, were working on some form of power outside the old field which long had been monopolized by the reciprocating engine. It was not a thing of the past, by any means. The huge transports and bombers still depended on it for power, and so did the personal plane. But the manufacturers were hard at work on jet propulsion and rockets. They also were participating in the program to develop atomic energy for aircraft of the future.

Aircooled Motors, Syracuse, N. Y., was engaged in production of Franklin aircooled engines for personal planes. They were of the horizontally-opposed type. Three basic models were in production, ranging from 75 to 225 h.p. The 4-cyl. 225 cu. in. Franklin had a maximum rating of 100 h.p. A 6-cyl. model with 335 cu. in. displacement had a maximum rating of 165 h.p. The 6-cyl. 500 cu. in. Franklin had a maximum rating of 225 h.p. Aircooled Motors also produced a line of vertical engines for helicopters. Those engines operated with vertical crankshaft, and some models were supplied as a packaged power plant with a built-in cooling system. The vertical engines were in the 170 h.p. range, developing rated power at 3,000 r.p.m.

Allison Division of General Motors Corporation, Indianapolis, Ind., during 1946 produced two types of turbo jet aircraft engines and the V-1710 liquid-cooled reciprocating engine. It manufactured all the J33 jet engines for the Lockheed P-80 Shooting Star and late in 1946 completed transfer from Chevrolet of the contract and facili-

ties to build the J35 axial flow jet engine which powered the Republic P-84 Thunderjet. The V-1710 engine production was directed to North American for the new P-82 Twin Mustang. In the meantime a development program went rapidly forward on new turbine engines under military contract. However, Allison's most valued contribution to the field of aircraft power lay in the accelerated development that it provided for the J33 engine. Originally designed by the General Electric Company, the J33 (I-40) became an exclusive Allison project shortly after the end of the war when all engineering, as well as production, responsibility for the engine was assigned to Allison. In the period of Allison responsibility more than 7,000 design changes were conceived, and substantial quantities were manufactured. Principal development lay in the endurance life of the engine, which in slightly more than a year was increased five-fold. Originally, and at the time when experience in jet engines was severely limited, it was difficult to run jet engines 15 hours without varying failures. During 1946, tests of 100 hours were common, and Allison early in 1947 was preparing to run an engine through a 150 hour type test, maintaining the same endurance standards as those required for reciprocating engines.

Allison also made progress toward increasing thrust power of the J33, and at the same time improved its economy.

During 1947 Allison was to place in production a new model J33 which, with the use of water injection at takeoff, would reduce takeoff distance some 20 per cent. This was to be an important contribution to the economy of the engine, because the inherent low efficiencies of a jet engine at takeoff consumed an inordinately high proportion of fuel in the tanks. Currently rated at 3,825 lbs. static thrust at 11,500 r.p.m., the J33 engine produced approximately 6,000 h.p. at 600 m.p.h. New models scheduled for production in 1947 promised to advance those ratings considerably.

The Allison V-1710 engines produced for the P-82 Twin Mustang were identified as the G6 R & L. Basically similar to the 70,000 V-1710 engines which powered World War II fighters, the G6 had a 6.0:1 compression ratio, 2.36:1 reduction gear ratio and two-stage supercharger. With a 1,600 h.p. takeoff rating at 3,200 r.p.m., it produced 1,250 h.p. at 30,000 ft. Other Allison developments included purchase of the RFC-owned aluminum foundry at Bedford, Ind., which supplied Allison cylinder head castings during the war. Reconverted to a general purpose foundry, it produced castings for Allison engines as well as for outside general customers. In addition, Allison negotiated a new lease with the RFC on a 2,000,000 sq. ft. plant

where all Allison engine production was concentrated. Another Allison plant, wholly owned by General Motors, was devoted to commercial production of non-aircraft items. Bearings production also continued in a plant devoted to bearings engineering and development. A number of other aircraft engine manufacturers continued to rely on this source for bearings.

Beech Aircraft Corporation, Wichita, Kans., was in production on the Beech controllable propeller, which was used on the new Beech Bonanza personal plane and the models of other manufacturers. During 1946, an extensive licensing program on the Beech controllable propeller was in effect, and it resulted in the granting of many Approved Type Certificates for installation on airplanes of the personal type manufactured by other companies. Several light airplane manufacturers offered the Beech propeller as optional equipment. Further licensing developments were to make these propellers available as standard or optional for additional light airplanes. Originally the Beech propeller was adaptable only to engines having a standard SAE O taper shaft, a standard SAE No. 10 shaft, and a standard SAE No. 20 shaft. Later developments made the propeller adaptable to engines having Nos. 1, 2, and 3 flange type crankshafts along with a variation of different types of controls which made the propeller adaptable to almost every aircraft-engine combination. Current production propellers were manufactured for engines ranging from 65 to 250 horsepower.

Curtiss-Wright Corporation Propeller Division, Caldwell, N. J., was producing high-performance propellers for both military and commercial aircraft. Curtiss propellers continued to play a dominant role in military aircraft, being specified exclusively for the 4 and 6-engine bombers and transports in production for the Army and Navy. Among the military aircraft on which Curtiss propellers were standard equipment were the: Consolidated Vultee B-36, Boeing B-50, the Douglas C-74, the Boeing C-97 cargo transport, Northrop F-15A Reporter, the Martin AM-1 Mauler, the Curtiss SC-2 Seahawk, the Martin JRM-1 Mars, the Martin PBM-5A Mariner, and the Lockheed XR60-1 Constitution. For the Consolidated Vultee B-36, Curtiss-Wright produced the world's largest propeller—19 feet in diameter—completing a development project undertaken 3 years earlier at a cost of \$3,500,000. Like all Curtiss propellers, the huge three blade hollow steel model for the B-36 incorporated reversing and automatic synchronization. It also included provision for a new feature—de-icing by passing heated air through its hollow steel blades.

For the first time many of the exclusive features developed by Curtiss-Wright for military aircraft were made available for the com-

fort and additional safety of commercial air passengers. Among them were hollow steel blades, automatic synchronization, which reduced vibration and eliminated fatiguing off-rhythm engine beats; and the reversible propeller which provided positive, smooth braking action under all landing conditions, and enabled backing or maneuvering of the airplane on the ground. Those features were incorporated in the outstanding commercial aircraft under production, including the Douglas DC-6, Lockheed model 649 and 749 Constellations, the Boeing model 377 Stratocruiser, the Consolidated Vultee 240 and the Republic RC-2 Rainbow. Curtiss propellers for those ships were specified by 15 airlines, including American Airlines, American Overseas Airlines, Transcontinental and Western Air and its international division Trans-World Airlines, Pan American World Airways, Northwest Airlines, Scandinavian Airways System, KLM, KNILM, Air France, Aer Rianta, United Airlines, British Overseas Airways Corporation and Qantas. Curtiss propellers were also specified for the French-built SE2010 airplane, a 4-engine land transport to be operated by Air France and other European airlines. Meanwhile Curtiss-Wright was carrying forward extensive research and development of radical propeller designs to meet the requirements of future aircraft gas turbines, and other high output power plants. Typical of the advance design under development was a 3-blade propeller with sweptback blades designed to carry propeller efficiency into the 700 m.p.h. range. This was the first sweptback blade propeller.

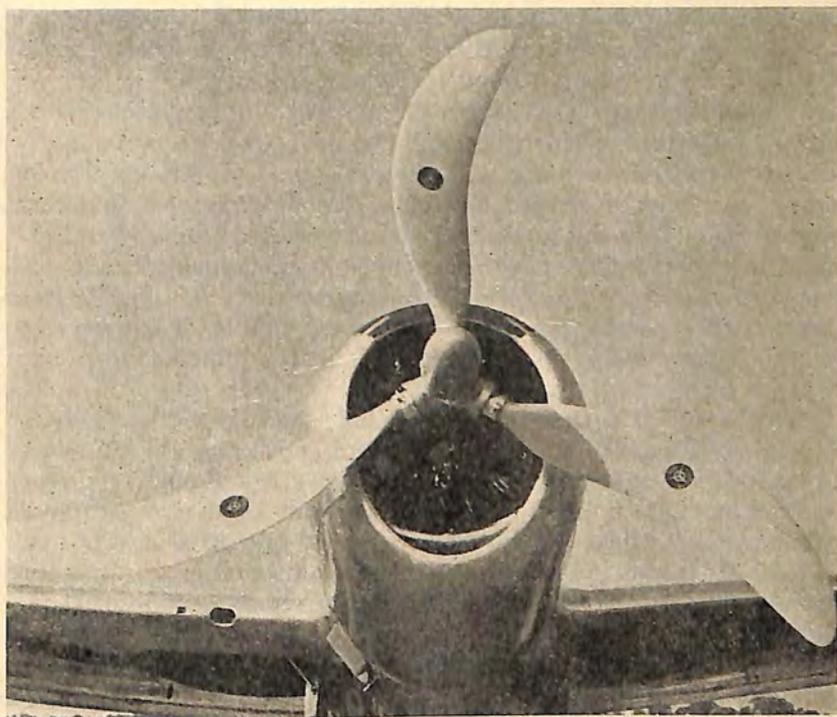
Tests conducted by the Propeller Division of Curtiss-Wright confirmed the growing belief that advances in blade design, especially with gas turbines, would carry propeller efficiency into the speed ranges previously believed unattainable by propeller-driven aircraft.

The Curtiss-Wright Propeller Division, climaxing more than 5 years of pioneering in research and development in the field of electronic flight training, delivered to the Army Air Forces a new type simulated-flight trainer for instrument flight and radio navigation instruction. Incorporating electronic devices for computation of the essential characteristics of an airplane in flight, this advanced mechanism was known as the Curtiss-Wright Dehmel electronic flight trainer. Production prototypes of the units were purchased by the Technical Training Division of the Army Air Forces. The Army version simulated the flight characteristics of an AT-6 airplane with instrument panel and cockpit arrangements specially modified for training purposes. Automatic radio range equipment to be used with other trainers also was ordered by the Army. Pan American Airways was among the airlines adopting the new trainer in pilot training and

navigation on which Curtiss-Wright spent more than \$1,000,000 in development costs.

Because the trainer could be adapted to duplicate exact arrangement of flight controls and cockpit arrangement as well as flight characteristics of any specific airplane model, very substantial savings in pilot instructional training could be realized. Unrestricted in maneuverability, the Dehmel trainer simulated any aerobatic maneuver. It embodied full aircraft instrumentation and provided all the radio signals of a navigational range and blind landing system, together with visual and audible markers. An outstanding feature of the new trainer was its compactness. Control mechanisms and other apparatus were contained in a fraction of the space needed in earlier types of simulated-flight trainers. The mechanism was operated entirely by electricity.

General Electric Company, Schenectady, N. Y., opened its flight



CURTISS-WRIGHT HIGH SPEED PROPELLER

test center, consisting of a large hangar with complete shop equipment, and continued the development of turbo-jet and gas turbine powerplants and turbosuperchargers. In the work at the flight test center a B-29, two B-24's and a small 2-engine transport were used. The B-29, for example, carried a TG-180 jet propulsion gas turbine below the bomb bay to permit checking under actual flight conditions. A Republic Thunderjet equipped with a TG-180 turbo-jet was assaulting the world's speed record toward the end of the year. While it did not establish a new record, it attained an officially clocked speed of 619 m.p.h. Other turbo-jet units were under development, with more power and better fuel consumption, with prospects for quantity production.

Development proceeded on the propeller-drive gas turbine, supplying 80 per cent of its total horsepower to drive a propeller and the remaining 20 per cent as jet. An early design of such a unit, the TG-100, was being flight tested in a Consolidated Vultee XP-81. The tests were expected to supply information to assist in development of higher powered prop-jet units. Two commercial airplanes were to be equipped experimentally with TG-100 prop-jets to determine the feasibility of such a power plant for commercial use.

A compound engine, in which the exhaust of a piston engine was directed through a turbine wheel and the power thus generated geared back to the piston-engine crankshaft, was under continued development, in collaboration with manufacturers of reciprocating aircraft engines. New forms of turbosuperchargers were developed for installation in a new bomber and in such high-speed high-altitude commercial transports as the Boeing Stratocruiser and the Republic Rainbow. Turbosuperchargers also were used in the Northrop B-35 Flying Wing and the Consolidated Vultee B-36 bomber, the largest airplane yet flown.

The higher plane speeds made possible through the use of turbo-jet engines demanded an entirely different approach to aerial combat, so the program of advanced forms of airborne ordnance equipment was continued for both Army and Navy air forces. Numerous studies of complete electrical systems on commercial aircraft also were made, with much useful information put at the disposal of air transport operators and many electrical components redesigned or newly designed in accordance with the information.

Hamilton Standard Propellers Division of United Aircraft Corporation, East Hartford, Conn., was in production of new types of propellers for postwar commercial and military aircraft. Among im-

portant Hamilton Standard developments released from classification as military secrets were the hollow-steel blade, lightest in the world for propellers over 13 ft. in diam., Hamilton Standard's use of square tips on new propellers for high speed, greater power absorption and higher efficiencies, automatic limited-band synchronization of propellers for multi-engined airplanes, adaptation of all new Hydromatic models to incorporate reverse thrust, perfection of the first one-piece Hydromatic propeller hub, and quantity production of a new, small version of the Hydromatic for executive and feeder type aircraft in the 300 to 800 h.p. categories. Two new giant test houses, each capable of accommodating propellers 30 ft. in diameter, were completed September 1, 1946. Added to previous test house facilities, they gave Hamilton Standard the most extensive privately operated propeller testing equipment. The new houses employed adjustable air funnels which smoothed out the air flow through the test cells, and were largely instrumental in making them free from air disturbances. Contained in one building 212 ft. long, 110 ft. across and 63 ft. high, the two houses were testing experimental propellers for the Army and Navy. The air funnels, known technically as cone-type orifices, were mounted on 40-ton structures that could be moved back and forth within each test house. Fifteen feet long, they could be contracted to a 15-ft. diam. or expanded to 30 ft. at one end. With this double adjustability the air flow within each test chamber could be restricted to conform to the size of the propeller under test.

The first commercial installation of equipment for synchronizing the engines and propellers of multi-engine aircraft was made by Chicago & Southern Air Lines on its luxury DC-4's. The synchronizer, developed by Hamilton Standard, also was specified on newer transport types. Hamilton Standard's synchronizer system permitted selection of either of two of an aircraft's 4 engines as a master by the pilot. The other three engines were slaves whose speed of operation was held rigidly to the speed which the pilot selected for the master. In case of malfunctioning of the master engine, the slave engines would follow the changed r.p.m. of the master by only plus or minus 3 per cent of the r.p.m. at which the master was set. For instance, if the master engine were set for 2,000 r.p.m., and suddenly decreased to 1,500, the slaves would only drop 60 r.p.m. to 1,940. In the event of a master failure, the pilot at once could switch to the alternate master, thus providing a second safety feature. Still another major safety provision was the fact that all four engines were at all times under control of their individual governors, whether or not the synchronizer was in

use. Thus, the synchronizer could be turned on or off at any time, and the propellers would continue to operate under constant speed control at the r.p.m. selected by the pilot.

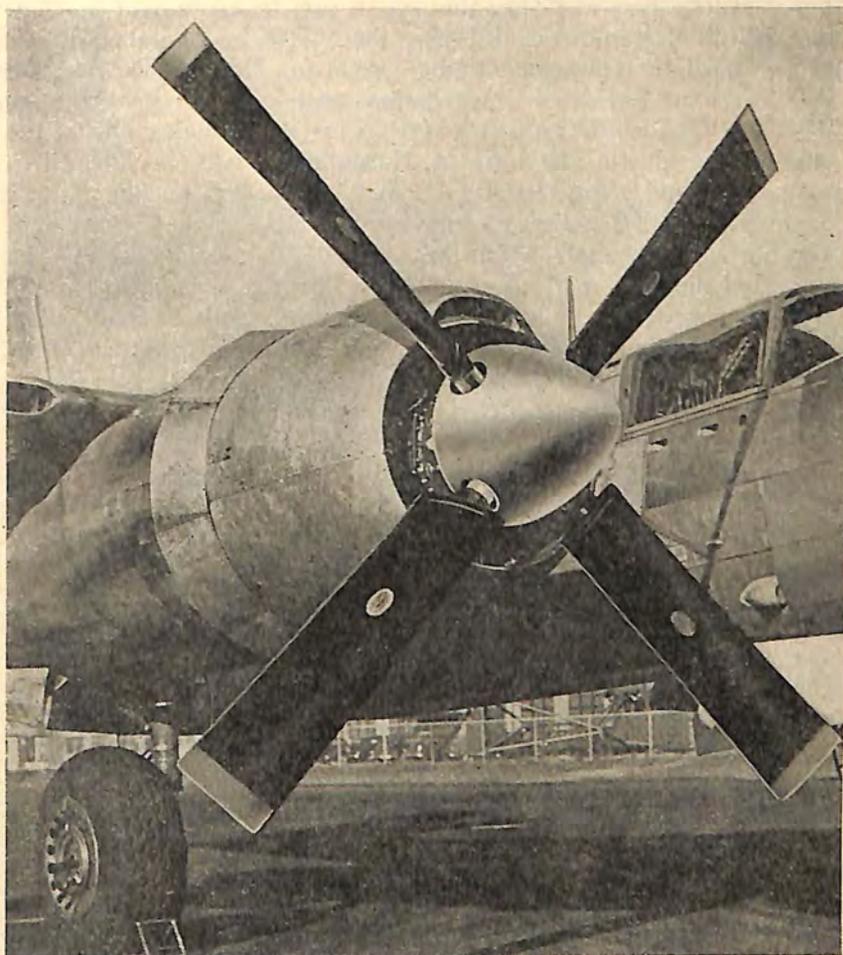
The new square-tipped blade, which was to appear on many new aircraft during 1947, was the result of years of aerodynamic research designed to maintain high propeller efficiencies as airplane speeds approached the speed of sound and horsepower substantially increased. Hamilton Standard's investigations showed that the square tip blade provided the best answer to the problems of efficient horsepower absorption, energy losses resulting from increased blade drag and propeller slipstream momentum, and the compressibility losses suffered by conventional blades at high speeds. Width added at the tip, it was proved, afforded the maximum increase in blade power absorption with the minimum weight increase, thus permitting the design of lighter blades. Because it carried the airfoil section for the blade's entire length, the square tip made it unnecessary to distort the airfoil design at the tip as was required with the round-tip blade. This contributed to superior blade performance and permitted the use of a thinner, less cambered airfoil at the tip, resulting in substantial reduction of compressibility effects.

Models of various new blade design, all radical in their departure from any previously used on an airplane, were undergoing tests in the United Aircraft Corporation wind tunnel at East Hartford. These blades, all designed to operate on airplanes capable of speeds up to 700 m.p.h., were revolutionary in their concepts as compared even to the Hamilton Standard square-tipped propeller blades.

The smaller version of the Hamilton Standard Hydromatic propeller was placed in production for the Beech D-18S and Beech D-18C, the Grumman Mallard and other executive and feederline type aircraft. Generally suited for aircraft ranging in passenger capacity from 4 to more than 12, it was used primarily on engines of from 300 to 800 h.p. Beech engineers found that the small propeller, incorporating the Hydromatic feathering feature, made it possible for the D-18 to increase its rate of climb 100 ft. per min. and raise its absolute ceiling by 2,400 ft. in single-engine operations.

Hamilton Standard's new reversing Hydromatic propeller incorporated the one-piece hub and the hollow-steel blade. Known as the 23260, the new Hydromatic was in heavy demand for a number of new aircraft, notably the Martin 202 and 303, the Consolidated 240 and the Lockheed 649 Constellation. The Martin Company ordered 350 for the 303 alone. Due to the design and construction of the three hollow-steel square-tip blades built for those aircraft, the new Hydromatic absorbed more

horsepower and delivered more thrust for a given diameter. At the same time, the light weight blade and innovations in the single piece hub structure gave the most favorable weight to size ratio. Changes in the actuating mechanism provided for either reverse thrust or feathering in less than 3 seconds. This extremely rapid reverse action enabled the pilot to reduce landing runs with a minimum of time lag after the airplane touched the ground, and gave extreme maneuverability while on



HAMILTON STANDARD SQUARE-TIPPED PROPELLER

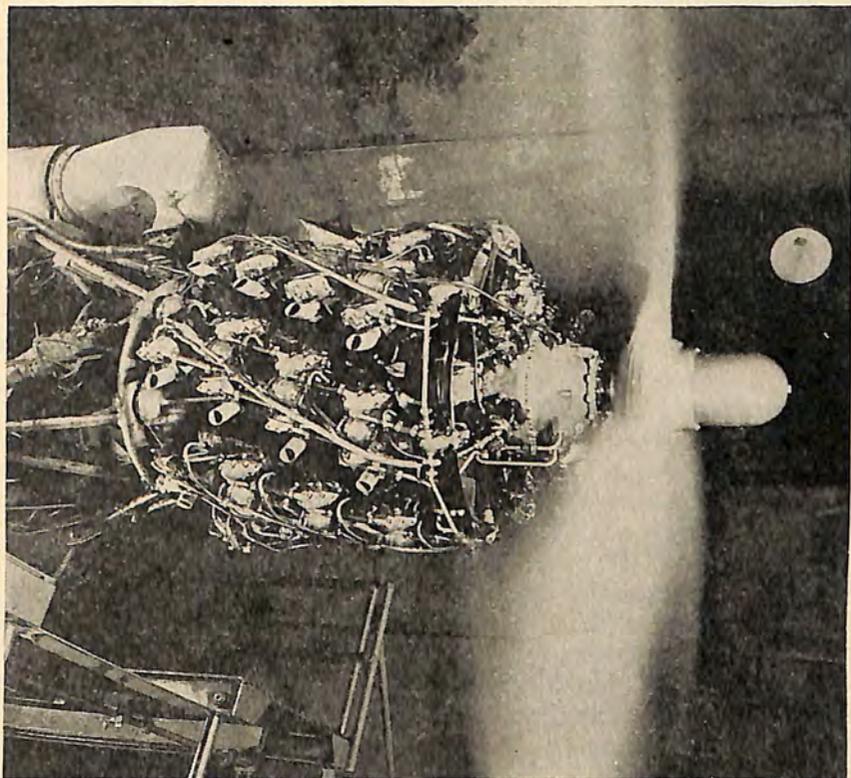
the ground. The new one-piece hub was made possible by development of a special pressure welding process.

Following a survey of the industry's requirements, the division consolidated its production lines on the following models: Controllable-counterweight models—the 2B20 for the Navy's new Fairchild XNJ-1 primary trainer, and the Cessna 190 and similar private type aircraft; the 2D30 for replacements on existing aircraft; hydromatic models—the 22D30 for the Beech D-18S, Beech D-18C, Columbia XJL observation plane and the Grumman Goose; the 22D40 for another executive type airplane; the 23D40 for the Grumman Mallard and South American-owned JU-52's; the 23E50 for Douglas DC-3's and Lockheed 18 replacements; the 33D50 for Douglas DC-3's; the 33E60 for some Lockheed Constellations and Fairchild Packets; the 43D50 for Canada's DC-4M, the 43D60 for the Douglas DC-6; the 23260 for the Martin 202 and 303, Consolidated 240, Lockheed 649 Constellation and some Douglas DC-6's; the 34D60 for the Navy's Vought F4U-5; the 24E60 for the Vought F4U-4; the 24260 for a Navy airplane; the 24D50 for the DC-4M and two models of the Super-Hydromatic for Army and Navy aircraft, among them the Army's Northrop Flying Wing, the YB-35 and Consolidated Vultee XP-81 and the Navy's Ryan XF2R-1. The last two aircraft employed turbine-propeller combinations.

American transports built during the war, including Douglas DC-3, or C-47, C-53, Douglas C-54, Curtis C-46, Beech C-45, Lockheed C-69 Constellation, were equipped with Hamilton Standard Hydromatics. As the result of the sale or lend-lease of hundreds of these airplanes to foreign countries, the export of spare propellers and parts soon assumed a substantial portion of the business. Airplanes equipped with Hydromatics continued to make records in many classes. The Navy's Lockheed bomber, Truculent Turtle, was equipped with four-blade, 15-ft. diam. Hydromatics for its record long-distance flight of 11,236 mi. from Perth, Australia to Columbus, O. The Army's Boeing B-29 Superfortresses in the Pacific area, also equipped with Hydromatics, made a number of outstanding weight-carrying and high altitude records.

Pratt & Whitney Aircraft Division of United Aircraft Corporation, East Hartford, Conn., virtually completed the conversion to peacetime operations of an organization which had undergone more than five wartime years of abnormal growth and expansion. Problems solved involved realignment of personnel, plant facilities, production lines, inventories and all other phases of the division's activities. At the beginning of 1947, Pratt & Whitney production lines were rolling

smoothly on new postwar models of engines for use in commercial and military aircraft. Also being vigorously pursued was the research and development program on advanced models of piston and turbine type engines. An engineering, installation and development staff of over 2,700 employees was carrying on the most extensive research and development program in Pratt & Whitney Aircraft's 21-years history. The bulk of the 1946 production consisted of two-row Twin Wasps and Double Wasps and four-row Wasp Majors. Twin Wasps of the 1,450 h.p. R-2000 series were shipped to Douglas for installation in new DC-4s and to the Navy, domestic airlines and buyers in 13 foreign countries for replacements and spares in R5Ds, DC-4s and converted C-54s. Shipments of 2,400 h.p. Double Wasps were principally for installation in Navy fighters such as the Vought Corsair, and in new



PRATT & WHITNEY WASP MAJOR TEST

Douglas, Martin and Consolidated commercial transports scheduled to make their appearance on the airlines in 1947. Wasp Majors ranging from 3,000 to 3,500 h.p. were produced for three new Army bombers—the Northrop B-35 Flying Wing, the Consolidated Vultee B-36 and the Boeing B-50; also for three big military transports—the Navy Lockheed XR60 Constitution, the Army Douglas C-74 Globemaster and the Army Boeing C-97 Stratofreighter; for two Army photographic reconnaissance planes—the Republic XF-12 and the Hughes XF-11, and for smaller and experimental aircraft. The balance of the 1946 production consisted of single-row Wasps and Wasp Juniors, 600 and 450 h.p. respectively, for Beech D-18S and Grumman Mallard installations and as spares and replacements for existing aircraft in the United States and in foreign countries, and twin-row R-1830 series Twin Wasps, 1,200 h.p., for Douglas DC-3 type aircraft operating over the world and Navy patrol boats.

While carrying on an accelerated program for the development of gas turbines, Pratt & Whitney was developing models of piston-type engines which demonstrated marked operating economies. One such promising development was the use of engine exhaust gases to power a gas turbine feed back, to effect a significant improvement in overall engine thermal efficiency. Equipment available for Pratt & Whitney use in United Aircraft Corporation's new wind tunnel laboratory included a 1,000 m.p.h. supersonic wind channel and a gas dynamics laboratory, with altitude burner stand and turbine blade cascade unit. Also in use was the installation engineering department's refrigerated high-altitude test chamber. These facilities were used for work on supersonic aerodynamic forms at subsonic and supersonic speeds, flow in diffusers, investigation of air flow problems in connection with turbine-type power plants and the effect of altitude on the performance of combustion chambers and turbines. A hot whirl pit for testing turbine components was completed, and two test houses were modified for the testing of jet engines. Plans were approved and land was acquired for the division's new gas turbine laboratory. Construction of that building was scheduled for 1947. The division's laboratory facilities were being further expanded by construction of an X-ray laboratory to house a new 1,000,000 volt X-ray machine for the sub-surface examination of turbine rotors.

The R-2800 Double Wasp, rated at 2,400 h.p. with water injection, was made available for commercial transports in 1946. Earlier versions of the R-2800 powered such celebrated wartime aircraft as the Republic P-47, Martin B-26, Vought F4U, Grumman F6F, Northrop P-61, Martin PBM-5, Douglas A-26, Lockheed PV and Curtiss

C-46. The design of the new commercial Double Wasp, designated the CA, reflected the knowledge gained from more than 100 million flight hours in military operations. The engine was being used to power three transport aircraft of the postwar era: the four-engine Douglas DC-6, two-engine Martin Models 202 and 303, and the two-engine Consolidated Vultee Model 240. The CA Double Wasp received an approved type certificate from the Civil Aeronautics Administration for use of combat-proved water injection to provide additional power in commercial operations. Provision was made in all CA series engines for use of water injection, if desired, to deliver 2,400 takeoff horsepower. The dry weight of two-row, 18-cyl. CA Double Wasp engines ranged from 2,327 to 2,360 lbs. and put them in the one-pound-per-horsepower class. The weight included such standard equipment as the carburetor, carburetor air screen, radio shielded ignition system, spark plugs, pressure type cooling deflectors, primer tubing and distributor, torquemeter, and provision for a feathering and reversible pitch hydraulic propeller. The bore was 5.75 in. and the stroke 6 in. The piston displacement was 2,804 cu. in. Four models of the CA engine were available for commercial applications, all with single-stage, built-in superchargers. Two models, the CA3 and the CA5, had single-speed superchargers, suitable for low altitude air transport operations or for use with an exhaust driven supercharger for extreme altitudes. The other two models, the CA15 and the CA17, had two-speed supercharger drives for effective operation at altitudes of more than 20,000 feet. The CA15 model had approved ratings for takeoffs using the high-speed drive, which improved takeoffs from airports at high altitudes. Power ratings, without water injection, of the CA3 and CA15 models were based on the use of 100/130 grade fuel: 2,100 h.p. for takeoff and 1,800 h.p. for continuous operation. The ratings of the CA5 and CA17 engines, with carburetor modifications and with 115/145 grade fuel, were certificated at 2,300 h.p. for takeoff and 1,900 h.p. for continuous operation, using the low-speed supercharger drive in the case of the CA17 engine. In addition to built-in provisions for the use of water injection, the CA Double Wasp incorporated many other improvements, most of them pioneered by Pratt & Whitney Aircraft. They included two position spark advance to provide fuel economy at cruising powers; spinner fuel injection to eliminate icing tendencies due to fuel evaporation in the induction system; forged, deep-finned, light weight cylinder heads and cylinder barrel cooling sleeves to provide ample cooling under all operating conditions; built-in torquemeter to provide the pilot or flight engineer with accurate information on power output under all conditions; cone

clutches and creeper desludgers, in the two-speed engines, to prevent clutch fouling; lead-silver-indium bearings to resist erosion and contamination while carrying heavy bearing loads and providing excellent lubricating characteristics; and second order counterbalances to oppose the second order forces and couples which normally produced vibration along and about the vertical and lateral axes of the engine.

While continuing the manufacture of engines and parts for its six basic engine types—450 h.p. Wasp Junior, 600 h.p. Wasp, 1,200 h.p. R-1830 series Twin Wasp, 1,450 h.p. R-2000 series Twin Wasp, 2,100 to 2,400 h.p. Double Wasp and 3,000 to 3,500 h.p. Wasp Major. The higher-powered types, the Double Wasp and the Wasp Major, promised the greatest production in 1947. In addition to the Double Wasp-powered commercial transports mentioned above, two other Pratt & Whitney-powered airliners were scheduled for 1947—the Boeing Model 377 Stratocruiser and the Republic RC-2 Rainbow, each powered by four Wasp Majors. A new commercial transport powered by Pratt & Whitney engines of less than 2,100 horsepower was Saab Aircraft Company's (Swedish) two-engine Scandia, which used two R-2000 series Twin Wasps. Another foreign-built transport, powered by four Wasp Majors, was Aerosudest's (French) SE-2010.

In addition, other aircraft powered by Pratt & Whitney engines included the Beech G-17 sports-executive transport, Canadian Fairchild Husky utility transport, Spartan Model 12A sports-executive transport, each with a Wasp Junior; the Bellanca Skyrocket, Canadian Car & Foundry Norseman and Northrop Pioneer transports, powered by Wasps; Canadian Car & Foundry CBY-3 transport and Vought XF5U Navy fighter, with R-2000 Twin Wasps; Fairchild C-82 Packet and Douglas YC-112 Army transports, Fleetwing's BTK-1 Navy torpedo bomber, the Lockheed PV-2 Harpoon and Martin PBM-5 Mariner Navy patrol bombers, and Martin PBM-5A amphibian and Northrop F-15 Reporter, Army photo-reconnaissance and P-61 Black Widow night fighter, all with Double Wasps; Curtiss XBTC-2 and Douglas XTB2D-1 Navy torpedo bombers, the eight-engine Hughes H-4 Hercules cargo flying boat, Martin AM-1 Mauler Navy attack plane and JRM-2 Navy seaplane cargo transport and XP4M-1 Navy patrol airplane.

Helicopters powered with Wasp Juniors included Sikorsky's Army R-5 and commercial S-51 and Bell's commercial Model 42, each with one engine; and McDonnell's two-engine XHJD-1 Navy helicopter. The Wasp Major was to power Kellett's Army Skycrane cargo helicopter.

The Ranger Aircraft Engines Division of the Fairchild Engine

and Airplane Corporation, Farmingdale, N. Y., continued its extensive research and engineering program while readjusting its manufacturing facilities to postwar requirements. Developmental work on a new, higher horsepower 12-cyl. engine for the Navy was completed, the engine passing its type tests in September, 1946. Design and developmental work on other Ranger engines was continued with the emphasis shifting to studies of gas turbines. Much of the new engineering program in 1947 was to be devoted to turbines.

In addition to developmental work on aircraft engines, Ranger designed and manufactured complete power packages for the Navy's newest scout plane, the XOSE-1. Built around a 550 h.p. 12-cyl. aircooled, inverted V type Ranger engine, the power package was designed for speedy installation and removal. The complete unit could be removed from the airplane or installed in less than 30 minutes. It contained all the essentials required to provide power for flight, including the complete oil system. Having assumed responsibility for all design ahead of the firewall, Ranger equipped the power package with quick disconnect fittings on all lines passing through the firewall, and made the engine cowling completely separate from the airframe. Unique cowling design made possible complete uncovering of the engine in a few moments. Together with hinged cowl panels, it greatly facilitated line maintenance.

The Ranger engine rebuilding program was continued. Started in 1945 to make six-cyl. Ranger engines available for civilian use, the program provided hundreds of factory rebuilt and factory guaranteed engines for Grumman Widgeons and new Fairchild F-24s. With manufacturing facilities consolidated under one roof in Farmingdale, Ranger also produced quantities of various items under subcontract.

The NEPA (Nuclear Energy for the Propulsion of Aircraft) Division of Fairchild Engine and Airplane Corporation was established at Oak Ridge, Tenn., in 1946. That division held the prime contract from the Army Air Forces to develop the use of atomic power to propel airplanes, and was engaged in correlating the activities of a number of other engine and electric companies who were contributing to the project.

The Warner Aircraft Corporation, Detroit, Mich., continued production of the Super Scarab Model 165 aircraft engine rated at 175 h.p. for takeoff and 165 h.p. normal, and the Super Scarab Model 185 engine rated at 200 h.p. for takeoff and 185 h.p. normal. In addition to aircraft engines, Warner continued the manufacture of hydraulic brake controls, and added a number of new developments especially suited to heavy aircraft, including dynaflo power brake valves, brake

master cylinders, pressure reservoirs and special purpose lock valves.

Wright Aeronautical Corporation, Wood-Ridge, N. J., consolidated all its facilities in the Wood-Ridge plant for production and development of new types of Cyclone engines for military and commercial flight, and continued engineering work on gas turbines and other types of advanced aircraft power plant. Wright purchased the 35-acre building in Wood-Ridge built by the government for wartime production of Cyclone 18's. The new plant was located only a few miles from Paterson, which had been the company's headquarters for more than a quarter of a century of aircraft engine manufacture. Meanwhile, the wartime plant in Cincinnati, O., was returned to the Government, and the Paterson plants were disposed of to private corporations and the War Assets Corporation. Test facilities at Wood-Ridge were enlarged to accommodate ever-increasing horsepower in reciprocating and gas turbine engines.

During the first postwar year, the Cyclone 18 powered the B-29, Constellation and P2V Neptune in record flights, among them the world's long distance record, the first long-range flight over the North Pole, and numerous speed, altitude and load-carrying tests. Aircraft powered by the Cyclone 18 had a postwar total of more than 90 national, international and airline records.

Wright Aeronautical in 1946 had engines in production from the 800 h.p. Cyclone 7 to the 2,500 h.p. Cyclone 18, a wide range of power designed for a wide range of aircraft. The Cyclone 7, introduced in 1945 at 700 h.p. was developed by 100 h.p., and was destined primarily for use in regional and shorthaul airplanes such as the three-engine Northrop Pioneer cargo and passenger transport. The Cyclone 9 of 1425 h.p., and one of the most powerful in the world per pound of weight, was produced in a power unit for the DC-4's of Chicago and Southern Air Lines. These planes became the world's fastest Sky-masters when equipped with the new engine. The power unit, designed by Wright, with a nacelle manufactured by the Rohr Aircraft Corporation, comprised a quickly detachable cowling and engine package which was mounted on the nacelle fire wall and had quick hookup connections to speed installation and maintenance.

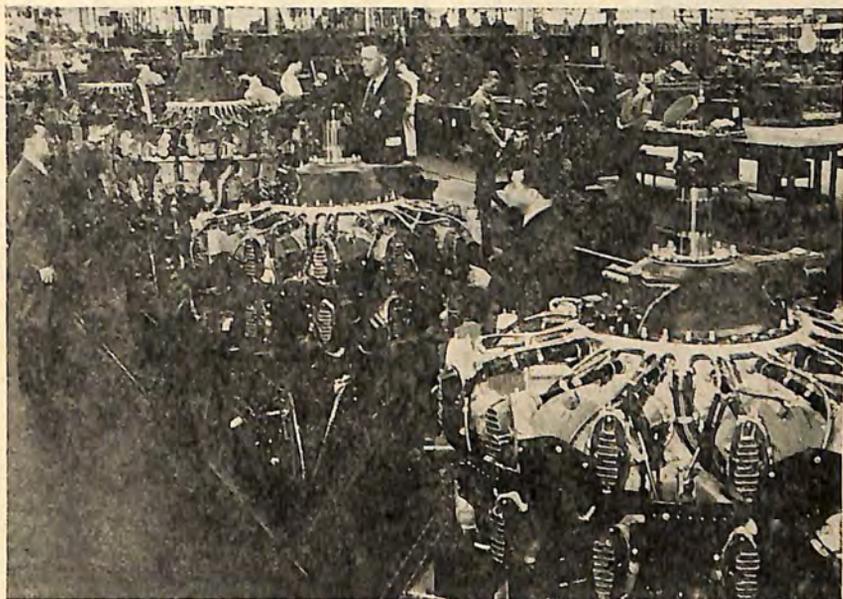
Output of the Cyclone 18, which powered all B-29's and Lockheed Constellations at 2,200 h.p., was increased during early 1946 to 2,500 h.p. with the production of the Cyclone 18BD for such aircraft as the Douglas AD-1, Curtiss XBT2C-1 and Lockheed P2V for the Navy. Incorporating developments like the forged aluminum cylinder head, which had proved its merits during the war on Cyclone 9's in combat aircraft, the Cyclone 18BD was among the most powerful aircraft

engines available for military or commercial flight. However, further increases in the Cyclone 18's power were planned by Wright engineers for 1947.

A majority of Cyclone 18 engines were equipped with a direct fuel injection system known as cylinjection. This system pumped fuel directly to each cylinder under high pressure, eliminating mixture of gasoline and air in the carburetor. Fuel savings as high as five per cent were reported on long flights by airlines using Constellations equipped with cylinjection.

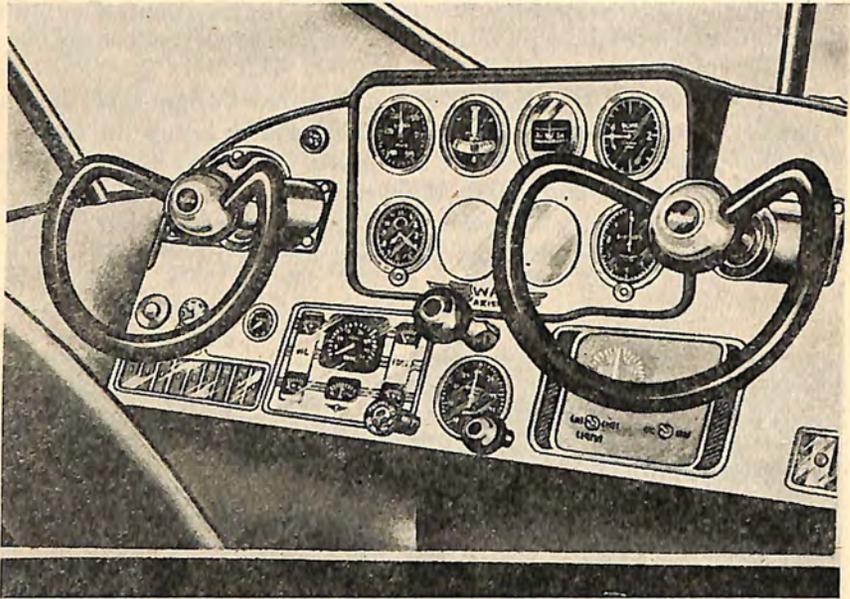
Although military security still prohibited release of details, Wright Aeronautical made substantial progress in the development of aircraft gas turbines of extremely high thrust as well as other types of specialized powerplants.

The Chinese Air Force, which manufactured Wright Cyclone 9's of the G-100 type during the war, obtained a new license in 1946 to produce the 1,200 h.p. G-200 type which had powered a large number of America's prewar and wartime air transports, and Chinese representatives made a first-hand study of Wright engineering and production practices at the new factory in Wood-Ridge.



WRIGHT CYCLONE ENGINE ASSEMBLY

Outstanding among the Wright-powered aircraft in service during 1946 were the Boeing B-29, Lockheed Constellation, Martin Mars, Lockheed P2V, Douglas AD-1, Douglas DC-4, Lockheed Lodestar, and Douglas DC-3. Among the planes which Wright was scheduled to power were the Northrop Pioneer and the CW-32, new Curtiss transport.



WACO ARISTOCRAFT INSTRUMENT BOARD

## CHAPTER XII

### NEW AVIATION ACCESSORIES

Development of Heat Resistant Metals for Higher Speeds—Problems Being Solved in High Altitude Equipment—New Navigational Instruments—Automatic Controls—Important Electronic Devices—Improved Fuels.

**T**HE manufacturers of aviation instruments, tools and parts were keeping pace with the aircraft designers in developing new things to make flying faster, safer and more reliable, at the same time more dangerous to any enemy of the future who might choose to attack the United States. The following paragraphs describe some of the activities of those companies making accessories for the aircraft industry.

Airadio, Inc., Stamford, Conn., producers of radio equipment, contributed to the safety, convenience and pleasure of private flying with its first peacetime product—an extremely light-weight, two-way communication set for private planes. The Airadio Super 52 was manufactured in a number of models to fit all types of light aircraft. Designed by engineers, who also were pilots, it included a built-in range filter, a tuned R.F. stage for better selectivity and maximum image suppression, both standard broadcast and radio range broadcast bands, slide-rule dial for better visibility and more accurate tuning, inter-phone communication, and both automatic and manual volume control. Easy to install and of attractive design, the weight of the complete equipment, receiver, transmitter and power supply, was only 10 lbs., 10 ounces, and dimensions were  $3\frac{3}{4}$  in. x  $5\frac{11}{32}$  in. x  $5\frac{23}{32}$  in. Another product of Airadio's Airborne Division destined to take its place on the list of desirable equipment for the private flyer, was Airadio's Super 41, a battery-operated receiver, with full sized components, at a total weight of two lbs. 13 ounces. Ease of installation and compactness in size were achieved in this receiver with dimensions the same as model 52. Easy and accurate tuning by means of the slide-rule dial, high sensitivity and selectivity for clear, long distance reception, and sharp tuning, built-in range filter, manual and automatic volume control, and adequate power output to furnish full head-

phone volume to several outlets simultaneously were features of the design.

Al-Fin Corporation, Hollis, Long Island, N. Y., a subsidiary of Fairchild Engine and Airplane Corporation, continued research and development work on its patented process of chemically bonding aluminum and its base alloys to ferrous metals, a process permitting the design of bi-metallic assemblies combining selected physical properties of both materials. That bonded construction, developed during the war for cooling aircraft engine cylinder barrels, facilitated production of units requiring strength of steel with the light weight, high heat conductivity, bearing properties, anti-corrosive qualities, and other characteristics of aluminum. Among such units manufactured by the Al-Fin process were muffed-and-finned engine-cylinder and compressor barrels, heat exchangers and other finned assemblies, aluminum-lined steel-backed sleeve bearings and bushings, steel-hubbed aluminum timing gears, bi-metallic pistons, cathode assemblies for radar tubes, cooling radiators for radio and power tubes, aluminum bottomed stainless steel cooking utensils, galvanometer integral pole and core and bracket assemblies. The process also was used for coating cast iron and steel pipe and tubing with aluminum, to prevent corrosion.

Aluminum Company of America, Pittsburgh, Pa., supplied two million pounds of Alcoa 75S a month for the aircraft industry during the latter part of 1946. Developed during the war to meet the needs of an aluminum alloy of unprecedented strength, this alloy was made available in sheet, extrusions, forgings, and rod. The saving in structural weight was one of the reasons why Alcoa 75S was specified in all new designs for military and commercial aircraft. Plus those aerodynamic advantages, Alcoa 75S with its complete group of sister alloys offered all manufacturers a wealth of experience, data, and a choice of suitable alloys in every commercial form. Because these Alcoa alloys were so versatile, they were widely used throughout the entire aircraft industry. Alcoa engineers continued to cooperate with the industry in providing alloys of maximum advantage in the field of aviation.

The B G Corporation, New York, completed development of numerous models of B G ceramic aircraft spark plugs which gave exceptionally satisfactory performance in service operation. The model RB19R, the high quality aircraft spark plug incorporating platinum alloy, electrodes and an integral resistor, was adopted, with few exceptions, by commercial airlines throughout the world. By its use, spark plug operating periods were increased to an average of 250 to 300 hrs. with many instances of considerably longer periods of opera-

tion. The RB19R was approved for practically every American engine requiring a long reach 18 m.m. shielded type spark plug. It had long life, good resistance to fouling, and would operate at leaner mixtures than were possible with the previously used heavy electrode type construction. Models of the same basic design, containing all the principal features of the RB19R, were also available in the 14 m.m. type for American and foreign-made engines. There also were developed a complete series of ceramic-insulated short reach shielded and unshielded models for the lower output private-owner class of engine. These models designated as the 700 series were available with and without resistors; and, while of considerably less expensive construction than the RB19R series, they incorporated the same high quality ceramic insulating materials. B G also developed and produced numerous models of spark plugs for straight and turbo-jet engines. Those plugs in most instances were specifically designed and developed for particular applications. Many models were being operated in various development projects. They had reached the production stage, and were standard equipment on several successful service installations. Development of spark plugs for low-tension high-frequency ignition systems was undertaken. B G developed its own design of high-frequency plug construction which proved of great interest to the manufacturers of this type of ignition equipment. Along with its own design, B G produced numerous special models for several manufacturers.

Breeze Corporations, Newark, N. J. conducted an extensive development program in the field of jet propulsion equipment and accessories, and during 1947 the company was expanding that program as well as developing new products for the aircraft industry. The Breeze background of engineering and production experience contributed immeasurably to solving many of the shielding problems created by higher sustained altitudes, greater projected speeds, television and other sensitive electronic devices. In the field of radio ignition and secondary shielding Breeze developed flexible metal spark plug lead assemblies greatly improved in shielding qualities and mechanical strength. Flexible shielded conduit and end fittings were improved, in the interest of safer and better electrical systems in aircraft.

To meet the urgent requirements of aircraft engineers and designers for a multiple connector to eliminate many of the shortcomings of connectors designed before and during the war, Breeze developed the new Breeze Monobloc connector. The Monobloc Connector had insertable and removable contacts to which the cable or wires were crimped mechanically rather than soldered. This mechanical crimping did away with the use of soldering flux which formerly contributed

greatly to the deterioration of contacts at the point of soldering. The crimping method also insured uniformity of attachment to connector contacts because it eliminated the human element involved in soldering jobs. Through use of insertable contacts, cables could be attached to the contacts on the assembly benches and then installed into the finished equipment, thereby eliminating the need for soldering wires or cable to connectors at the point of installation. In designing that connector, Breeze engineers excluded many of the component parts characteristic of ordinary aircraft connectors, thus reducing possibility of malfunction due to flashover, condensation, erroneous assembly or breakage. Advances in automotive, aircraft, marine and industrial engineering offered infinite possibilities for the application of Breeze mechanical and electrical actuating devices. The value of those devices in aeronautics was established through the operation of trim tabs, cowl flap shutters, wing flaps, landing gears, propeller controls and allied mechanisms.

Breeze also developed a fast acting cylinder head temperature bulb generally considered to be a distinct improvement over the thermocouple method of obtaining temperature readings. Among miscellaneous products, Breeze continued to manufacture flexible shielded conduit, conduit fittings, Breeze type multiple connectors, flexible shafts and case assemblies and flexible metal tubing.

The Champion Spark Plug Company, Toledo, O., continued to furnish aircraft spark plugs to many of the airlines and engine manufacturers and to the military services. A modified, shielded, long reach spark plug for airline use was tested and approved by the engine manufacturers and put into production the latter part of 1946. This plug was an improvement over the earlier long reach Champion types, providing better electrode life and wider range. A liquid type ceramic spark plug cleaner was developed for airline use. Preliminary tests indicated that it would add materially to the useful life of spark plugs because of less erosive action on the electrodes. Continued intensive research on spark plug design and materials was being carried on through 1947.

Chicago Aerial Survey Company, Chicago, Ill., continued with the development of special aerial photographic equipment for the Army. These projects included design of new aerial cameras and the redesign and improvement of existing standard Army photographic equipment. These special developments required considerable increase in engineering facilities. In addition to the expansion of the research and design engineering departments, aerial surveying services in wider and more complete form were again made available after having been

discontinued for the duration of the war. The company's Sonne continuous strip camera which had a remarkable war record in both the Army and Navy, was adapted for peacetime survey applications. The unusually large scale photographs proved to be particularly useful in highway performance studies for the location and evaluation of pavement cracks. The application of the Sonne strip camera to highway, railway and pipeline study was well received where minute details, permanent records, speed and decreased maintenance costs were of paramount interest. A specialized version of the Sonne strip camera was an integral part of a new revolutionary method of aerial geophysical exploration for petroleum and metallic minerals. Here the camera provided a means of continuously recording the terrain over which the airplane flew while delicate instruments interpreted geophysical data. Conventional photographic and mapping surveys were offered in addition to the Sonne strip photography. In the field of photogrammetry and precise controlled mosaics, the company enlarged its capacity both with equipment and expert personnel. This provided a more complete photographic engineering service, combining the use of aerial photographs with conventional precision ground survey methods and including such advance steps as the evaluation of geological and soil conditions by the interpretation of stereoscopic aerial photographs.

Crescent Insulated Wire & Cable Co., Trenton, N. J., one of the large manufacturers of electrical wires and cables for the aircraft industry, furnished quantities of wires and cables in all sizes for use in construction and servicing of airfields and related facilities. They included cables for power and lighting of airport buildings, beacons and other installations. Smaller cables made by Crescent were used to power portable drills, tools and many other industrial appliances for airport use.

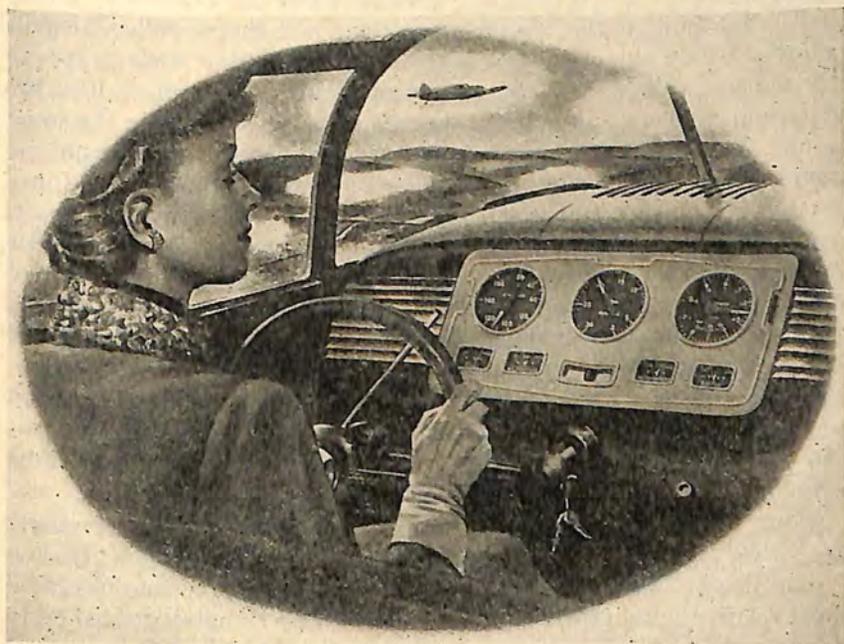
Duramold Division of Fairchild Engine and Airplane Corporation, Jamestown, N. Y., designed and manufactured several products, including a 12-ft. lightweight car-top boat of molded plastic bonded plywood, for use as a rowboat or with an outboard motor. Easily fastened to the roof of an automobile sedan, the Duramold boat was designed especially for sportsmen, campers and vacationers. In the Duramold process, which was used during the war for the fabrication of aircraft and aircraft components, the boat hull was constructed in laminated fashion with thin layers of wood veneer criss-crossing. Double curvatures could be formed by this method, smoothly and without joints or screws. The mahogany veneers were bonded together with plastic, waterproof, thermosetting resins. Then the entire laminated hull was solidified into one strong piece by baking it under heat and

steam pressure in an autoclave. Duramold also entered the radio field, manufacturing radio cabinets as a subcontractor. Duramold carried on extensive laboratory research in the field of high-frequency dielectric heating and in the use of thermosetting resins for bonding wood veneers, glass cloth, expanded synthetic rubber, and other materials. In the Duramold process laminations of low-density materials, identical or in combination with other materials, could be molded into flat, curved, or complex shapes by the use of plastic resins. Sandwiched and molded under heat and pressure, Duramold products combined strength with light weight. The process had many applications in the aeronautical field.

Dzus Fastener Company, Babylon, N. Y., supplied its line of fasteners which were in general use among the manufacturers of both military and civilian aircraft. The Dzus fasteners in fact found even wider application than during the war years when they were in great demand. Light plane manufacturers profiting by war production experience used fasteners advantageously, even in low-priced aircraft. Transport aircraft designed for heavier loads and greater range were confronted with an increased problem of accessibility for servicing and maintenance, and Dzus fasteners helped in the solution. Military aircraft met new problems in higher speeds. The Dzus company kept pace with changing conditions and expanded research facilities and personnel. Their program for 1947 included constant design improvement to meet new requirements for higher load carrying capacity, simplified installation and wider adaptation. Special attention was paid toward retaining all the desirable features such as misalignment correction, ability to compensate for thickness variations, endurance to vibration and fatigue and ease of operation which made the Dzus fastener popular.

The Eclipse-Pioneer Division of Bendix Aviation Corporation, Teterboro, N. J., completed its reconversion from war to peacetime conditions, discontinued seven plants in neighboring communities, took back products together with their tooling from 23 subcontractors, and continued its program of research and production of a wide range of flight and navigation instruments and aircraft accessory equipment. Outstanding in the instrumentation field was the development of a system known as Flight Path Control (FPC) for use in conjunction with automatic range flying and automatic landing approaches. The system was designed as an adjunct to the Eclipse-Pioneer all electric automatic pilots. While developed primarily for existing instrument landing system control equipment, it could be readily adapted to other forms of radio control. The standard instrument approach cross

pointer meter was wired into the system to provide the pilot with means for locating the approach channel prior to turning on the fully automatic system, as well as providing him with a reassuring visual indicator during actual approach. The nerve center of the FPC system was the flight path computer. This unit integrated the signals transmitted by the radio gear and relayed them to the rudder and aileron channels of the automatic pilot for correct localizer or azimuth control, including automatic correction for drift, and to the elevator channel and power system for correct coordination of elevator with throttles to establish and maintain the proper constant airspeed on glide path. The system used in the flight computer completely disregarded the beam width or sensitivity of the radio equipment and constrained the aircraft to fly down the center of the beam regardless of its width. Accuracy was such that landings were made consistently on the exact same spot of the runway each time. If a go around procedure became necessary, the equipment took the airplane straight on through without any bucking as it approached and passed over the localizer transmitter. Design was such that practically any conceivable addition to control of automatic flight could be readily adapted to the system.



ECLIPSE-PIONEER INSTRUMENT PANEL

Another Eclipse-Pioneer development was the dual radio and magnetic compass indicator for use by pilots in navigating and maintaining the direction of their aircraft without the necessity for numerical or graphical calculations. In addition to duplicating the function of the directional gyro without the necessity for periodic precession corrections, it also could be used for straight line navigation, or making good a predetermined track, obtaining magnetic bearing indications directly, direct indication of drift and drift angle correction, reading reciprocal bearings directly, a heading indicator when flying toward a non-directional station, maintaining continuous running fixes, determining and checking ground speed, and maintaining holding positions.

The Magnesyn system was developed to the extent where Magnesyns for every important engine function were rolling off the production line. These instruments were designed to duplicate the function of the long established Autosyn system which commenced the elimination of bulky and hazardous fuel, oil, and other mechanical lines directly from a source of measurement to an indicator unit. Replacing the Autosyn system with Magnesyns saved an average of 40 per cent in weight. Magnesyn transmitters did not require shockmounted installations, again saving weight and eliminating an extra installation detail. One unit in the Magnesyn system was the so-called plug-in indicator, which plugged into a regular radio tube type socket. It was only  $1\frac{1}{4}$  in. in diam. and  $1\frac{7}{8}$  in. in length, including half an inch for the receptacle plugs. It could be mounted by itself for use in the same manner as one of the larger Magnesyn indicators, or it could be grouped with a number of other similar indicators for associated functions. As Magnesyn equipment began to replace Autosyns on aircraft, a revamped Autosyn with extremely high precision characteristics was developed for commercial application with precision servo control equipment. It served the need for transmitters (synchro generators), differential-generators, receivers (synchro control transformers) and resolvers (sine-cosine generators). All those units were designed to the same outline dimensions and weighed only 5 oz. They operated from 26 volts, 400 cycles. Maximum system error spreads of approximately  $\frac{1}{2}$  degree were maintained, and could be reduced to  $\frac{1}{4}$  degree by matching units.

Along the lines of completely new thinking was the development of a small control device known as a Convector tube. It was a Y-shaped, gas filled tube, capable of giving an appreciable electrical signal relative to its position about vertical. The signal depended upon the rate at which gas convection currents left a heated filament and rose along the vertical, and the angle that the filament made with the

vertical. Inasmuch as the signal had sense to whether the displacement was to the right or to the left of null, it was possible to use the tube for control of servo mechanisms and instruments. In addition to these specific items, considerable research was being put forth constantly by Eclipse-Pioneer toward development and perfection of control equipment for guided missiles as well as for additional functions for flight path control.

Notable among the development of Eclipse-Pioneer accessory items was a 4 unit direct current aircraft generating system. The four units, totaling only 74½ lbs., consisted of a 24 volt, d.c. generator, nominally rated at 300 amps.; a generator control panel, providing voltage regulation and line switch control; a 29 volt (d.c.), 400 ampere line switch; and an overvoltage protector. The generator, incorporating all the advantages brought to light by 30 years of engineering and design of generators, included among other features, a series compensating circuit connected in the negative line for minimizing brush sparking and providing required voltage drop, without the use of an external resistor (which consumes power) for equalizer circuit operation in parallel generator systems. The control panel was a single compact unit with all the devices necessary for the automatic differential remote control and voltage regulation of a generator. All the functional units of this panel were compactly mounted on the mounting base by means of two quick locking fasteners. External electrical connections were made to the base, thus the packaged group was easily removed for service and replacement. The over-voltage protector disconnected from the line a faulty generator and associated control equipment without causing transient conditions to cut out associated parallel generating equipment. The main set of contacts on this hermetically sealed unit had a magnetic blowout feature for completely extinguishing the arc formed when the highly inductive field circuit was opened as the generator operated under full field at takeoff speed.

Eclipse-Pioneer also developed 2 new lightweight inverters of sufficient rating to do the job that formerly required several smaller units. One unit, weighing only 23.5 lbs., was rated at 750 V.A., for 3-phase operation, or 500 V.A., for single-phase operation. The other, weighing only 36 lbs., was rated at 2000 V.A., for 3-phase or 1500 V.A. for single-phase operation. Both units incorporated the carbon pile feature for automatic voltage and frequency regulation as well as built in radio interference filters. A fan, mounted integrally with the armature of each unit, provided for forced cooling. In addition, development and production continued in the direction of a complete line of starters for all sizes of conventional engines, culminating in a 27-lb.,

30 volt starter for the 3,600 h.p. engine. Starters for operation on 115 volts, d.c., and 110 volts a.c., also were made available. Several starters of various sizes were developed to meet the requirements unique to gas turbine engines. A complete line of accessory equipment, including gear boxes and fuel systems, was being developed for use with jet and rocket engines.

Fenwal Incorporated, Ashland, Mass. continued the development and production of Thermoswitch controls for aircraft and Thermoswitch fire detectors. These units had met with widespread use during the war. The aircraft industry used Thermoswitch units for such temperature control applications as combustion heaters for cabin heating and wing heating, carburetor air temperature indicators, oil temperature alarms, and fire detectors. Thermoswitch units consisted of a cartridge-like, seamless brass or stainless steel tube in which was mounted an assembly comprised of 2 silver contacts mounted on struts of low expansion coefficient. Rise in temperature caused the outer shell to expand, allowing the contacts to make (or break, depending upon the desired action) when the calibration point temperature was reached. The design was without loose parts or auxiliary devices; and because of high current carrying capacity and freedom from effects of vibration, the Thermoswitch units were particularly applicable to aircraft uses. As a result of vast experience in aircraft fire detection equipment, Fenwal announced a new hermetically sealed fire detector and a patented detector circuit. The detector unit was a modification of standard Thermoswitch models and when tested showed an extremely rapid response time, negligible vibration effects and complete sealing against moisture, contamination and tampering. The unique system provided instant alarm should fire occur anywhere in the aircraft. An alarm circuit was provided for each section of the aircraft protected by the extinguisher system. An alarm light on the instrument panel flashed immediate warning and indicated the zone of fire. Outstanding circuit innovations included, along with simplicity and dependability, a means of providing a current path to each detector even in the event of a break in the loop circuit during flight. No relays or other auxiliaries were required with this system. The unit was designed to stand flash fires—once a fire was extinguished the unit was ready to indicate another fire. Meanwhile Fenwal engineers continued development and refinement of other aircraft fire detection and temperature control devices.

Flightex Fabrics, Inc., New York, with a splendid war record for supplying aircraft fabrics for the Army and Navy air forces under the Flightex trade name, was playing an important peacetime role in pro-

viding fabrics for the personal aircraft industry and other manufacturers using fabric covered surfaces. Flightex also was completing development work on a number of new items which were to be offered to the industry in 1947.

General Electric Company, Schenectady, N. Y. developed new aircraft auxiliaries to meet the demand for more power. The new commercial aircraft required high-capacity generators with at least a 3 to 1 speed range. Heavy electrical loads were found during loading and taxiing, and also while awaiting clearance for takeoff. Passenger convenience loads also ran the power requirements up to where such ships as the new Douglas DC-6, Boeing Stratocruiser, Republic Rainbow and Lockheed Constellation required from 36 to 72 kw. of power. A new 9-kw. 3,000/8,000-r.p.m. 30-v d-c generator was designed for such requirements. A new line of high interrupting capacity trip-free circuit breakers was developed to insure circuit protection and continuity of service on main feeder buses. A 200-amp frame size inverse-time overcurrent circuit breaker with trip-free action was capable of interrupting 15,000 amperes fault current at 50,000 ft., and weighed only 1¼ lb. A 50-amp frame size circuit breaker, weighing only 4 oz., had an interrupting capacity of 8,000 amperes fault current. A unit power center brought together in one drawout panel the voltage regulator, reverse-current relay, circuit breaker, and auxiliary control of the generator, permitting the engineer to lay out the simplest, most efficient and safest distribution system. An improved high-tension dual ignition system was developed for the new Pratt and Whitney R-2800-C engine used on many new commercial airplanes. Basic motors, both a-c and d-c, were adapted and modified for improved performance without added weight. A special ignition transformer was developed to ignite the oil used in gas-turbine aircraft. Contributing to the extremely light weight and small size of new transformers for operation of low-voltage accessories such as landing lights and heated flying suits was the use of silicone-fiberglass insulation.

A new compass-controlled directional-gyroscopic system combined the measurements performed by a compass and directional gyro to eliminate the short-time instability of the former and the relatively long-time drift of the latter. The complete system, which included a directional gyroscope, a stabilizer-control unit, a remote-compass indicator, and a remote-compass transmitter, provided a stable indication of direction relative to magnetic North. The trend on the new planes, particularly the jet types, to smaller instrument panels, created a demand for smaller-size indicators of all types. One of the first of this class of instruments to be developed was the tachometer indicator

having all the desirable accuracy and operating characteristics of the larger-size instrument. For some time it had been apparent that it would be desirable to use temperature bulbs instead of thermocouples on aircraft cylinder heads. The new system, using a minimum of lightweight leads, overcame the major objections to the thermocouple system.

The B. F. Goodrich Company, Akron, O., completed experiments on the Rotovane tire, an airplane tire equipped with vanes to start the wheels rotating before the aircraft touches the surface during a landing.

Jardur Import Company, New York, was the exclusive importer from Switzerland of the well-known Jardur aviation waterproof Bezel-meter chronographs and the Jardur aviation waterproof wrist-watches. The Swiss cases containing the fine quality 17 jewel movements were of the latest thin type. The Jardur precision timers were especially designed for the pilots, and incorporated outstanding features necessary and desirable in all flying procedure. The Jardur company also was marketing their new Jardur-Warner air navigational plotter, a compact precision instrument with a tolerance within a fractional part of a degree. It was designed by L. A. Warner, former Navy officer and instructor in advanced navigation at the Naval air training station in Pensacola, Fla. The plotter was made of Vinylite for permanent wear, and it met the exacting requirements of student, private and commercial pilots, because of its simplicity and ease of operation. It was used in all kinds of chart work, solution of wind problems, deviation graphs, radio navigation and celestial navigation.

Kollsman Instrument Division of Square D Company, Elmhurst, N. Y. announced an angle of attack indicator, capable of indicating the stall point of the aircraft, most efficient cruising speed and other important flight data regardless of aircraft acceleration, altitude or changes of air density. A new tachometer generator less than one-half the size and weight of the standard generator, yet offering the same qualities of the larger unit was produced. The Kollsman Mach air-speed indicator gave the pilot a continuous indication of both his existing airspeed and its relation to the speed at which he entered the shock wave pattern. It provided for setting of the design Mach number of the aircraft within the limits of .6 to .9 Mach number and a maximum speed stop of 350 to 700 m.p.h. A Mach limit switch also was developed for use on a new design of high speed transport plane to prevent inadvertent entrance into the supersonic speed ranges and consequent damage to the aircraft. A complete set of cabin pressurization controls were developed for the new Douglas DC-6.

Krembs & Co., Chicago, Ill., developed a line of fluxine fluxes of especial interest in aircraft manufacturing where accurate welding was essential. Krembs fluxine fluxes Nos. 18, 43, 41 and 7 were in growing demand. They had passed the severest tests, gave better results and were more economical. For example, 50 lbs. of fluxine flux 43 did the work of 80 lbs. of a competing product, without injurious fumes. Safety from fumes was a feature of the Krembs products.

The Leece-Neville Company, Cleveland, O., produced aircraft generators, regulators, relays and motors. In addition to the conventional DC systems, Leece-Neville continued development and production of high output alternator-rectifier combination systems. These new units, which delivered up to 400 amperes at 30 volts, were made available for postwar military purposes as well as for commercial airline use. Experience gained in providing alternator-rectifier combinations to meet military requirements opened up possibilities for their use on small aircraft. A carbon-pile voltage regulator, used so extensively by the air forces, was modified for commercial applications. Several types of pump motors were developed which operated safely when immersed in fuel, and were used primarily on jet propulsion planes. Similar motors with comparable ratings also were made available for applications where air blast ventilation could be supplied. Engineering research to combine automotive and aircraft type electrical equipment in the interest of economy progressed satisfactorily.

Lodwick Aircraft Industries, Lakeland, Fla., specialized in conversion of surplus Government aircraft for use by civilians, namely for passenger service, executive use and cargo. During 1946 several planes were completed for internationally known aviation men and firms and two for the Peruvian Government, one to be used by the President. Among the conversions completed were a B-25 for Lt. Gen. James H. Doolittle, a B-23 for Gar Wood Industries, a C-47 for Island Air Ferries, a C-47 for J. W. Pawley, a C-47 for Sperry Gyroscope Co., three C-47's for Florida Fresh Air Express, a twin motor Beechcraft for Averell Harriman, and a twin motor Beechcraft for Albert I. Lodwick. Other conversions included several twin motor Cessnas, a Jacobs Beechcraft, AT-6's and BT's. In addition to the conversions, Lodwick Aircraft Industries also offered complete service, repair and maintenance on all types of airplanes. This was a CAA Approved Station. Lodwick Industries, a division of Lodwick Aircraft Industries, and agent for the War Assets Administration was handling Government surplus items, including parts and supplies for aircraft, shop and testing equipment, parachutes and parachute canopies.

Lord Manufacturing Company, Pittsburgh, Pa., during the war

supplied the major portion of vibration isolating mountings and dynafocal engine suspensions used by the armed services. The drastic cut in requirements for aircraft components which followed the war was balanced somewhat by requirements for conversion of military aircraft to peacetime use. This was particularly true in the transport field. The same Lord designs of special tube-form mountings and engine suspension assemblies were required to replace war-weary parts in DC-3's, and thousands of Lord dynafocal suspensions were supplied for reconversion of other models of aircraft.

The immediate demand for personal planes, with emphasis upon smoothness and comfort, created considerable activity in improving mounting systems for aircraft engines from 75 to 400 h.p. This demand for mountings having superior vibration isolating qualities resulted in the development of Lord conical mounting systems. These shear-type mountings were designed to fit engine brackets originally made to utilize common grommets. The installation of Lord shear-type conical mounts reduced pilot fatigue, improved pleasure and comfort in personal planes, and provided improved protection for instruments and radio equipment. In the transport field, progress was made in improvement of wartime designs. Typical was the new Lord MR36-J dynafocal suspension for R2800-C engines. The MR36-J suspension, through its weight-saving, increased aircraft payload by 10 lbs. per engine without sacrifice of strength. Alterations to the snubbing feature of the dynafocal mountings resulted in performance characteristics superior to wartime models. Another development was the Lord light-weight MR-40D dynafocal suspension for R-4360 engines. Development was proceeding on mountings for straight-jet and prop-jet engines, a number of which already had been mounted and had proved satisfactory in service.

To meet the demand for mountings which would protect instrument panels, communication equipment and accessory equipment from vibration without regard for the direction of the disturbing force, Lord developed a new line of mountings named Multiplane. These plate-form mountings had equal spring rates axially and radially. Of particular interest to the aircraft engineer was the fact that Multiplane mountings eliminated the necessity for multiple-mounting arrangements previously used. Simpler to install, lower in cost and easier to service, they proved to be a definite step forward in the protection of delicate aircraft equipment. Another development was a new method of flexibly supporting aircraft radio equipment. In the past, it had been common practice to mount each radio unit separately. The new practice was to group individual units upon a common rack and

install Multiplane mountings to support the entire assembly. This system decoupled the equipment and provided natural frequencies below the operating range of disturbances in the airplane. It also supplied greater stability and improved isolation.

Propeller turbine installations, both direct-connected and extended-shaft type, were mounted successfully by Lord engineers. Extended-shaft types required mounting of the gear box as a separate unit. A satisfactory arrangement was worked out, using the same principle of focalized support which has been used for reciprocating engines. It was designed to satisfy Army specifications regarding natural frequencies. Lord also was active in designing special bonded rubber items such as seals and washers for pressurized cabin installations, a number of which utilized Lord fractional h.p. couplings and multiple h.p. couplings for supercharger and accessory drives.

The MacwhYTE Company, Kenosha, Wisc., produced for the aircraft industry tie rods, cable assemblies for controls, and terminals both loose and attached.

The Glenn L. Martin Company, Baltimore, Md., during the war developed a new elastic plastic, Marvinol resin, a polyvinyl type which extensive tests proved to be suitable for multi-colored wire insulation and many other items replacing natural rubber, including sheeting, shoes and soles, food packages, umbrellas and upholstery materials. The company marketed Marvinol in the form of white powder, and it was bought by the manufacturers of the fabricated products. A three and a half million dollar plant was being put up in Painesville, O., where all production and laboratory work on Marvinol was to be concentrated. It had a wide variety of applications in aircraft—interior finishes, floor and seat coverings, small parts and other articles requiring water, oil and acid-resistant properties. The company also produced ground handling equipment for all types of plane, including adjustable passenger ramps of aluminum alloy. Another development was a new method of photo lofting by which drawings reproduced on metal, wood or other surfaces saved thousands of hours in building jigs and assembly fixtures directly on photo-printed drawings without tracing. This also prevented errors.

Honeycomb was a new featherweight construction material developed by the Martin company and the U. S. Plywood Corporation. Made of honeycomb of cloth or paper sandwiched between and firmly bonded to thin sheets of aluminum, stainless steel, wood veneer or plastic, it was used as flooring in the Martin 202 and 303 transports, where because of the strength of the laminated sheets, the floor became one of the principal structural members of the fuselage. There were

hundreds of uses for the new material, including both flat sheets and curved surfaces. They ranged from walls and partitions in railroad cars to luggage.

Manufacture of Martin Marvinol, a vinyl-type plastic developed by the Martin company, expanded so greatly due to the demand that a \$3,500,000 plant was being built at Painesville, O. for the manufacture of that product. The Martin company did not enter the plastics fabrication field, but was manufacturing Martin Marvinol in powder form to be converted by various manufacturers into a wide variety of end products, including coverings for such items as furniture, luggage, books, handbags and shoe uppers. Other uses included waterproof wallpaper; table, shelf and floor coverings; electric cable coverings, insulating tapes, raincoats, shower curtains, and similar items. A number of Marvinol products are incorporated in the Martin 2-O-2. Such diversified lines helped The Glenn L. Martin Company maintain one of the largest working forces employed in aircraft manufacture during 1946. In February, 1946, the company had 10,400 employees. This number increased steadily throughout 1946 until at the end of the year, employees totaled almost 18,000.

Minneapolis-Honeywell Regulator Company, Minneapolis, Minn., introduced a new fuel quantity indicator, a capacitance type fuel gage accurate to within 5 per cent under extreme conditions of temperature, altitude and plane attitude. The system consisted of a tank unit, cylindrical tubes constructed one inside another and operating as parallel plates of an electric condenser, an electronic amplifier, which translated in terms of electric current the capacitance of the tank unit, and the remote motor driven indicator, which registered the fuel quantity on the instrument panel. It was standard equipment on the Boeing Stratocruiser and B-50, and commercial aircraft. The Honeywell Autopilot was redesigned and improved. The new E-6 Autopilot was less than one-half the weight of its predecessor, and was being produced for the Boeing B-50 and the Consolidated Vultee B-36. The wartime Turbosupercharger Regulator was redesigned for installation in those airplanes and also the Northrop B-35 and Republic XF-12.

The Pioneer Parachute Company, Manchester, Conn., was making many new improvements in parachute efficiency. A principal development was the improved light weight, body-hugging P3-B parachute which was as easy to slip on as an ordinary flying jacket, offering users something entirely new in comfort and safety. Another late development was a quick-fit parachute harness that could be simply adjusted on the wearer, regardless of size or weight, in 3 seconds, by a quick tug

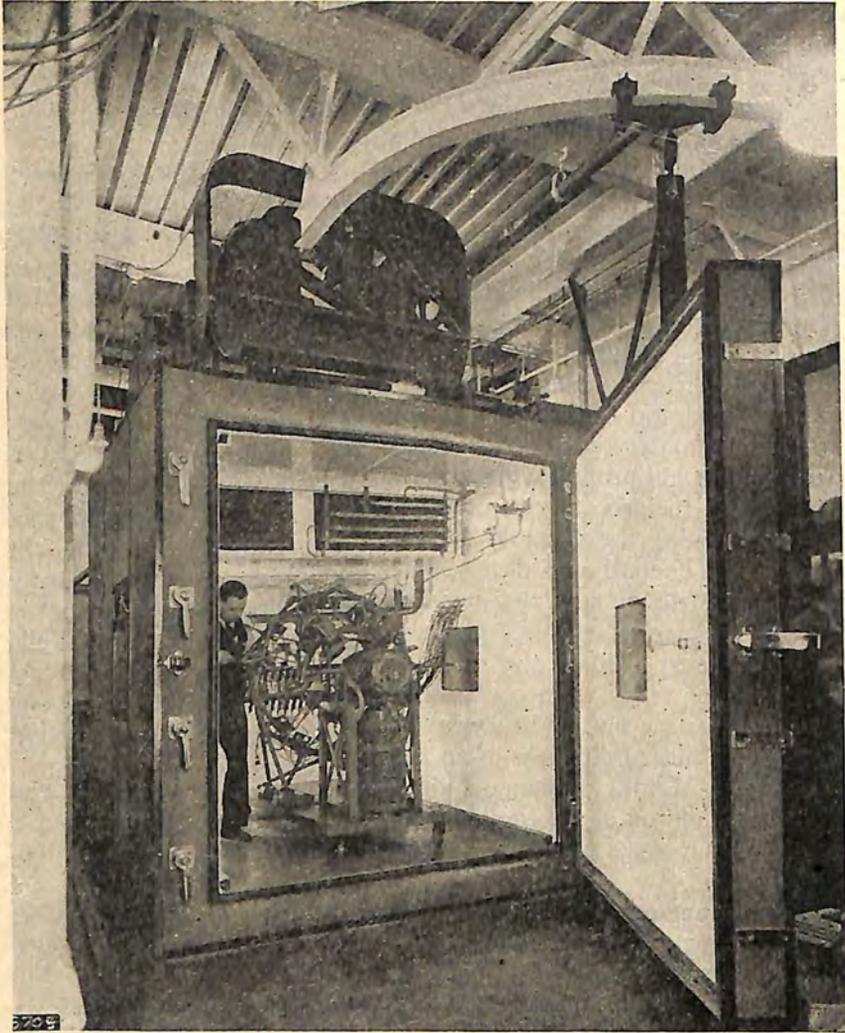
of chest and leg straps. It could be loosened for comfort while in flight, and instantly tightened in an emergency. It could be put on while standing or sitting, either inside or outside a plane. The development of the Quick-Fit Harness overcame the necessity of having each harness fitted to the individual pilot or passenger.

SKF Industries, Philadelphia, Pa., devoted to postwar aviation the techniques and production facilities for bearings that had been developed during the war period. As a result, SKF offered a complete selection of ball and roller bearings. Much of the SKF development work was focused on suitable bearings to operate at the elevated temperatures and high rotative speeds encountered in aircraft gas turbines. As a result of laboratory investigations and ever-increasing practical experience under turbine conditions, SKF made progressive improvements and refinements in both bearing design and manufacture. The familiar construction of the SKF cylindrical roller crankshaft bearing and propeller thrust ball bearing which had proved their reliability in reciprocating aircraft engines was instrumental in successfully meeting the exacting demands of gas turbine operation. In addition, SKF continued development and production of the many types of anti-friction bearings employed on auxiliary apparatus, rocker arms, superchargers, starters, generators and other accessories. Balls and rollers were held to size within 25 millionths of an inch, while dimensions of races were controlled within ten thousandths of one inch. The surface finish of raceways was improved until it was being measured in three millionths of an inch.

Salsbury Motors, Pomona, Calif., a subsidiary of Northrop Aircraft, was building small engines, clutches and transmissions, and a variety of improved industrial turret trucks powered by a 6 h.p. engine.

Saval Company, Los Angeles, Calif., specialized on design and production of a complete series of manual, motor, solenoid and pressure operated selector and shut-off valves for 3,000 psi pressure in the quarter, three-eighths, half inch and three-fourths inch tube size for hydraulic, pneumatic and gas services in aircraft. All those units incorporated Saval's patented "Shear-Seal" design providing many exclusive features. Saval's large experimental engineering department was available for special prototype design and fabrication.

Scintilla Magneto Division of Bendix Aviation Corporation, Sidney, N. Y., converted operations from a wartime basis to peacetime levels, and made significant advances in the development of several products which previously had been retarded by the pressure of war production demands. The Bendix-Scintilla low tension ignition system



SCINTILLA'S ALTITUDE CHAMBER

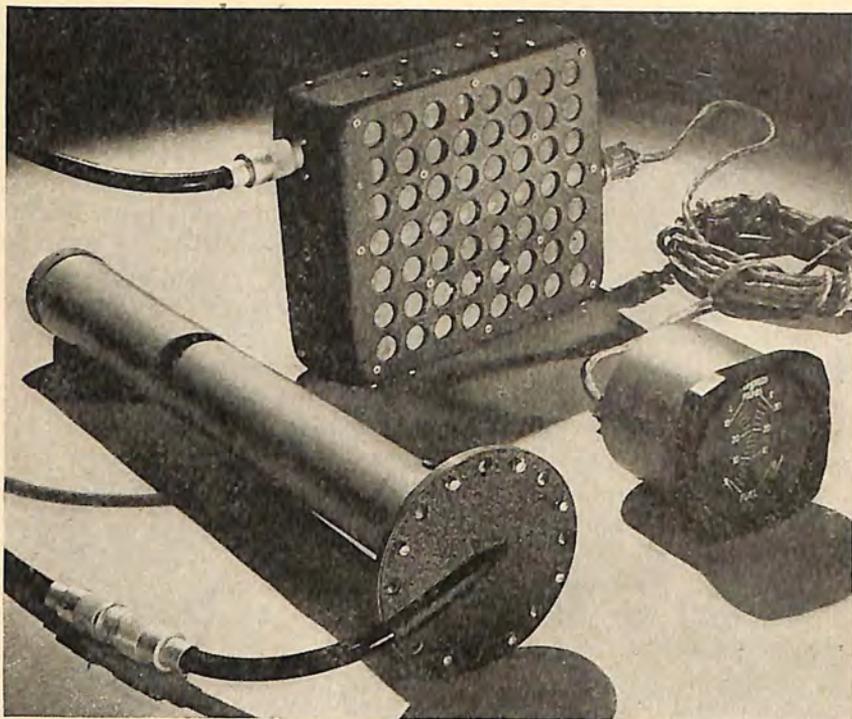
for spark-ignited internal combustion aircraft engines was perfected and put into production, with several major aircraft engine manufacturers contracting for the equipment. Production of high tension magnetos and high tension ignition systems for aircraft and industrial engines constituted a large portion of the company's output. Aircraft ignition switches incorporating new features also were produced in

large quantities. Electrical connectors for aircraft, industrial and ordnance use were much in demand, resulting in establishment of regular production schedules for those items. Other products included one-half engine speed and one and one-half engine speed magnetos for aircraft use; ignition wiring harnesses for aircraft and industrial use; immersion-proof ignition for aircraft, industrial and ordnance use; high tension magnetos for outboard marine engines; ceramic parts; filters for suppression of ignition disturbances contributing to radio interference; electrical wiring harnesses for Diesel buses; molded plastic parts; supercharger pumps for aircraft; aircraft distributor assemblies; aircraft and automotive battery ignition systems; automotive connector blocks; fuel injection pumps and nozzle holders for use on industrial Diesel engines; distributor heads and fingers for aircraft; coils for aircraft and industrial engines; booster coils for aircraft, and a variety of electrical testing instruments.

In addition to standard items, Scintilla maintained an intensive research program. During 1947 special emphasis was to be placed on refining and improving products already in production, and developing other products for special applications in the aircraft, industrial and ordnance fields. Scheduled as major projects in the above categories were ceramics, high frequency spark plugs, multi-cylinder fuel injection pumps for automotive type Diesel engines, high frequency ignition systems for aircraft, immersion-proof ignition for aircraft, industrial and ordnance applications, and ignition for jet propulsion and gas turbine aircraft engines, and a small single-cylinder magneto for use on industrial engines.

Simmonds Aerocessories, Inc., New York, Vermont and California, presented two new products of special interest: 1—the Simmonds Pacitor Gauge, an electronic fuel gauge developed to solve one of the long-standing problems of aviation, accurate measurement of fuel at all flight attitudes and temperatures, and 2—the Simmonds Light Duty Push-Pull Control. The Pacitor gauge was installed by American Airlines on a fleet of converted C-54's, and was specified by Douglas for the DC-6. The Simmonds light duty push-pull control, No. 4L, was an addition to the established Simmonds push-pull line of controls as used in nearly a million aircraft and tank installations during the war.

The Simmonds Pacitor gauge circuit included three basic elements—the tank unit, or condenser, which comprised simple parallel plates, and was installed in the fuel tank; the power unit, which translated in terms of small direct current the electrical capacity of the tank unit as the dielectric changed from liquid to air; and the cockpit indicator,



THE SIMMONDS PACITOR GAUGE

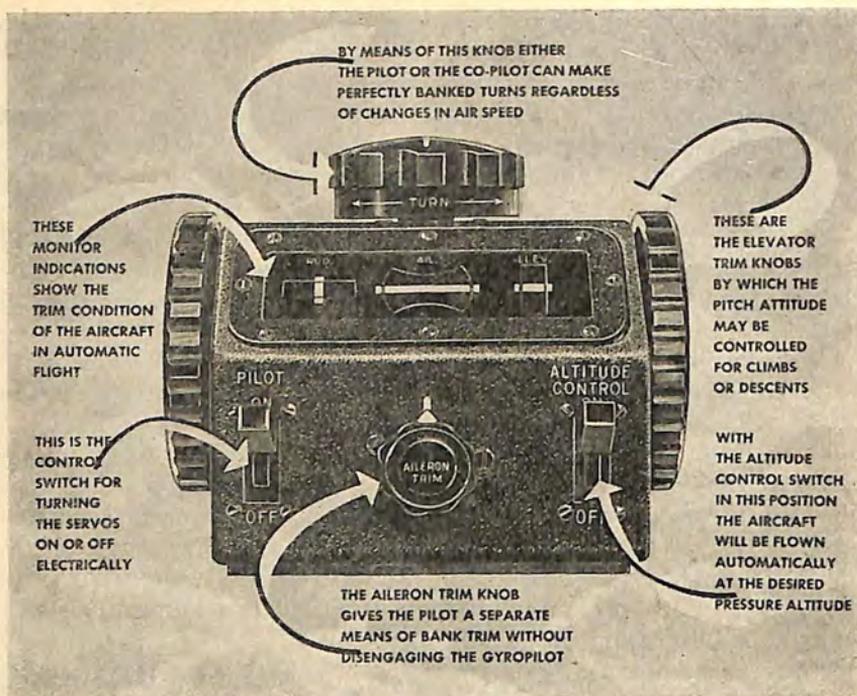
which registered these changes on the instrument panel. There were no moving parts in the Simmonds Pacitor gauge and, once installed, the circuit required a minimum of service or maintenance. Use of the Pacitor gauge resulted in important weight savings by elimination of excess fuel carried solely as a safety factor. Another advantage of the gauge was its reliability in extreme changes in flight attitude or temperature. It measured a mass of fuel over all ranges of fuel temperature and basic specific gravities to within 3 per cent.

Sinclair Refining Company, New York, while continuing to supply the Army and Navy air forces with aviation fuels and lubricants, was directing a substantial amount of its research and development toward ever-increasing product efficiency demand for reciprocal and jet engines. Research laboratories in East Chicago developed a minimum number of greases to cover the complete requirements of the present-day aircraft. This was accomplished through combined efforts of the

engineering staffs of the major airlines, aircraft and engine manufacturers, and the aviation and staff engineers of Sinclair Refining Company. Their successful efforts were directed toward standardizing and minimizing aircraft greases. An outstanding aircraft oil was developed and put in service on some of the major airlines. It was particularly adaptable to Pratt & Whitney and Wright Cyclone engines. Tests constantly were being conducted on aircraft oils to meet increasing demands placed upon lubricants by higher horsepower engines and future engines. To minimize the lead content of aviation gasoline, Sinclair was conducting laboratory engine tests with different variables of leaded gasoline, enabling them to analyze specific deposits remaining in the engines. The experiments were in keeping with stringent requirements placed upon fuels and lubricants to obtain the ultimate in safety and the maximum in efficiency. The third edition of Sinclair's Aircraft Engine Lubrication booklet was widely used in various classrooms throughout the country where problems concerning aircraft engine lubrication were discussed. The booklet's contents embraced general design of aircraft engines, medium and high output engines, oil circulation systems of the major aircraft engines, specifications and tests, aviation greases, and all other pertinent data relating to aircraft and engine lubrication engineering problems.

Sperry Gyroscope Company, Great Neck, N. Y., produced its revolutionary precision gyropilot A-12 for both airline and military use. Passenger and cargo airlines both at home and abroad were specifying the A-12 for their fleets of transports either being delivered or under construction. The transports included the Boeing 377 Stratocruiser, Consolidated 240, Douglas DC-3, DC-4 Skymaster and DC-6, Martin 202 and 303, and Republic Rainbow. As a result of extensive service testing of the A-12 (AAF type E-4) the Army Air Forces had a program for use of the gyropilot and its automatic approach accessory in new production aircraft.

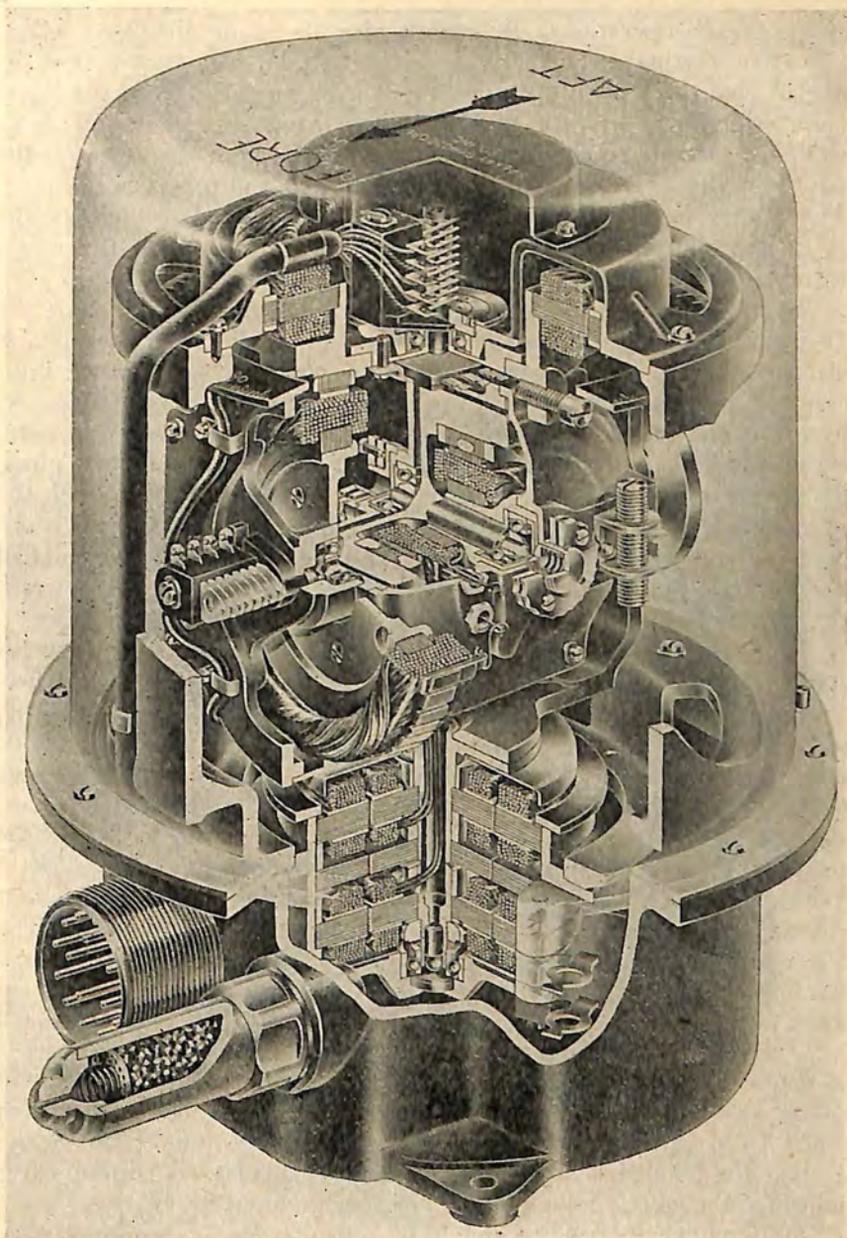
When in 1946, United Air Lines became the first to put into scheduled service the A-12 gyropilot with automatic approach control, United officials acclaimed the device as marking an important advance toward greater schedule reliability and complete automatic flight. Airlines which were installing approach control, planned to use this feature in conjunction with localizer and glide path equipment being installed in many airports by CAA. Tests by the Services, the airlines and the Sperry air laboratory ships indicated that precise automatic approaches by the control accessory and existing landing systems were dependable. The little black box of the automatic approach control component also could be used for flying the new VHF ranges between



SPERRY A-12 GYROPILOT PEDESTAL CONTROLLER

airports. The approach control coupled the VHF range signals to the A-12 gyropilot in such manner that the A-12 flew the range between cities automatically. Sperry engineers pointed out that with the electronic gyropilot as a basic instrument, a plane not only could approach closed-in airports by automatic means, but it also could navigate safely, surely and automatically on VHF beams defining a flight lane between major cities.

Following several years of flight testing experimental versions of an automatic airspeed control, Sperry introduced its model E-1, comprised of 3 components—a throttle servo, an airspeed control amplifier and an airspeed control switch. By automatically operating all throttles as though they were one, the Sperry E-1 airspeed control maintained the airspeed existing at the time it was turned on. Any one throttle could be reset manually, if desired, while the airspeed control was on, by slipping the friction clutch. This new device, nearing the production stage, was most useful during holding, let-down



CUTAWAY VIEW OF THE SPERRY GYROSYN COMPASS CONTROL,  
A-12 GYROPILOT

and approach operations. By maintaining the same air speed before and after starting down the glide path, the pilot was sure that every degree change in pitch attitude caused a degree change in the flight path, which was essential for good performance. When an A-12 equipped aircraft reached the desired distance from the runway, the pilot took the wheel, pressed the release button and proceeded to land. The Sperry E-1 airspeed control was completely independent of the A-12 gyropilot except that the electric release button on the wheel turned off both airspeed control and the gyropilot.

Sperry expanded its line of small aero instruments to include the H-3 gyro horizon, a newcomer rivaling the popularity of the air and electric operated attitude gyros. The H-3, while not novel in the indication it provided, was a step forward in instrumentation, in that its gyro was non-tumbling. It provided unlimited indication in bank; and eliminated the caging mechanism and its attendant knob. In pitch, the climbs or glides up to 27 degrees could be indicated, although the gyro would not upset when that range was exceeded. The precision-built horizon indicator was constructed to meet the requirements of high altitude flying and extreme temperature operations. Turn error compensation was provided in this electrically driven instrument.

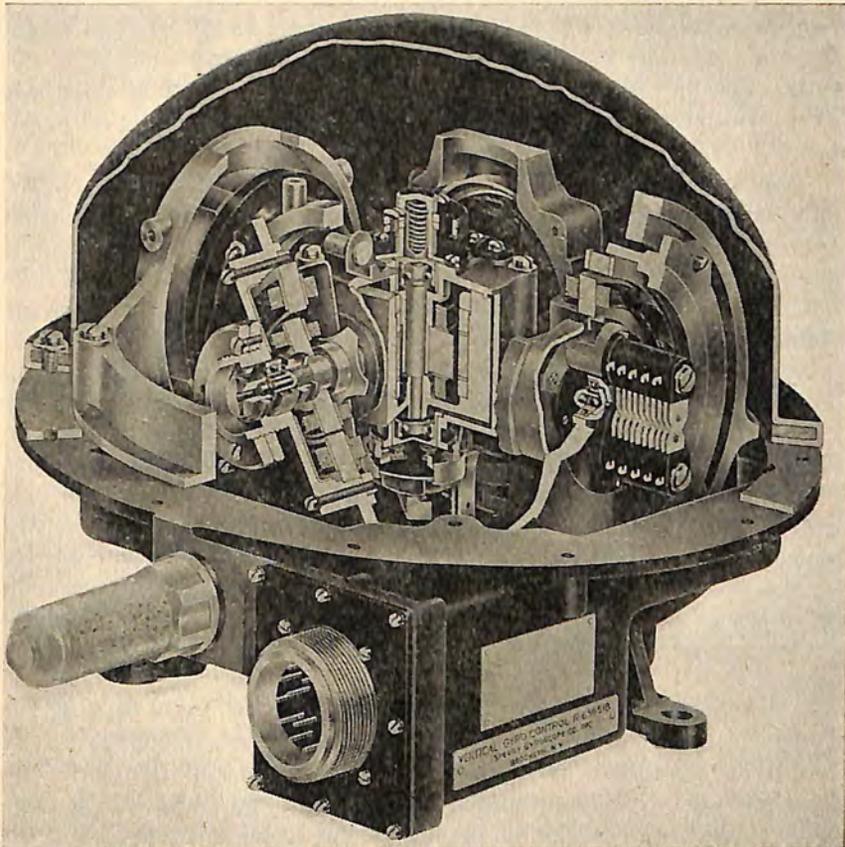
Five other gyro instruments, all designed to meet the demand for standard 3 3/16 in. panel cut-out mounting and incorporating new features important to commercial and private flying, were introduced by Sperry. Two of the 3 new directional instruments were gyrosyn compasses which operated electrically, and like earlier models, gave pilots an indication of magnetic north without northerly turning error. Because the heading did not drift, periodic course resetting was not required. The C-2 gyrosyn had a rotating pointer moving against a fixed dial, with a reference marker or course setter added for convenience in turning to a new course or remembering an old one. The C-2A featured a rotating dial with a fixed lubber line, with reciprocal headings indicated through a window in the lower half of the instrument face.

To satisfy the requirements of the small personal airplane, the G-3 directional gyro was developed by Sperry as a companion instrument to the widely-used model F-3 air-driven attitude gyro. This instrument had a fixed dial with a rotating pointer, but the pointer could be set so that the pilot always flew in the upper quadrant. A course setter indicated the course to be flown. The G-3 was non-tumbling.

New model Sperry F-4 and F-4A attitude gyros were being produced for those pilots preferring pattern indication. The gyros in both were electric-driven, non-tumbling, and were compensated for

turn error. The F-4A had a supplementary sensitive pitch indication which aided the pilot in determining the trim condition of his aircraft with a high degree of accuracy at points near level flight trim attitude.

New models of detonation indicating equipment were introduced by Sperry, including a new knockometer for detecting trace knock and discrimination between fuels separated by a fraction of an octane number. The products in this category were designed to meet the requirements of the airline operator, the engine designer or research engineer and the fuel refiner. Latest development in this field was the engine analyzer, first airline installations of which were to be made in 1947. The instrument provided continual visual analysis of the



CUTAWAY VIEW OF SPERRY VERTICAL GYRO CONTROL,  
A-12 GYROPILOT

complete aircraft power plant during flight. On the analyzer scope, the flight engineer could examine at any time during flight the characteristic patterns of engine vibration, ignition system performance and synchronization between magnetos and between engines. These patterns detected located and identified malfunctions and imminent failures that might occur during engine operations, and they permitted the flight engineer to adjust the engine for optimum performance. Patterns could be examined singly for an individual cylinder or simultaneously for all cylinders. The installation of models for either 2 or 4 engine craft included vibration pickups which screwed on the cylinder. Manifold, synchronizing switch and junction box were mounted in the engine enclosure. Cylinder and condition selector switches and the indicator could be supplied either in one unit ready for mounting or as separate units for mounting in an instrument panel or flight engineer's console. Location of an amplifier power supply was optional. The indicator was a 3-in. oscilloscope tube with a start-stop sweep, with power requirements 0.6 amp., 115 volts, 400 cycles, single phase.

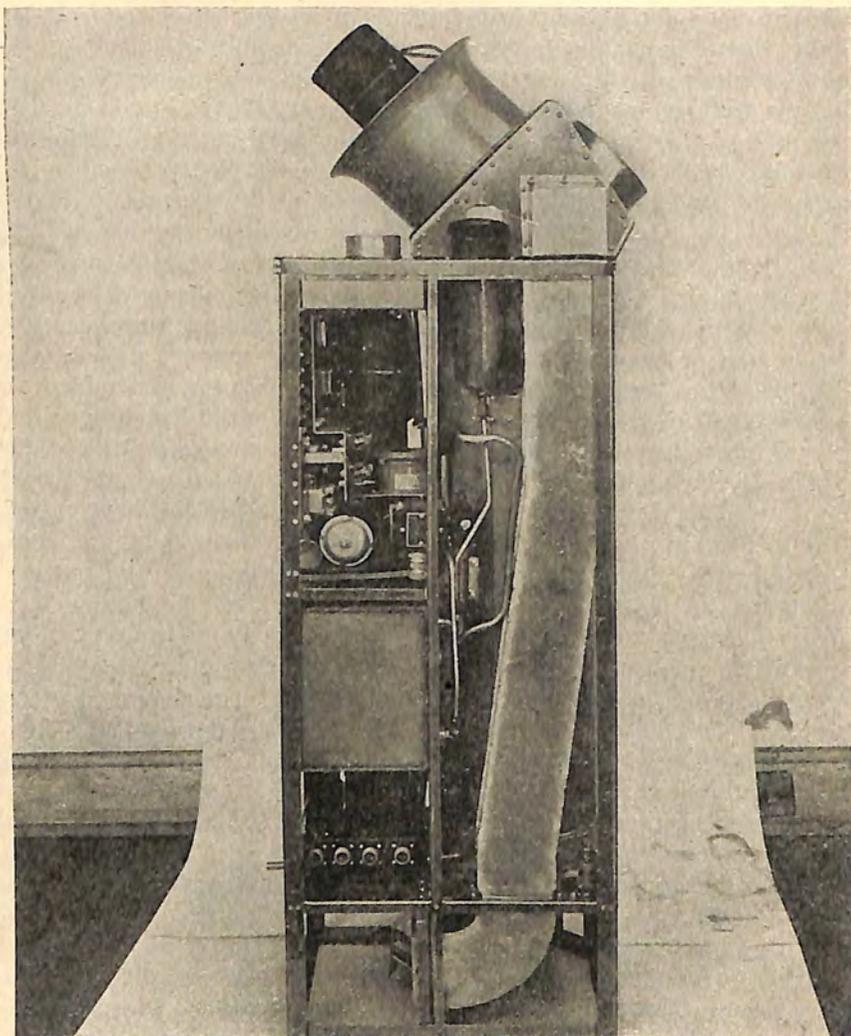
Standard Oil Company of California, San Francisco, in November, 1946, announced the reinstatement of its prewar plant roof air marker program. This activity when completed would add 700 airway guide signs to the air marker pattern in the 7 Pacific West States, Alaska and Hawaii, where Standard of California sold aviation petroleum products.

Stratos Corporation, Babylon, Long Island, N. Y., an affiliate of Fairchild Engine and Airplane Corporation, developed airborne cabin pressurizing and air-conditioning systems capable of maintaining sea-level pressure at altitudes up to 10,000 ft. At altitudes up to 24,000 ft. it maintained cabin pressure equivalent to 8,000 ft. Comfortable temperature was maintained automatically. Stratos Corporation was awarded a \$2,000,000 contract by the Glenn L. Martin Company for construction of cabin pressurizing and air-conditioning equipment for the Martin 3-0-3 transport. This was in addition to AAF contracts for development of airborne pressurizing and air-conditioning equipment.

Superior Tube Company, Norristown, Pa., in 1946 equalled its production figures of the war years. Plans that were interrupted in 1940 were immediately put on schedule when Germany capitulated so that when the war with Japan ended in August, 1945, there was a completely blueprinted outline of the equipment to be revamped; and the company resumed on a large scale production for civilian consumption. Before the end of 1945, nearly all this program had been completed so

that in 1946, the production of tubing in steels, alloy and stainless steels, nickel, monel, inconel and beryllium copper had been set up with its distributor organization. A feature of 1946 was the heavy demand for the tubes trademarked Weldrawn, principally in stainless. Distribution of that type of tubing was beyond anything that had heretofore been attained. In the field of electronics, the plant erected for the exclusive production of that type of tubing, principally nickel, had to be speeded up so that the pent up requirements of the country could be met. In connection with that department arrangements were made for the distribution in the export markets. A new line outside of any connection with aviation, in fact almost new for tubing, was the heavy production of beryllium copper. It was found that for fishing rods this metal was the long awaited for ideal, suitable for either fresh or salt water fishing. By the end of 1946 a great variety of designs had been approved by manufacturers of rods. The notable feature of the whole development being the salt water market. At the close of 1946 Superior Tube Company acquired by purchase from the War Assets Administration, the Pacific Tube Company which in 1943 was engineered by the Superior organization for the Government and put into operation in August of the same year. Pacific Tube Company operated as a separate corporation, producing up to the end of 1946 alloy and carbon steel tubing, as well as stainless steels. Early in 1946 that company also started the production of bars. The management of the company announced that this mill on the West Coast would be a service mill, with enough ground available to put mill capacity in specialty fields up to any market requirements.

Surface Combustion Corporation, Toledo, O., adapted to transports and personal aircraft its Janitrol heater with whirling flame, which had been developed during the war and installed on military planes of all types. Further development work resulted in improved positive spark ignition systems, greater BTU output in lighter and smaller packages and a wider range of models. Early in 1947, the line ranged from 15,000 to more than 300,000 BTU ratings. The new Janitrol for commercial planes was a complete heating package containing heater, all controls and accessories in one compact unit. They could be replaced in 15 minutes. That quick replacement feature eliminated the former necessity of holding an airliner on the ground for long maintenance work on heaters. A new 100,000 BTU combustion-type Janitrol, operating independently of the engines, and in a single package was developed for the hundreds of DC-3s reconverted after the war. It provided heat on the ground while engines were not running, and also provided a fuel pump, high voltage and dependable spark ignition



SURFACE COMBUSTION'S AIRCRAFT HEATER

system, ventilation and combustion air blowers, sensitive thermostatic temperature controls and other component parts. It weighed only 100 lbs., and was enclosed in an aluminum alloy jacket 12 by 15 by 49 in. in size. It was adaptable to many other types of airplane. The Douglas Globemaster was equipped with several Janitrol heaters for cabin

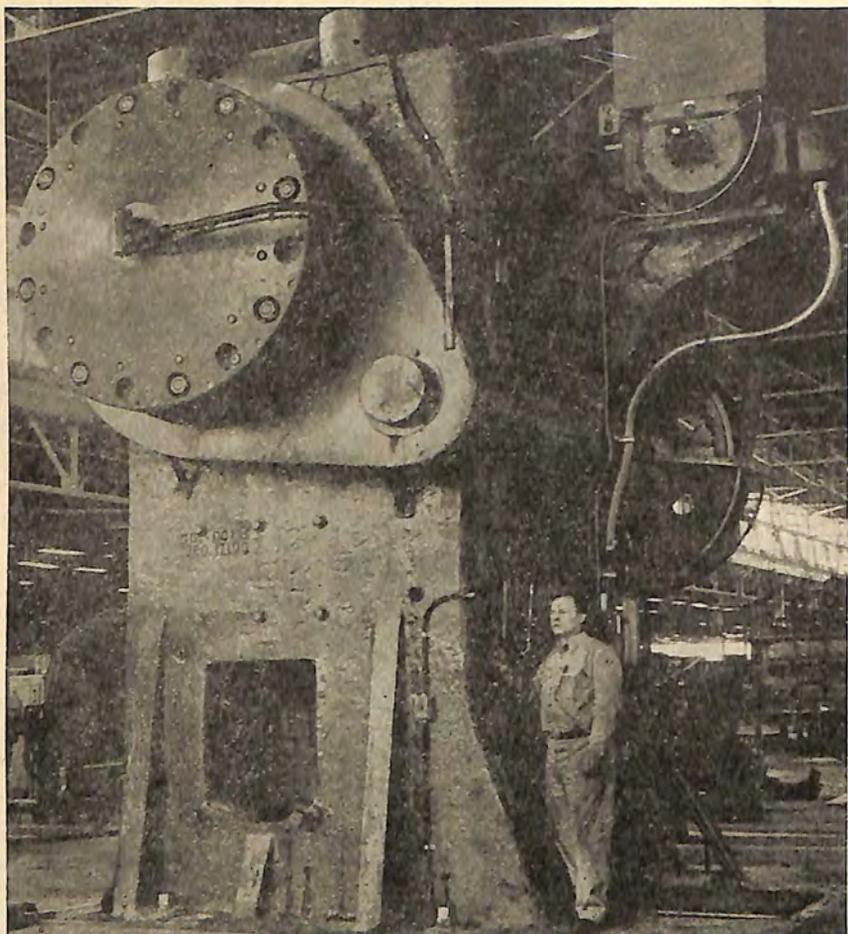
and instrument heating, and also for hot wings. The Douglas DC-4 and DC-6, Curtiss-Wright Commando, Lockheed Constellation in some models, and some still secret military planes used Janitrols, while special Janitrols were being installed on several personal plane models. A late model 49 Constellation had a Janitrol especially designed for the plane's pressurized cabin. Janitrol heaters were being used in increasing numbers for anti-icing installations.

The Texas Company, New York, accelerated its research efforts. Of the several million dollars spent each year for this purpose, a substantial amount was allocated to research on aircraft fuels, lubricants and lubricating greases. The company was successful in reducing the number of products required for aircraft lubrication. Four greases were all that were required, and it was believed that even that number could be reduced. One was the development of a low evaporation low temperature grease which could be used at temperatures of  $-75$  deg. F. and lower, yet was suitable for temperatures as high as 250 deg. F. and, for limited periods of time, at 300 deg. F. Improved fuels and lubricants for both jet and reciprocating engines were developed.

Thompson Products, Cleveland, O., greatly expanded its production of jet engine turbine wheels, nozzle diaphragms, and compressor rotor and stator assemblies. The company in its Euclid, O., plant increased the number of employees working on jet propulsion components from 240 to 1,125. It was manufacturing a substantial part of all military jet propulsion contracts, through jet engine builders. Overall employment in the company's five plants increased from 8,000 at the end of 1945 to 12,400 early in 1947.

Continuing production of aircraft fuel systems for peacetime use, Thompson Products was manufacturing a wide range of hydraulic couplings, centrifugal and axial flow compressors and other hydraulic and pneumatic devices for aircraft. Many of those units called for wheels with complex blade contours to gain maximum operating efficiency. Special milling processes for shaping such blades gave broadest scope to the designing engineers. The production of sodium-cooled exhaust valves and other hardened and ground parts for piston-type aircraft engines rose steadily with the peacetime expansion of commercial and private flying.

Topflight Tool Company, York, Pa., besides its popular line of aircraft production tools, developed a new kind of pressure sensitive tape label which soon was in wide demand in this country and abroad. It was during the war that laminated, pressure sensitive tape labels came into being. One of the largest aircraft plants wanted parts markers to expedite fighting equipment down the assembly line. During the ex-

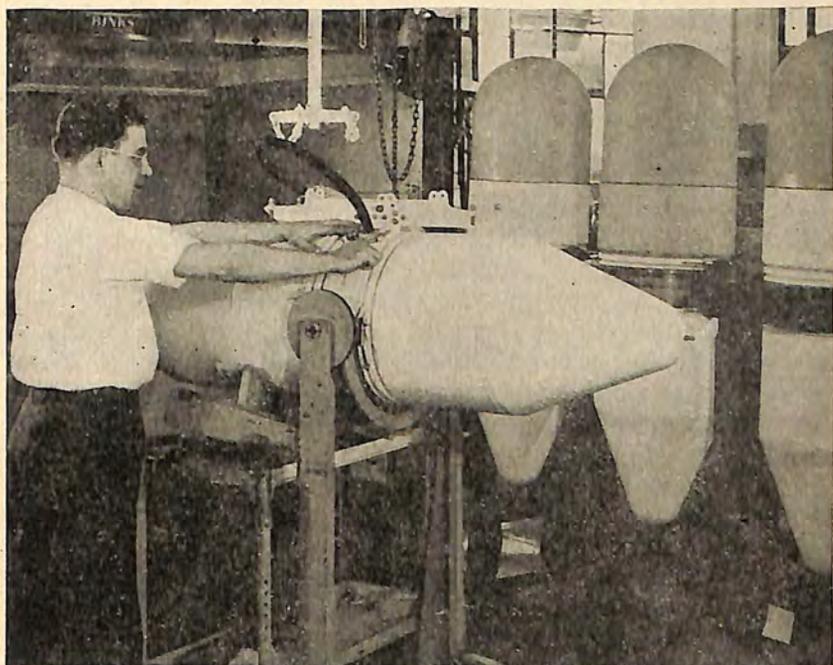


THOMPSON PRODUCTS COINING PRESS FOR JET BLADES

perimental stage, Topflight Tool Company became interested in this marking problem, and developed a tape printing machine to accommodate aircraft customers. As peace came and priorities were relaxed, Topflight introduced printed tape labels from a creative point of view; and acceptance was immediate. Because industry had a wartime acquaintance with the efficiency of marking labels the basis had been provided for acceptance in that field. Manufacturers easily saw the advantages of marking labels for peacetime production programs.

Aside from marking, coding and identifying, Topflight followed through with trade mark, service instruction and advertising labels attached to finished products. Topflight labels were a pressure sensitive product. They performed sticking jobs with a minimum loss of time and maximum rate of dependability. They were produced in rolls to fit standard tape dispensers. Another outstanding feature of the labels was the fact that they were laminated. Lamination was accomplished by adding a layer of transparent tape over the printed surface. Aside from protecting the printed surface against abrasion, water, oil and grease, lamination built up strength and added sparkling freshness to the labels.

The Western Electric Company and Bell Telephone Laboratories, New York, continued their service to the air forces and made available to commercial aviation many types of equipment and components developed during the war. In addition, they cooperated with the airlines and manufacturers in adapting the latest developments to meet the problems facing postwar aviation. The ARC-1 radio transceiver was



WESTERN ELECTRIC EQUIPMENT

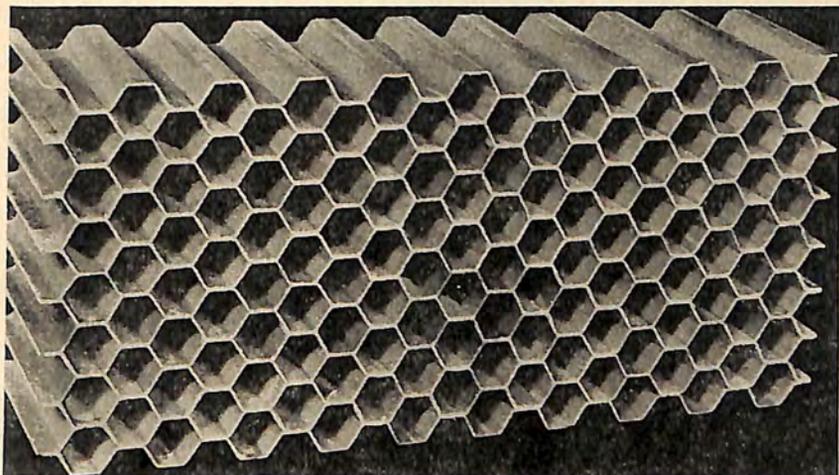
accepted as standard airborne equipment for VHF communications by every airline operating in the United States and many in other countries. As airline operations depended to an increasing extent on VHF communications, the ARC-1 continued to serve aviation in peace as it did in war. Extensive tests were made in cooperation with TWA to determine the manner in which radar could best serve commercial aviation and the type of equipment necessary to perform the functions required. The results of these tests were satisfactory, and did much to hasten the use of radar on commercial flights.

Many new components supplied by Western Electric made possible the development of improved instruments and other devices. Varistors of various types were developed for an ever increasing number of applications in aviation. Thermistors, a varistor with resistance varying inversely with temperature changes, found increased usage in various types of temperature measuring and control devices. Glass sealed switches and relays were widely used in high altitude planes and jet controlled rockets. Aviation research and manufacture were provided with new tools to aid in further development. The Fastax camera, a high speed camera capable of film speeds of up to 8,000 frames per second, became more generally available for use where it was desirable to observe high speed motion in detail. The Mirragraph (Multiple-Image-Recording-Reproducing-Analyzing-Graph) was further developed for study of vibration and vibratory stresses in structures, propellers and engines, either in flight or on the ground. This device, handled by the Electrical Research Products division of Western Electric, recorded in graph form simultaneous phenomena from up to 12 sources. Thus the details of an experiment or test can be recreated and analyzed in the laboratory for study. The Western Electric Noise Analyzer and Recording Frequency Analyzer were developed for the purpose of providing simplified, reliable, and portable equipment for acoustic measurement and analysis and testing and inspection of products for quality control. They found multiple applications in noise measurements and analysis in the aviation industry.

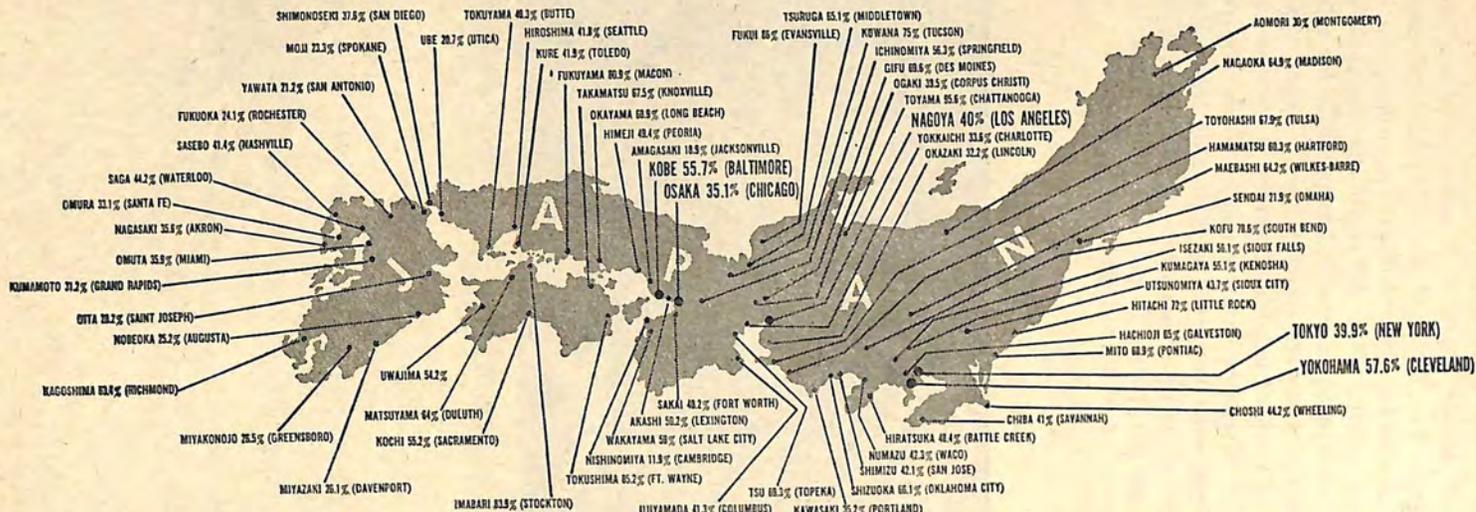
Aviation communications was further improved by the advent of the lightweight Model 31 Teletype Printer and Converter which was introduced experimentally in 1946. This equipment, developed by the Teletype Corporation, was smaller and lighter than a standard typewriter, and it transmitted printed communications between plane and ground over existing radio circuits.

Although the demands of the armed forces were reduced greatly from the efforts of the preceding years, Bell Laboratories and Western

Electric continued with development work and limited production on new types of equipment. For instance, the AN/ARC-28 radio relay equipment was developed and produced to provide improvements over the AN/ARC-18 equipment. The AN/ARC-28 provided greater flexibility and reliability in operation as well as facilities for emergency communication in the event one of its two transceivers happened to fail. The AN/ARC-12, another new development, provided for amplitude modulated radio telephone communications in the frequency range of 225-350 megacycles between aircraft and from aircraft to ground stations. Many design problems were solved in providing this equipment operating in the higher frequency band.



U. S. PLYWOOD MARTIN WELDWOOD HONEYCOMB CORE



U. S. Army Air Forces Map

## THE STRATEGIC BOMBING OF JAPAN

This map shows how our AAF bombers covered Japanese centers and what per cent of each city was destroyed. The size and importance of the cities are shown by comparable American cities.

CHAPTER XIII  
STRATEGIC BOMBING SURVEY OF JAPAN

How We Attained Superiority Over Japan's Air Forces—Our Bombing Strategy—Success of Japan's Kamikaze Pilots—Our AAF 20th Air Force Devastates the Japanese Homeland—Report on the Results of Atomic Bombing—Recommendations for American Security.

THE United States Strategic Bombing Survey was established on November 3, 1944, to study the effects of our aerial attacks on Germany. The Summary Report regarding the German survey was published in *The Aircraft Year Book* for 1946. On August 15, 1945, President Truman requested the Survey to conduct a similar study of the effects of all types of air attack in the war against Japan. The following Summary Report was issued in July, 1946. The officials of the Survey in Japan, all civilians, were: Franklin D'Olier, Chairman; Paul H. Nitze, Henry C. Alexander, Vice Chairmen; Harry L. Bowman, J. Kenneth Galbraith, Rensis Likert, Frank A. McNamee, Jr., Fred Searls, Jr., Monroe E. Spaght, Dr. Louis R. Thompson, Theodore P. Wright, Directors; and Walter Wilds, Secretary. The Survey's complement provided for 300 civilians, 350 officers, and 500 enlisted men. Sixty per cent of the military segment of the organization for the Japanese study was drawn from the Army, and 40 per cent from the Navy. Both the Army and the Navy gave the Survey all possible assistance in the form of men, supplies, transport and information. The Survey operated from headquarters in Tokyo, with subheadquarters in Nagoya, Osaka, Hiroshima, and Nagasaki, and with mobile teams operating in other parts of Japan, the islands of the Pacific, and the Asiatic mainland. The Survey secured the principal surviving Japanese records and interrogated top Army and Navy officers, Government officials, industrialists, political leaders and many hundreds of their subordinates throughout Japan. It was thus possible to reconstruct much of wartime Japanese military planning and execution, engagement by engagement and campaign by campaign, and to secure reasonably accurate data on Japan's economy and war production, plant by plant, and industry by industry. In addition, studies were made of Japan's overall strategic plans and the

background of her entry into the war, the internal discussions and negotiations leading to her acceptance of unconditional surrender, the course of health and morale among the civilian population, the effectiveness of the Japanese civilian defense organization and the effects of the atomic bomb. Following are essential excerpts from the Strategic Bombing Survey of Japan:

"Following the initial (Japanese) successes at Pearl Harbor, Malaya and in the Philippines, Wake and Guam were occupied in December, and Rabaul in January. The Japanese gained air superiority in Burma with the loss of 102 planes and, with troops specially trained for jungle fighting, occupied that area at a cost of 7,000 soldiers killed. At the end of four months of war, they had carried out the substance of their initial program and with greater ease than they had foreseen. Total merchant shipping losses were 51 ships. Much of the equipment which had originally been scheduled for movement into the southern islands was found to be unnecessary and was left behind in order to achieve greater speed. Certain of the Japanese leaders were concerned by the skillful and unexpectedly determined resistance of our ground forces in the Philippines. They attributed this in part to inefficient Japanese close-air support. But in some circles, the skill and determination with which our isolated forces conducted the defense was correctly assessed as an ominous cloud on the horizon.

"The magnitude of these successes encouraged the more daring Japanese planners to consider expansion beyond the original perimeter. During their discussions, the Doolittle raid of April 18, 1942, struck Tokyo. Although the damage caused was inconsequential, the reach of the attack supported a growing feeling that the Japanese perimeter would gain in strength if it had greater defense in depth.

"Accordingly a new plan was approved, providing for (a) an advance into the Solomons and Port Moresby, to be followed, if successful, by a further advance into New Caledonia, Samoa and the Fiji Islands, (b) the capture of Midway, and (c) the temporary occupation of the Aleutians. Accomplishment of such a program would cut off the line of communication between Australia and the United States, reduce the threat from Alaska, and deny the United States all major staging areas more advanced than Pearl Harbor.

"By stretching and overextending her line of advance, Japan was committed to an expensive and exacting supply problem, she delayed the fortification of the perimeter originally decided upon, jeopardized her economic program for exploiting the resources of the area already captured, and laid herself open to early counter-attack in far advanced and, as yet, weak positions.

"Prior to Pearl Harbor it had been decided that, in the event of war, Germany would have to be eliminated first, and that our initial role in the Pacific would, in large measure, be defensive. But Japan's offensive capabilities were underestimated; it was thought possible to hold the Malaya barrier, successfully engage the Japanese fleet in the Central Pacific, and lay the foundations for an eventual advance against Japan itself. The United States plan had little basis in reality. With the forces then available no adequate plan of defense was possible. The loss of relatively antiquated battleships at Pearl Harbor did not substantially reduce the actual combat capabilities of our Navy at that time as opposed to the Japanese Navy with its superiority in aircraft carriers and battle line speed. To have implemented an adequate plan in December 1941, would have required better intelligence regarding Japanese intentions and capabilities, an earlier understanding of the predominant and indispensable role of air strength and full public support for the necessary appropriations, well before the actual outbreak of war. As it developed, all that we could do prior to May 1942, apart from the resistance of our isolated forces in the Philippines and sporadic carrier and land-based air raids, was to build up our strength in Australia and the islands lying between Pearl Harbor and Australia, while bringing to fruition our training and production programs.

"United States preparations were still inadequate when it became evident that the Japanese intended to advance south from the Bismarck Archipelago, and thus threaten our communications with Australia. It was decided nevertheless to attempt to hold Port Moresby and a line north of Espiritu Santo and the Fiji Islands. Exceptional intelligence gave us advance information that a group of transports, protected by the Japanese carrier Shoho and by a covering force including two other carriers, was on its way to occupy Port Moresby in May 1942. This information enabled us to concentrate at the appropriate point two of our four carriers then available in the Pacific (one had come to the Pacific from the Atlantic, but two were returning from the Doolittle raid on Tokyo), and to sink the Shoho by torpedo-plane and dive-bomber attack. In the ensuing air engagement with the covering force, we damaged one of the Japanese carriers in that force, but lost the Lexington. The Japanese force had two carriers left to our one, but their air groups had been badly depleted. The transports turned back from Port Moresby to return to Rabaul and, for the first time, the Japanese advance had been checked. The combat in this Battle of the Coral Sea was entirely carrier air action.

"Similar intelligence provided advance information as to the Japa-

nese move toward Midway in June. In this case, the transports were supported by an advance striking force, including the most powerful surface forces yet assembled in the war and four of Japan's remaining eight operational carriers. An additional Japanese carrier was in a supporting force farther to the north. Again only weaker forces were available to the United States; three carriers, the Enterprise, Yorktown, and Hornet, the only ones available for combat action in the Pacific at that time, were rushed to the attack. Our planes located the Japanese fleet and sank three of the enemy carriers, and so damaged the fourth that she subsequently fell an easy prey to a United States submarine. Deprived of its carriers the Japanese Fleet was forced to retire despite its preponderance in heavy ship strength. Survey interrogations of surviving officers from the Japanese carriers indicate that they were sunk by carrier-based dive bombers. Two-thirds of the pilots on the Japanese carriers sunk were rescued by Japanese destroyers. Some of the Japanese carrier-based planes discovered our carriers and succeeded in damaging the Yorktown so seriously that she went dead in the water and was sunk by a Japanese submarine. Except for the finishing off of stragglers by submarines, the combat in this engagement was entirely air action.

"Immediately after Midway, the Japanese had four carriers fit for action, shortly to be joined by a fifth; but of these only one was large. In addition, they had six carriers under repair or construction. The United States had three large carriers operational in the Pacific and 13 carriers, and 15 escort carriers, either being readied for operation, or under construction. The Japanese Navy, thereafter, was hobbled by its weakness in the air, and could engage our forces only at night or under cover of land-based air until that air strength was rebuilt. A balance of naval air power in the Pacific, and as a consequence a balance of naval power as a whole, was thus achieved at Midway.

"The scene of intense conflict shifted back to the islands south of Rabaul, the seas surrounding them, and the air over both. The Japanese had determined to renew their efforts to capture Port Moresby, if necessary by the overland route from the northern shore of New Guinea, and were constructing airfields in the Solomons. The United States Joint Chiefs of Staff ordered a two-pronged attack; one directed toward northern New Guinea from Port Moresby, the other up the chain of the Solomon Islands beginning with Guadalcanal; both with the final objective of capturing Rabaul. Gen. MacArthur and Adm. Ghormley considered the forces available to them inadequate, but, in view of the importance of maintaining the line of communication with Australia, they were ordered to go ahead with what they

had. A test of the Japanese perimeter thereby developed earlier than the Japanese had expected.

"While the Southwest Pacific command was building airfields in northern Australia, Port Moresby and Milne Bay, the Japanese landed, on July 21, 1942, at Buna on the north coast of New Guinea opposite Port Moresby and infiltrated over the Owen Stanley Range. Their lines of communications were cut by air attacks, their advance columns strafed and their attack held and pushed back by ground forces, in part supplied by air. The Japanese testify that they were unable to reinforce this attack to the extent they had planned because of developments at Guadalcanal.

"On August 7, 1942, a surprise landing was made on Guadalcanal. Three United States carriers gave initial air support and the Marines who landed quickly captured the airfield (later named Henderson Field) which was under construction by the Japanese. Interrogation of the senior Japanese commanders involved in the Solomons campaign indicates that they originally misjudged the strength of our attack and sent in only one reinforcement battalion of 500 men on fast destroyers from Truk. After this battalion was virtually destroyed, they sent in five more which again were not quite sufficient. Finally, they attempted to send in whole divisions. Thirty thousand troops were landed but, by that time, it was too late. Local control of the air provided by planes based on Henderson Field made it possible, but barely possible, to defend our unloading supply ships in the daytime, and made it impossible for the Japanese to land, except at night and then under hazardous and unsatisfactory conditions. The efforts of the Japanese to run in reinforcements at night, and at times to shell our shore installations, resulted in a series of night naval surface engagements which caused heavy losses to both sides. Our air strength was initially limited, was maintained by desperate and irregular reinforcement, and at one time was reduced by enemy naval bombardment to only five operational airplanes. The Japanese constructed a chain of airfields between Guadalcanal and Rabaul, and attempted to raid our ships and installations. In the air actions, however, they suffered increasingly heavy losses, not merely in numbers, but also in proportion to United States losses. The Japanese paint a vivid picture of the intolerable position in which inability to achieve air control placed them. Gen. Miyazaki testified that only 20 per cent of the supplies dispatched from Rabaul to Guadalcanal ever reached there. As a result the 30,000 troops they eventually landed on Guadalcanal lacked heavy equipment, adequate ammunition and even enough food, and were subjected to continuous harassment from the air. Approximately 10,000 were

killed, 10,000 starved to death, and the remaining 10,000 were evacuated in February, 1943, in a greatly weakened condition.

"By the end of 1942, the most serious of the Japanese attempts to drive us off Guadalcanal had been thrown back and Allied operations to capture the Buna area were drawing to a close. We were securely established in these critical areas and had gradually built up local superiority in all arms, air, ground and sea. Our losses had been heavy. The Japanese, however, had suffered a crucial strategic defeat. Their advance had been stopped, their strategic plan fatally upset, many of their best pilots lost, and Allied forces firmly installed in positions in the Solomons and New Guinea, which threatened the anchor of their perimeter at Rabaul. In opposing this threat, the Japanese committed in piecemeal fashion and lost all of their fully trained Navy air units, including those rescued at Midway, and a portion of their best Army air units. The Japanese never fully recovered from this disaster, the effects of which influenced all subsequent campaigns. For the first time, the few Japanese who had all the facts at their disposal appreciated the seriousness of the situation. Greatly expanded programs for the training of pilots and the production of aircraft, radar and communications equipment, antiaircraft guns and ammunition, cargo vessels and tankers, were drawn up, but time was required to implement them. The initiative had passed to the United States.

"After the engagements of 1942, certain basic lessons of combat in the Pacific theater had been learned. It appeared that the widely spread Japanese positions could be bypassed or captured, provided that air superiority in the necessary areas was achieved, and provided the required naval support, adequate assault craft, properly trained troops, and full logistics were available. Major preparations were required before decisive advances could be undertaken. In the meantime, however, unremitting pressure could be kept on the Japanese. Due to the geography of the empire, the Japanese ground forces depended for their effectiveness upon overseas support in all areas except the main home islands, and even there, overseas imports of raw materials were required. In China, Korea, and Manchuria, an over-water lift to the mainland was involved, and shipping was employed in the supply of troops in Malaya, Burma, and continental regions of the southwest. The islands of the eastern perimeter were completely dependent on supply by sea. Deployed as the Japanese ground forces were on detached land masses, dependent on inadequate shipping, their defeat was necessary only at points of United States choosing. The bulk of them could be bypassed.

"The Japanese Navy, which included two 64,000-ton battleships of

great fire-power and speed, had lost both operational freedom and striking power due to its limited carrier-based air strength. By late 1943, the United States had available sufficient carriers for clear-cut superiority in the air, and had added to the fleet sufficient modern heavy ships to offer reasonable protection against the Japanese surface strength were it to be committed under bad weather or other conditions limiting the degree to which our superiority in the air could be brought to bear. The ability to destroy the Japanese surface forces, if they were committed, was essential. Furthermore, their destruction would increase the freedom and ease of our further advances.

"The limitations imposed by geography and the range of Japanese land-based planes made it impossible for the Japanese to achieve sufficient mobility of their land-based air forces to concentrate their full air strength against us at any crucial point, prior to the invasion of the Philippines and Okinawa. Most of the island atolls were too small to support the necessary airfields, and in New Guinea, the Solomons and the Marianas, logistic, airfield construction and ferrying problems made such concentration impossible. Even within the limits so imposed, poor Japanese staff work and tactics resulted in piecemeal employment of their available air strength. Over and above these weaknesses, Japanese aircraft production, pilot training and maintenance were so far behind our own that it was evident that general air superiority over the Japanese could be achieved. This objective received first priority.

"The Japanese shipping target was immediately available. In the first year of the war, submarines, capable of long-range offensive action inside the Japanese perimeter, sank more than 10 per cent and airplanes four per cent of the merchant ship tonnage which Japan possessed at the start of the war. The strangulation of Japanese over-water movement, thus begun, could be continued both by the submarine and by attack from the air.

"Japanese industry and her home population would not be within effective striking distance of United States long-range bombers until bases within 1,500 nautical miles of Japan could be secured. An advance to strategic positions across the Pacific would give us bases from which to complete the interdiction of Japan's overwater shipping, to mount large scale air attacks against the Japanese home islands, and to prepare for an invasion of the home islands themselves.

"Such was the situation when the United States began its widespread offensive. While major preparations were still in progress, and the heavy attrition of the Solomons and eastern New Guinea campaign was chewing up Japan's best air groups and depleting her shipping

and supplies, the first long-range moves in the advance across the Pacific were undertaken. These began unostentatiously with the assault against Attu, on the northern flank of the Japanese defense perimeter in May 1943. On the southern flank, the offensive continued with an advance to Munda in June, to Salamaua, Lae, and Finschhafen on New Guinea in September, and Bougainville in November 1943. In the Central Pacific it began with the assault on the Gilbert Islands in November 1943.

"Thereafter, the amphibious advance toward Japan continued over two routes. One was up the north coast of New Guinea to the Philippines, the other across the Central Pacific through the Marshalls to the Marianas and Palau and then subsequently on to Iwo Jima and Okinawa. Basically, the advance was for the purpose of projecting United States power to points which cut Japan's supply lines to the south and were within striking range of the Japanese home islands. Objectives were seized for one or more of four purposes: To provide forward airfields so that shore-based aircraft might maintain and project forward United States control of the air; to furnish advance bases for the fleet; to secure land areas for the staging of troops in succeeding advances; and, in the case of the Marianas, to provide bases for long-range air attacks on the Japanese home islands.

"In the New Guinea area it continued to be possible to choose objectives for our advance where the enemy was weak, to seal off these objectives from enemy reinforcement and cover advances to them with land-based air, and, in certain instances, to supply the operation entirely by air. Marilinan, Nadzab and other inland bases on New Guinea, which eventually had complements as large as 25,000 men, were occupied, supplied and later moved forward entirely by air. The range of these advances was limited to the combat radius of fighter aircraft.

"For long-range amphibious advances against strongly defended positions a typical pattern developed. Japanese bases flanking the United States objective were smothered by a concentration of air power. Such bases as were within reach were hammered by shore-based air. Carrier-based air and available shore-based air softened the area to be occupied, and as the amphibious force moved up, fast carriers advancing beyond the objective struck swift blows at all positions which could threaten the objective area. With close air support from both escort and fast carriers and a concentration of gunfire from combatant ships of the support force, an amphibious assault over the beaches was made. The objective was secured under air support and

cover from the carriers, which were not withdrawn until airfields ashore could be prepared and activated.

"The amphibious steps along the two principal lines of advance toward Japan were well-timed and mutually supporting, even though concentration on one line might have been more rapid. The losses inflicted at Rabaul, primarily by land-based planes from the Solomons and New Guinea, forced the Japanese to the decision not to support their garrisons in the Gilberts, were they to be attacked. The Central Pacific advance into the Gilbert and Marshall Islands in late 1943 and early 1944, and the threat of a fast carrier task force strike against Truk, which eventuated in February 1944, cleared the Japanese Fleet from the New Guinea flank and assisted the move into the Admiralties in March 1944, and the long step up the coast of New Guinea to Hollandia in April 1944, which was followed by a further advance to Wakde and Biak in May 1944. When the Japanese attempted reinforcement of northern New Guinea, the Central Pacific advance into the Marianas in June 1944, forced the abandonment of the operation. The Japanese committed their carriers in the defense of the Marianas, and lost in the Battle of the Philippines Sea practically all their carrier-based air groups sufficiently trained for combat, as well as three carriers sunk. Noemfoor was taken while the Japanese were preoccupied in the Marianas. Landings on Morotai were timed with those in the Palaus.

"While the landings in the Palaus were in progress, the fast carrier task force struck Japanese aircraft, airfields and shipping in the Philippines. Preliminary to the Leyte operation, the fast carrier task force with a concentration of more than 1,000 planes attacked Okinawa, Formosa and the Philippines, exacting a large toll of Japanese air power. B-29 strikes from China against air installations on Formosa supported this operation. The landing at Leyte Gulf in the Philippines was correctly assessed by the Japanese as their last opportunity, short of a defense of the Japanese home islands, to throw in all their available forces to check the United States advance in a decisive engagement.

"Three days after the landing at Leyte they committed their entire fleet in a three-pronged attack. The plan contemplated that a carrier force advancing from the north would draw off our main strength, while heavy surface forces approaching through Surigao and San Bernardino Straits and covered by Japanese Army and Navy planes from airfields in the Philippines would destroy our transports and supporting strength off the landing beach. The Japanese strategy succeeded

in drawing off our main strength to the north. The southern Japanese force was destroyed in a night surface engagement in Surigao Straits. Four carriers in the northern force were sunk off Luzon. Although one of its super-battleships had been sunk by torpedo plane attack, the central force penetrated close to our transports still possessed of overwhelming surface strength. The Japanese commander of the central force testified to the Survey that lack of expected land-based air support and air reconnaissance, fear of further losses from air attack, and worry as to his fuel reserves induced him to withdraw. As a result of this decision to retire, the Japanese failed to secure the objective for which catastrophic losses had been risked and suffered by the other two Japanese forces.

"In the ensuing actions in the Philippines, the Japanese lost all the troops and supplies deployed there, plus three and one-half divisions sent in from China and Manchuria. In the Philippines campaign as a whole they committed and lost 9,000 planes. On March 1, 1945, the Japanese decided to send no further supplies to their ground forces outside of the home islands. Except for delaying actions they had been forced to concentrate solely on defense against invasion. While the liberation of the Philippines was being completed, the Central Pacific forces made the difficult moves into Iwo Jima and Okinawa.

"The Allied strategic plan contemplated that the actual defeat of Japan would be accomplished by operations in the Pacific. In the meantime, however, it was essential to defend India and to assist China. We could not afford to make substantial forces available. Our contribution in the China-Burma-India theater was almost entirely air and logistic support. The geography of the theater was such that overland transportation was virtually impossible beyond the Indian bases. As a consequence, the air in the China-Burma-India theater was called upon, not only to give protection against and to fight down enemy air and disrupt Japanese shipping and rail transportation, but also to transport the men and supplies for all forces and provide much of the fire power even in ground operations.

"Full superiority over Japanese air forces was gradually attained. British ground forces at Imphal which had been surrounded by an attacking Japanese force were supplied by Allied air. The Japanese force was in turn isolated by air attack and destroyed. The troops that liberated Burma were moved, supplied, and supported by air. Japanese logistics in Burma and China were disrupted. China was kept in the war. Over 1,180,000 tons of supplies and equipment and 1,380,000 troops were transported by air. The air movement over the

'hump' between India and China attained a peak rate of 71,000 tons in one month.

"In the fall of 1943, it was decided to attack Japanese industrial targets in Manchuria and Kyushu with B-29s flying from advanced bases in China. When this decision was reached, Guam, Saipan and Tinian had not yet been captured, and no other bases were available sufficiently close for direct strikes at the Japanese 'Inner Zone' industries. The principal bottleneck in air operation in China was the transportation from India by air of the necessary supplies, most of which were allocated to supplying Chinese ground forces. As a result, the B-29s had sufficient supplies for only a small number of strikes per month. Data secured by the Survey in Japan established that these strikes caused more severe damage to the Manchurian steel plants selected as targets than assessment of aerial photography had revealed. With the benefit of hindsight, however, it appears that the overall results achieved did not warrant the diversion of effort entailed and that the aviation gasoline and supplies used by the B-29s might have been more profitably allocated to an expansion of the tactical and antishipping operations of the Fourteenth Air Force in China. The necessary training and combat experience with B-29s provided by this operation might have been secured through attacks on 'Outer Zone' targets, from bases more easily supplied. In November 1944, long-range bomber attacks from Guam, Saipan and Tinian were initiated. The B-29s based in China were transferred to these bases in April 1945.

"By March 1945, prior to heavy direct air attack on the Japanese home islands, the Japanese air forces had been reduced to Kamikaze forces, her fleet had been sunk or immobilized, her merchant marine decimated, large portions of her ground forces isolated, and the strangulation of her economy well begun. What happened to each of these segments of Japan's vanishing war potential is analyzed in the following sections.

"Japanese production of aircraft of all types rose from an average of 642 planes per month during the first nine months of the war to a peak of 2,572 planes per month in September 1944. The rise was particularly great during 1943, after the Japanese had learned the lessons of the 1942 campaigns. Aggregate production during the war was 65,300 planes.

"Japanese army and navy plane losses from all causes, both combat and noncombat, rose from an average rate of some 500 planes per month in the early months of the war to over 2,000 per month in the

latter months of 1944. Aggregate losses during the course of the war were of the order of magnitude of 50,000 planes, of which something less than 40 per cent were combat losses, and something over 60 per cent were training, ferrying, and other noncombat losses.

"The Japanese thus were able to increase the numerical strength of their air forces in planes, in almost every month of the war. Numerical strength increased from 2,625 tactical planes at the outbreak of the war to 5,000 tactical planes, plus 5,400 Kamikaze planes, at the time of surrender. Aggregate flying personnel increased from approximately 12,000 at the outbreak of the war to over 35,000 at the time of surrender.

"United States aircraft production and pilot training exceeded the Japanese totals by wide margins, but only a portion of this strength could be deployed to the Pacific. United States first line strength in the Pacific west of Pearl Harbor increased from some 200 planes in 1941, to 11,000 planes in August 1945. It was not until late 1943 that we attained numerical superiority over the Japanese air forces in the field. Even in 1942, however, the relatively few United States air units in the Pacific were able to inflict greater losses than they sustained on the numerically superior Japanese. Aggregate United States plane losses during the course of the Pacific war, not including training losses in the United States, were approximately 27,000 planes. Of these losses 8,700 were on combat missions; the remainder were training, ferrying and other noncombat losses. Of the combat losses over 60 per cent were to antiaircraft fire.

"As previously stated, Japanese pilots at the outbreak of the war were well-trained. The average Army pilot had some 500 hours before entering combat, and Navy pilots 650 hours. These experienced pilots were largely expended during the bitter campaigns of the opening year and a half of the war. The Japanese paid far less attention than we did to the protection, husbanding and replacement of their trained pilots, and were seriously hampered in their training program by a growing shortage of aviation gasoline. Average flying experience fell off throughout the war, and was just over 100 hours, as contrasted to 600 hours for United States pilots, at the time of surrender. Inadequately trained pilots were no match for the skilled pilots developed by the United States.

"At the time of the initial Japanese attack, Japanese fighter planes, although less sturdily built, more vulnerable and weaker in fire power than the United States fighters, had certain flight characteristics superior to those of United States fighters then available in the Pacific. The Japanese improved the quality of their planes during the war,

greatly increased the power of their aircraft engines, ultimately exceeded United States fighters in fire power and had first-class aircraft in the design and experimental stage at the end of the war. They lacked, however, the widespread technical and industrial skill to match the United States in quantity production of reliable planes with increased range, performance and durability. After the initial campaigns, the United States always enjoyed superiority in the overall performance of its planes.

"By American standards, the Japanese never fully appreciated the importance of adequate maintenance, logistic support, communications and control, and airfields and bases adequately prepared to handle large numbers of planes. As a result, they were unable to concentrate any large percentage of their air strength at any one time or place. Neither did they appear to have the ability to control large formations in the air with any degree of efficiency. Local air control and its tactical exploitation the Japanese understood and achieved in their early offensives.

"But along with all other military powers prior to the war, the Japanese had failed fully to appreciate the strategic revolution brought about by the increased capabilities of air power. The ability to achieve general and continuing control of the air was not envisaged as a requirement in their basic war strategy, as was the planned destruction of the United States Fleet. Had this basic requirement been well understood it is difficult to conceive that they would have undertaken a war of limited objectives in the first place. Once started on a strategic plan which did not provide the means to assure continuing air control, there was no way in which they could revise their strategy to reverse the growing predominance in the air of a basically stronger opponent who came to understand this requirement and whose war was being fought accordingly.

"By the summer of 1944, it had become evident to the Japanese air commanders that there was no way in which they could equal the United States air arms at any point. Their losses were catastrophic, while the results which they were achieving were negligible. The one and only asset which they still possessed was the willingness of their pilots to meet certain death. Under these circumstances, they developed the Kamikaze technique. A pilot who was prepared to fly his plane directly into a ship would require but little skill to hit his target, provided he got through the intervening screen of enemy fighters and antiaircraft fire. If sufficient Japanese planes attacked simultaneously, it would be impossible to prevent a certain proportion from getting through. Even though losses would be 100 per cent of the planes and

pilots thus committed, results, instead of being negligible, might be sufficient to cause damage beyond that which we would be willing to endure.

"From October 1944, to the end of the Okinawa campaign, the Japanese flew 2,550 Kamikaze missions, of which 475, or 18.6 per cent were effective in securing hits or damaging near misses. Warships of all types were damaged, including 12 aircraft carriers, 15 battleships, and 16 light and escort carriers. However, no ship larger than an escort carrier was sunk. Approximately 45 vessels were sunk, the bulk of which were destroyers. The Japanese were misled by their own inflated claims of heavy ships sunk, and ignored the advice of their technicians that a heavier explosive head was required to sink large ships. To the United States the losses actually sustained were serious, and caused great concern. Two thousand B-29 sorties were diverted from direct attacks on Japanese cities and industries to striking Kamikaze airfields in Kyushu. Had the Japanese been able to sustain an attack of greater power and concentration they might have been able to cause us to withdraw or to revise our strategic plans.

"At the time of surrender, the Japanese had more than 9,000 planes in the home islands available for Kamikaze attack, and more than 5,000 had already been specially fitted for suicide attack to resist our planned invasion.

"As stated earlier in this report Japan started the war with 10 carriers. Six were sunk during the engagements of 1942. The Japanese during the course of the war constructed or converted from other types of ships a total of 17 additional carriers including five escort carriers; of the conversions one was made on a Yamato-class battleship hull and two, carriers only in part, were the result of removing the after turrets of battleships and installing small hangars and launching decks. Due to the loss of their trained carrier air groups in 1942-43 and the time required to train new ones, the Japanese did not commit their carriers again until 1944. In the engagements of that year the Japanese lost seven carriers without themselves securing appreciable results. Seven more were lost in home waters to submarine or air attack. All Japanese carriers sunk were lost either to our carrier-based aircraft or to submarines with the exception of one which was finished off by surface vessels after it had been mortally damaged by carrier airplanes.

"The Japanese had two Yamato-class battleships, each of 64,000 tons, armed with 18-inch guns and minutely compartmented, which were more powerful than any United States battleship. One was sunk

in the Sibuyan Sea, the other south of Kyushu, both by carrier torpedo-planes.

"Japan began the war with 381 warships aggregating approximately 1,271,000 tons. An additional 816 combat ships totaling 1,048,000 tons were constructed during the war. Five hundred and forty-nine ships of all types and sizes, totaling 1,744,000 tons were sunk. Approximately 1,300,000 tons of Japanese warships in the carrier, battleship, cruiser and destroyer categories were included in the aggregate tonnage sunk. Of this total roughly 625,000 tons were sunk by Navy and Marine aircraft, 375,000 tons by submarines, 183,000 tons by surface vessels, 55,000 tons by Army aircraft, and 65,000 tons by various agents. Only 196,000 tons in these categories remained afloat at the end of the war. The tonnage sunk by surface ships was principally in night actions. A shortage of Japanese destroyers after 1943 and inadequate Japanese air antisubmarine measures contributed to the successes of United States submarines against the Japanese fleet.

"After the liberation of the Philippines and the capture of Okinawa, oil imports into Japan were completely cut off; fuel oil stocks had been exhausted, and the few remaining Japanese warships, being without fuel, were decommissioned or were covered with camouflage and used only as anti-aircraft platforms. Except for its shore-based Kamikaze air force and surface and undersea craft adapted for anti-invasion suicide attack, the Japanese Navy had ceased to exist.

"Japan's merchant shipping fleet, was not only a key link in the logistical support of her armed forces in the field, but also a vital link in her economic structure. It was the sole element of this basic structure which was vulnerable to direct attack throughout a major portion of the war. Japan entered the war with some 6,000,000 tons of merchant shipping of over 500 tons gross weight. During the war an additional 4,100,000 tons were constructed, captured or requisitioned. Sufficient information was secured by the Survey in Japan concerning this 10,100,000 tons to tabulate ship by ship, (a) the name and tonnage, (b) the date, location, and agent of sinking or damage, and (c) the present condition and location of such ships as survived. The sources from which evidence was obtained were in some respects conflicting. Where possible these conflicts have been resolved. The Joint Army and Navy Assessment Committee has tentatively arrived at similar results and is continuing its efforts further to refine the evidence. The Survey believes that the figures included in the following breakdown will not differ significantly from the final evaluation of the Joint Army and Navy Assessment Committee.

"Eight million nine hundred thousand tons of this shipping were sunk or so seriously damaged as to be out of action at the end of the war. Fifty-four and seven-tenths per cent of this total was attributable to submarines, 16.3 per cent to carrier-based planes, 10.2 per cent to Army land-based planes and 4.3 per cent to Navy and Marine land-based planes, 9.3 per cent to mines (largely dropped by B-29s), less than one per cent to surface gunfire, and the balance of four per cent to marine accidents.

"Due to their ability to penetrate deeply into enemy-controlled waters, submarines accounted for approximately 60 per cent of sinkings up until the final months of the war. During 1944, carrier task forces made deep sweeps which accounted for large numbers of ships. After April 1945, when Japanese shipping was restricted to the Korean and Manchurian runs and to shallow inland waters, mines dropped by B-29s in Japanese harbors and inland waterways accounted for 50 per cent of all ships sunk or damaged. In isolating areas of combat from ship-borne reinforcements land-based aircraft also sank large numbers of barges and vessels smaller than 500 tons gross weight, not included in the tabulation prepared by the Survey. In the Survey's opinion those air units which had anti-shiping attacks as their prime mission and employed the required specialized techniques, equipment and training achieved against ships the best results for the effort expended.

"The Japanese originally allocated two-thirds of their shipping fleet to the logistic support of their military forces in the field. They expected that after their original advance had been completed, they would be able to return increasing numbers of ships to the movement of raw materials for their basic economy. After the beginning of the Guadalcanal campaign, however, they were kept under such constant and unexpected military pressure that the contemplated returns after that date were never possible.

"Up to the end of 1942, ship sinkings exceeded new acquisitions by a small margin. Thereafter, the aggregate tonnage sunk increased far more rapidly than could be matched by the expansion of the Japanese shipbuilding program. The size of the usable fleet thus declined continuously and at the end of the war amounted to little more than 10 per cent of its original tonnage. The Japanese belatedly attempted to build up a convoy system, to re-route freight movements to rail lines, and to abandon more distant sources of supply, but these measures acted only as palliatives and not as cures. Furthermore, convoying and re-routing decreased the freight moved per ship by a factor amounting to 43 per cent in the closing months of the war. In 1944,

tanker losses became particularly heavy and were thereafter the first concern of the Japanese shipping authorities.

"The basic economic consequences of ship sinking will be discussed in a later section. From the standpoint of the Japanese armed forces in the field it will be noted that 17 per cent of army supplies shipped from Japan were sunk in 1943, 30 per cent in 1944, and 50 per cent in 1945. A shortage of fleet tankers was a continuing limitation on the mobility of the Japanese fleet and contributed to its defeat in the two crucial battles of the Philippine Sea. Inadequate logistic support, due in large part to lack of shipping, was one of the principal handicaps of the Japanese air forces. Attacks by submarines, long-range search and attack planes, mines, and carrier- and land-based planes were mutually supporting and complicated the Japanese defenses. Long-range air search found targets for the submarines; convoying which offered some protection against submarines increased the vulnerability to air attack; ships driven into congested harbors in fear of submarines were easy prey for carrier strikes; and mines helped to drive ships out of shallow water into waters where submarines could operate. Had we constructed more submarines, earlier concentrated on tankers and more fully coordinated long-range air search and attack missions with submarine operations, the ship sinking program might have been even more effective.

"The Japanese built up their army ground forces from a strength of approximately 1,700,000 at the outbreak of war, to a peak strength of approximately 5,000,000. Japanese army medical records indicate that the aggregate number deployed in the Solomons, New Guinea, Marshalls, Gilberts, Carolines, Marianas, Philippines, Okinawa, Iwo Jima, and the Aleutians was approximately 668,000, of whom 316,000 were killed in action; some 220,000 were deployed in Burma, of whom 40,000 were killed; and 1,100,000 were deployed in China, of whom 103,000 were killed. Most of the remainder were in Manchuria, Korea, or the home islands, and did not actively participate in the decisive campaigns of the war.

"The strategy of our advance and the limitations imposed on Japanese overwater transportation became such that the Japanese could concentrate only a small portion of their available Army ground forces strength at any of the critical island positions which we determined to capture. Japanese soldiers were unique in their willingness to face death and endure hardships. At every point where our Army or Marine forces engaged the Japanese on the ground after 1942, we enjoyed full air superiority. In every instance, except Ormoc in the Leyte campaign, we had eliminated Japanese ability to reinforce the

critical area with either men or supplies. At Ormoc the Japanese were able to land 30,000 troops, but these reinforcements arrived piecemeal over too long a period of time to be effective and many of the transports were sunk prior to unloading heavy equipment. In every instance where the Japanese had prepared defenses in a landing area these had been softened up by aerial bombardment and usually by naval shelling as well. It often proved impossible, however, to destroy more than a small percentage of the defending Japanese soldiers in preliminary softening up operations of even the greatest intensity. The Japanese were dug in, in tunnels, trenches and caves which were hard to find and often impossible to destroy, either by bombing or by naval shelling. Most of their fixed artillery positions were eliminated, but even some of these survived. The weight of fire on the immediate invasion beaches was generally such that the Japanese retired a short distance inland, but once we advanced beyond the beaches, it became necessary to destroy the remaining Japanese in costly close-range fighting. It was demonstrated, however, that Japanese resistance was effectively weakened and our casualties lighter when the appropriate weapons were employed with sufficient weight and accuracy in both preliminary softening up operations and subsequent close support.

"A Japanese estimate indicates that in the southern regions, approximately 25 per cent of their combat deaths resulted from aerial bombardment, 58 per cent from small arms fire, 15 per cent from artillery, and the remaining two per cent from other causes.

"In those places where it was essential to eliminate Japanese ground resistance in close-range fighting, great precision had to be developed in air-support operations in order to be certain not to hit our own troops, and to assure hits on the small targets which the critical Japanese positions presented. This required highly specialized training and the closest coordination between the ground and air forces through an intricate system of ground and air observers and unified control by ground-ship-air radio communication. In the Pacific war this system was continuously improved by the Navy and Marines in connection with succeeding amphibious operations against strongly defended positions and reached a high degree of effectiveness. In the Philippines campaign, the Army air forces employed comparable techniques, and General Yamashita has testified to his feeling of complete helplessness when confronted with this type of opposition.

"In the Southwest Pacific, it often proved possible to effect landings at lightly held positions, and thus bypass large bodies of enemy ground forces. In the Central Pacific, many of the islands the Japa-

nese expected us to attack were bypassed, and the garrisons left to wither and die. Survey examination of the bypassed islands in the Pacific and interrogation of the Japanese survivors confirmed their intolerable situation. Their planes and ground installations were destroyed by air attack. Cut off from any supplies or reinforcements, except occasionally by submarine, their food ran out. On certain of the islands, Japanese actually ate Japanese. It appears, however, that our air attacks on these bypassed positions were often continued longer and in greater weight than was reasonably required or profitable.

"The orientation of the Japanese economy toward war began in 1928, and continued with increasing emphasis during the Manchurian and Chinese campaigns. By 1940, total production had arisen by more than 75 per cent; heavy industrial production by almost 500 per cent; and 17 per cent of Japan's total output was being devoted to direct war purposes and expansion of her munition industries, as against 2.6 per cent at that time in the United States. Construction of industrial facilities in these years assumed—for the Japanese conditions—gigantic proportions. Her aircraft, aluminum, machine tool, automotive, and tank industries were erected from almost nothing during this period.

"This industrial expansion was based and depended on the availability of raw materials. Great efforts were devoted to the increase of raw material output in the home islands. In some respects, major results were achieved. Coal production in Japan rose from 28,000,000 tons in 1931 to 55,600,000 tons in 1941. Domestic iron mining made considerable progress. Nevertheless, no country could have been farther from self-sufficiency, with respect to raw materials, than Japan. The development of basic material sources on the continent of Asia constituted almost the central issue of Japan's economic policy during this period.

"Although progress in Manchuria and China helped significantly to alleviate Japan's raw material shortages in coking coal, iron ore, salt and foods, insufficiency of raw materials continued to be the most important limiting factor on Japanese industrial output. Negligible quantities of oil and no bauxite sources existed within Japan's 'Inner Zone'. Output of aluminum ingots had risen from 19 tons in 1933 to 71,740 in 1941, 90 per cent of which was produced from bauxite imported from the Dutch East Indies. Plans to develop a synthetic oil industry failed to yield significant results and Japan was almost wholly dependent on oil imports from the United States or the Dutch East

Indies. A similar dependence on imports existed for rubber, ferro-alloys such as manganese, chrome, nickel, cobalt and tungsten, and for nonferrous metals such as tin, lead, and mercury.

"Pending seizure and economic exploitation of the oil and bauxite resources of the southern area, stock piling of these vital materials was a necessity. By the end of 1941, bauxite stocks of 250,000 tons, constituting a seven months' supply, and 43,000,000 barrels of oil and oil products were stored in Japan.

"Considering the economic performance of the decade, one cannot but be impressed by the intensity of the effort and the magnitude of the results. Nonetheless, Japan remained with an economy having approximately 10 per cent of the potential of the United States economy. It was desperately vulnerable to attack on its shipping. Having a comparatively small, newly developed industry, it had to work without much cushion of under-utilized physical plant capacity. Having had little experience with mass production, the country had no opportunity to build up a large force of industrially and mechanically trained personnel. This meant shortages of skills, ingenuity and ability to improvise later on, when the economy was under the stresses and strains of large-scale warfare. This economic potential could support a short war or a war of limited liabilities. The accumulated stocks of munitions, oil, planes and ships could be thrown into action and produce a devastating effect on unmobilized enemies. When this initial blow failed to result in peace, Japan, without significant help from Germany, was doomed. Its economy could not support a protracted campaign against an enemy even half as strong as the United States.

"In addition, the success of the initial Japanese military operations delayed total economic mobilization until after the defeats of late 1942. Computed in constant prices, the gross national product rose from a level of 39.8 billion yen in the fiscal year beginning with April 1940, to only 41 billion yen in the fiscal year 1942. That this was due to an inadequate realization of requirements and inadequate planning, and not to the inherent limitations of the Japanese economy, is clear from the expansion that was secured after 1942. In the fiscal year 1943, the gross national product rose to 45.4 billion yen, and in 1944 to 50 billion yen. The share of the gross national product devoted to direct war and munitions expenditures increased from 23 per cent in 1941 to 31 per cent in 1942, 42 per cent in 1943 and 52 per cent in 1944. In 1944, half of the remaining national product was accounted for by food. In 1943, however, the United States was devoting 45 per cent of its vastly greater national product to direct war purposes. By the summer of 1944, the Japanese had exhausted the possibility of forcing a

greater share of their economy into direct war activities. Their plants, railroad and mines were being, and had been for some time, under-maintained to a point where breakdowns were becoming more and more serious. The civilian population was underfed, was receiving practically no new clothing or miscellaneous civilian supplies, and was being worked to a degree of fatigue which was reflected in rising rates of absenteeism.

"By 1944, Japan had increased ingot steel capacity to 225 per cent of the 1937 capacity. A shortage of raw materials, however, which began with the United States embargo on scrap iron exports in July 1941, and was never overcome, prevented the operation of Japanese steel mills at anything approaching capacity. Japanese coal would not produce satisfactory metallurgical coke without the admixture of stronger continental coking coal; domestic iron ore was both limited in quantity and of lower grade than imported ores. The combination of limited quantities of high-grade imported raw materials and lower-grade domestic materials held production of ingot steel in the home islands to 6,800,000 tons in 1941, to a peak of 7,800,000 tons in 1943, and caused it to decline to 5,900,000 tons in 1944. This compared with a 1937 production of 5,800,000 tons and a theoretical capacity, using high-grade materials, of 13,600,000 tons in 1944. By the middle of 1944, the increasing stringency of shipping and the interdiction of many of Japan's shipping routes had reduced coal and ore imports by two-thirds. Stockpiles of imported materials had already been heavily eaten into, and ingot steel production began to decline rapidly. In March 1945, imports of coal virtually ceased, and iron ore was cut off entirely, as the Japanese elected to devote their remaining shipping capacity to the hauling of vitally needed foodstuffs and salt. It is estimated by the Survey that, using only domestic raw materials, the Japanese steel industry could not have maintained a rate of production of ingot steel in excess of 1,500,000 tons per annum. By August 1945, the rate of output was still somewhat in excess of this figure, but would soon have been reduced. The decline in Japan's steel production can be attributed to its dependence on shipping and the destruction of that shipping. Had this industry not been mortally wounded by shipping attack and had its destruction by bombing been called for, the effectiveness of the few strategic bombing attacks directed against the steel industry indicates that destruction of the principal plants by bombing or paralysis of the industry by disruption of railroad transportation would have been possible, but only at a later date.

"The steel shortage constituted an over-all limitation on the war potential of the Japanese economy. Japanese planners were, however,

able to secure very substantial increases in the production of those military products which the experiences of the war had demonstrated to be of outstanding importance. Aircraft production of all types, including training planes, was stepped up from 700 planes per month in the summer of 1942, to 2,572 planes in September 1944. Aircraft engine production was not only increased correspondingly in numbers, but average horsepower was doubled. Aircraft and antiaircraft gun and ammunition production was expanded tenfold. Radar and communications equipment was stepped up fivefold. The most important consumer of steel was the shipbuilding industry. The increasingly critical nature of Japan's shipping situation caused her to expand her naval and merchant shipbuilding programs to a point where 35 per cent of all steel consumed was being used in that industry alone. Construction of merchant ships increased from approximately 238,000 tons in 1941, to 1,600,000 tons of steel ships and 254,000 tons of wooden ships in 1944. During 1942, warship deliveries included one battleship of 64,000 tons and six small carriers totaling 84,000 tons. In 1944, no battleships, but four aircraft carriers of 114,500 displacement tons and 141,300 tons of escort vessels and submarines were delivered. The increases in production of high-priority items involved the scaling down of steel availability for lower priority items, such as tanks, larger caliber guns and trucks, and the almost complete elimination of steel for civilian requirements, construction, or export.

"During 1944, the effects of the net loss of shipping and slow-down in ship operations became such that by the end of the year it no longer was possible to protect even high-priority war production by further shifting of allocations of scarce materials from items of lesser priority. In addition to steel, other basic elements of the economy were involved. Oil, although not as important as steel in its broad impact on the remainder of the economy, was of critical importance to Japan's military machine and to her merchant marine. Oil imports from the south began declining in August 1943, and had been eliminated by April 1945. Crude oil stocks were virtually exhausted; refinery operations had to be curtailed; and stocks of aviation gasoline fell to less than 1,500,000 barrels, a point so low as to require a drastic cut in the pilot-training program and even in combat air missions. Bauxite imports declined from 136,000 tons in the second quarter of 1944, to 30,000 tons in the third, and stockpiles were only 3,000 tons. Stockpiles and the time delay between the various stages of production cushioned for a time the inevitable effects of the blockade on finished munitions production, but by November 1944, the over-all level of Japanese war

production had begun to turn down, including even the highest priority items, such as aircraft engines.

"It is the opinion of the Survey that by August 1945, even without direct air attack on her cities and industries, the over-all level of Japanese war production would have declined below the peak levels of 1944 by 40 to 50 per cent solely as a result of the interdiction of overseas imports. By mid-1944, those Japanese in possession of the basic information saw with reasonable clarity the economic disaster which was inevitably descending on Japan. Furthermore, they were aware of the disastrous impact of long-range bombing on Germany, and, with the loss of the Marianas, could foresee a similar attack on Japan's industries and cities. Their influence, however, was not sufficient to overcome the influence of the Army which was confident of its ability to resist invasion.

"Basic United States strategy contemplated that the final decision in the Japanese war would be obtained by an invasion of the Japanese home islands. The long-range bombing offensive from the Marianas was initiated in November 1944, with that in mind as the primary objective. As in Europe prior to D-day, the principal measure of success set for strategic air action was the extent to which it would weaken enemy capability and will to resist our amphibious forces at the time of landings. This led, originally, to somewhat greater emphasis on the selection of targets such as aircraft factories, arsenals, electronics plants, oil refineries, and finished military goods, destruction of which could be expected to weaken the capabilities of the Japanese armed forces to resist at the Kyushu beachheads in November 1945, than on the disruption of the more basic elements of Japan's social, economic, and political fabric. Certain of the United States commanders and the representatives of the Survey who were called back from their investigations in Germany in early June 1945, for consultation stated their belief that, by the coordinated impact of blockade and direct air attack, Japan could be forced to surrender without invasion. The controlling opinion, however, was that any estimate of the effects of bombing on the Japanese social fabric and on the political decisions of those in control of Japan was bound to be so uncertain that target selection could safely be made only on the assumption that ground force invasion would be necessary to force capitulation.

"With the benefit of hindsight, it appears that the twin objectives of surrender without invasion and reduction of Japan's capacity and will to resist an invasion, should the first not succeed, called for basically the same type of attack. Japan had been critically wounded by



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## LOADING FIRE BOMBS THAT BURNED JAPAN

military defeats, destruction of the bulk of her merchant fleet, and almost complete blockade. The proper target, after an initial attack on aircraft engine plants, either to bring overwhelming pressure on her to surrender, or to reduce her capability of resisting invasion, was the basic economic and social fabric of the country. Disruption of her railroad and transportation system by daylight attacks, coupled with destruction of her cities by night and bad weather attacks, would have applied maximum pressure in support of either aim. This point of view was finally adopted. Although urban area attacks were initiated in force in March 1945, the railroad attack was just getting under way when the war ended.

"The total tonnage of bombs dropped by Allied planes in the Pacific war was 656,400. Of this, 160,800 tons, or 24 per cent, were dropped on the home islands of Japan. Navy aircraft accounted for 6,800 tons, Army aircraft other than B-29s for 7,000 tons, and the

B-29s for 147,000 tons. By contrast, the total bomb tonnage in the European theater was 2,700,000 tons of which 1,360,000 tons were dropped within Germany's own borders. Approximately 800 tons of bombs were dropped by China-based B-29s on Japanese home island targets from June 1944, to January 1945. These raids were of insufficient weight and accuracy to produce significant results.

"By the end of November 1944, four months after seizure of the islands, the first of the long-range bomber bases in the Marianas became operational. The number of planes originally available was small and opposition was significant. Losses on combat missions averaged 3.6 per cent. The tonnage dropped prior to March 9, 1945, aggregated only 7,180 tons although increasing month by month. The planes bombed from approximately 30,000 feet and the percentage of bombs dropped which hit the target areas averaged less than 10 per cent. Nevertheless, the effects of even the relatively small tonnage hitting the selected targets were substantial. During this period, attacks were directed almost exclusively against aircraft, primarily aircraft engine, targets. The principal aircraft engine plants were hit sufficiently heavily and persistently to convince the Japanese that these plants would inevitably be totally destroyed. The Japanese were thereby forced into a wholesale and hasty dispersal program. The continuing pressure of immediate military requirements for more and more planes during the campaigns in the Pacific had prevented any earlier moves to disperse. When dispersal could no longer be avoided, the necessary underground tunnels, dispersed buildings, and accessory facilities such as roads, railroad spurs and power connections were not ready. As a result the decline in aircraft engine production, which shortages in special steels requiring cobalt, nickel and chrome had initiated in mid-1944, became precipitous.

"On March 9, 1945, a basic revision in the method of B-29 attack was instituted. It was decided to bomb the four principal Japanese cities at night from altitudes averaging 7,000 feet. Japanese weakness in night fighters and anti-aircraft made this program feasible. Incendiaries were used instead of high-explosive bombs and the lower altitude permitted a substantial increase in bomb load per plane. One thousand six hundred and sixty-seven tons of bombs were dropped on Tokyo in the first attack. The chosen areas were saturated. Fifteen square miles of Tokyo's most densely populated area were burned to the ground. The weight and intensity of this attack caught the Japanese by surprise. No subsequent urban area attack was equally destructive. Two days later, an attack of similar magnitude on Nagoya destroyed two square miles. In a period of 10 days starting March 9, a total of

1,595 sorties delivered 9,373 tons of bombs against Tokyo, Nagoya, Osaka, and Kobe destroying 31 square miles of those cities at a cost of 22 airplanes. The generally destructive effect of incendiary attacks against Japanese cities had been demonstrated.

"Thereafter, urban area attacks alternated with visual and radar attacks against selected industrial or military targets. In April, an extensive program of sowing minefields in channels and harbors at night was added. In the aggregate, 104,000 tons of bombs were directed at 66 urban areas; 14,150 tons were directed at aircraft factories; 10,600 tons at oil refineries; 4,708 at arsenals; 3,500 tons at miscellaneous industrial targets; 8,115 tons at airfields and sea-plane bases in support of the Okinawa operation; and 12,054 mines were sown.

"Bombing altitudes after March 9, 1945, were lower, in both day and night attacks. Japanese opposition was not effective even at the lower altitudes, and the percentage of losses to enemy action declined as the number of attacking planes increased. Bomb loads increased and operating losses declined in part due to less strain on engines at lower altitudes. Bombing accuracy increased substantially, and averaged 35 to 40 per cent within 1,000 feet of the aiming point in daylight attacks from 20,000 feet or lower.

"Monthly tonnage dropped increased from 13,800 tons in March to 42,700 tons in July, and, with the activation of the Eighth Air Force on Okinawa, would have continued to increase thereafter to a planned figure of 115,000 tons per month, had the war not come to an end.

"Three-quarters of the 6,740 tons of bombs dropped by carrier planes on the Japanese home islands were directed against airfields, warships, and miscellaneous military targets, and one-quarter against merchant shipping and other economic targets. Most of the warships sunk in home ports had already been immobilized for lack of fuel. The accuracy of low-level carrier plane attack was high, being at least 50 per cent hits within 250 feet of the aiming point. The attack against the Hakodate-Aomori rail ferries in July 1945, sank or damaged all twelve of the ferries, 17 steel ships, and 149 smaller ships.

"The physical destruction resulting from the air attack on Japan approximates that suffered by Germany, even though the tonnage of bombs dropped was far smaller. The attack was more concentrated in time, and the target areas were smaller and more vulnerable. Not only were the Japanese defenses overwhelmed, but Japan's will and capacity for reconstruction, dispersal, and passive defense were less than Germany's. In the aggregate some 40 per cent of the built-up area of the 66 cities attacked was destroyed. Approximately 30 per cent of the entire urban population of Japan lost their homes and many

of their possessions. The physical destruction of industrial plants subjected to high-explosive attacks was similarly impressive. The larger bomb loads of the B-29s permitted higher densities of bombs per acre in the plant area, and on the average somewhat heavier bombs were used. The destruction was generally more complete than in Germany. Plants specifically attacked with high-explosive bombs were, however, limited in number.

"The railroad system had not yet been subjected to substantial attack and remained in reasonably good operating condition at the time of surrender. Little damage was suffered which interfered with main line operations. Trains were running through Hiroshima 48 hours after the dropping of the atomic bomb on that city. Damage to local transport facilities, however, seriously disrupted the movement of supplies within and between cities, thereby hindering production, repair work and dispersal operations.

"Japan's electric power system was properly rejected for specific attack because of the large number of small targets presented. Urban incendiary attacks destroyed the electric distribution systems in the burned-out areas simultaneously with the consumer load previously served by them. The hydro-electric generating plants and the transmission networks survived without substantial damage. Twenty-six urban steam-generating plants were damaged as an incident to other attacks, the aggregate loss of capacity being less than one-seventh of Japan's total generating capacity.

"The urban area incendiary attacks eliminated completely the residential and smaller commercial and industrial structures in the affected areas and a significant number of important plants, but a portion of the more substantially constructed office buildings and factories in those areas and the underground utilities survived. By 1944, the Japanese had almost eliminated home industry in their war economy. They still relied, however, on plants employing less than 250 workers for sub-contracted parts and equipment. Many of these smaller plants were concentrated in Tokyo and accounted for 50 per cent of the total industrial output of the city. Such plants suffered severe damage in urban incendiary attacks.

"Four hundred and seventy thousand barrels of oil and oil products, 221,000 tons of foodstuffs and two billion square yards of textiles were destroyed by air attacks. Ninety-seven per cent of Japan's stocks of guns, shells, explosives, and other military supplies were thoroughly protected in dispersed or underground storage depots, and were not vulnerable to air attack. Physical damage to plant installations by either area or precision attacks, plus decreases due to dispersal forced



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#### TOKYO'S FIFTH AVENUE AFTER BOMBER ATTACKS

by the threat of further physical damage, reduced physical productive capacity by roughly the following percentages of pre-attack plant capacity: oil refineries, 83 per cent; aircraft engine plants, 75 per cent; air-frame plants, 60 per cent; electronics and communication equipment plants, 70 per cent; army ordnance plants, 30 per cent; naval ordnance plants, 28 per cent; merchant and naval shipyards, 15 per cent; light metals, 35 per cent; ingot steel, 15 per cent; chemicals, 10 per cent.

"The economic consequences of the physical damage wrought by air attack are closely interrelated with the concurrent effects of the interdiction of imports, the cumulative effects of under-maintenance of plants, and the declining health, vigor and determination of the Japanese people. Let us first consider the level of Japanese industrial activity in July 1945, the last full month before surrender. Electric power and coal consumption were both almost exactly 50 per cent of the peak reached in 1944. Production efficiency had, however, declined and the overall industrial output was approximately 40 per cent of the 1944 peak. Output varied considerably as between industries,

hit and unhit plants, and by areas. Output of air frame was 40 per cent of the 1944 peak; aircraft engines, 25 per cent; shipbuilding, 25 per cent; army ordnance, 45 per cent; and naval ordnance, 43 per cent. Oil refining had declined to less than 15 per cent of the 1943 output. Primary aluminum production was nine per cent of the 1944 peak. Although nitric acid production had declined to about 17 per cent of the 1944 peak, explosives production was about 45 per cent of the 1944 figure.

"In each one of these industries, the occasion for the decline appears to have been different. Electric power consumption fell, not because more power was not available, but because demand had declined. Coal supply was primarily limited by the decline in inter-island shipping from Hokkaido and Kyushu, and the inability of the railroad system completely to fill the gap. Despite a decline in demand, shortages of coal were universal throughout the economy. Airframe production was limited primarily by the continuing effects of the dispersal program brought on by the initial bombing, and aggravated by the subsequent destruction of numerous plants prior to completion of dispersal. Had the level of production been any higher, however, aluminum stocks would have been exhausted and aluminum would have become the controlling bottleneck. In any event, not enough aircraft engines were being produced to equip the airframes. Aircraft engine production was plagued by shortages of special steels, but in July 1945, plant damage and delay in completing the underground and dispersed plants started in the spring of the year temporarily prevented the full use of the small stocks of such steels available at the time. Output of radar and radio equipment was limited by plant capacity, the small factories supplying parts having been destroyed in the Tokyo city raids and many of the larger plants either destroyed or forced to disperse. Shipbuilding and heavy ordnance production were limited by the availability of steel. Oil refineries, aluminum plants and steel plants were basically limited by lack of foreign raw materials. Explosive plants were still using up inventories of nitric acid but would shortly have had to adjust their output to the current availability of nitric acid.

"The Japanese labor force had declined in efficiency due to malnutrition and fatigue, the destruction of much of the urban housing and the difficulties of local transportation. Production hours lost through all causes including absenteeism, sickness, air-raid alerts and enforced idleness rose from 20 per cent in 1944 to over 40 per cent in July 1945. The size of the labor force employed did not materially decline and the productive hours actually worked remained sufficiently high to indicate that such influence as manpower deficiencies may have

had on the over-all level of production in July 1945, was largely ascribable to the continued drafting of highly skilled workers into the armed services and to the inefficient administration of manpower in meeting the rapidly shifting requirements resulting from bombing, rather than to over-all lack of labor.

"A Survey investigation of production in plants employing more than 50 employees in 39 representative cities of Japan indicates that production in those plants which suffered any direct physical damage dropped off by July 1945, to 27 per cent of peak output in 1944, while production in the undamaged plants fell off to 54 per cent. Production in all plants in the sample, including both hit and unhit, dropped to 35 per cent of peak by July 1945. It appears probable that the indirect effects of the urban raids through increased absenteeism, disruption of supply lines and administrative confusion fully compensate for diversions of manpower and material from hit to unhit plants. The difference between 54 per cent, being the rate of production in unhit plants, and 35 per cent, being the average for all plants, is, therefore, a conservative indication of the impact of air attacks, both urban and precision, on production in these cities.

"Even though the urban area attacks and attacks on specific industrial plants contributed a substantial percentage to the over-all decline in Japan's economy, in many segments of that economy their effects were duplicative. Most of the oil refineries were out of oil, the alumina plants out of bauxite, the steel mills lacking in ore and coke, and the munitions plants low in steel and aluminum. Japan's economy was in large measure being destroyed twice over, once by cutting off of imports, and secondly by air attack. A further tightening of Japan's shipping situation, so as to eliminate remaining imports from Korea and coastwise and inter-island shipping, coupled with an attack on Japan's extremely vulnerable railroad network, would have extended and cumulated the effects of the shipping attack already made.

"Much of Japan's coastal and inter-island traffic had already been forced on to her inadequate railroads. The principal coal mines of Japan are located on Kyushu and Hokkaido. This coal traffic, formerly water borne, was moving by railroads employing the Kanmon tunnels and the Hakkodate-Aomori rail ferry. The railroads on Honshu include few main lines and these lines traverse bridges of considerable vulnerability. Japan is largely a mountainous country lacking automobile roads, trucks or the gasoline to make use of them. A successful attack on the Hakkodate rail ferry, the Kanmon tunnels and 19 bridges and vulnerable sections of line so selected as to set up five separate zones of complete interdiction would have virtually eliminated

further coal movements, would have immobilized the remainder of the rail system through lack of coal, and would have completed the strangulation of Japan's economy. This strangulation would have more effectively and efficiently destroyed the economic structure of the country than individually destroying Japan's cities and factories. It would have reduced Japan to a series of isolated communities, incapable of any sustained industrial production, incapable of moving food from the agricultural areas to the cities, and incapable of rapid large-scale movements of troops and munitions.

"The Survey believes that such an attack, had it been well-planned in advance, might have been initiated by carrier-based attacks on shipping and on the Hakkodate ferry in August 1944, could have been continued by aerial mining of inland waterways beginning in December 1944, and could have been further continued by initiating the railroad attack as early as April 1945. The Survey has estimated that force requirements to effect complete interdiction of the railroad system would have been 650 B-29 visual sorties carrying 5,200 tons of high explosive bombs. Monthly tonnages equal to one and one-half times that required to effect the original interdiction should have been sufficient, in view of the Japanese lack of preparation and slowness in effecting repairs, to maintain the interdiction by destroying such bridges and other facilities as the Japanese were able to repair. The use of Azon guided bombs, which could have been made available at that time, would have greatly increased accuracy against targets of this type and reduced force requirements to approximately one-sixth of those given above. An integrated program employing both carrier planes and B-29s would have capitalized on the differing operational capabilities of each.

"The economic effects of the transportation attack would have had a direct impact on the Japanese people and on their determination to continue the war. In order to bring maximum pressure on the civilian population and to complicate further the Japanese economic problems, night and bad weather attacks on urban areas could have been carried out simultaneously with the transportation attack. One of the important factors inducing Japan's leaders to accept unconditional surrender was a realization that the Japanese armed forces had lost their ability to protect the people and that under the impact of direct air attack and lowered livelihood their confidence in victory and determination to continue the war were rapidly declining.

"Total civilian casualties in Japan, as a result of nine months of air attack, including those from the atomic bombs, were approximately 806,000. Of these, approximately 330,000 were fatalities. These casu-

alties probably exceeded Japan's combat casualties which the Japanese estimate as having totaled approximately 780,000 during the entire war. The principal cause of civilian death or injury was burns. Of the total casualties approximately 185,000 were suffered in the initial attack on Tokyo of March 9, 1945. Casualties in many extremely destructive attacks were comparatively low. Yokohama, a city of 900,000 population, was 47 per cent destroyed in a single attack lasting less than an hour. The fatalities suffered were less than 5,000.

"The Japanese had constructed extensive firebreaks by tearing down all houses along selected streets or natural barriers. The total number of buildings torn down in this program, as reported by the Japanese, amounted to 615,000 as against 2,510,000 destroyed by the air attacks themselves. These firebreaks did not effectively stop the spread of fire, as incendiaries were dropped on both sides of the breaks. They did, however, constitute avenues of escape for the civilian population.

"The Japanese instituted a civilian-defense organization prior to the war. It was not until the summer of 1944, however, that effective steps were taken to reduce the vulnerability of Japan's civilian population to air attacks. By that time, the shortage of steel, concrete and other construction materials was such that adequate air-raid shelters could no longer be built. Each family was given the obligation of providing itself with some kind of an excavation covered with bamboo and a little dirt. In addition, tunnels were dug into the sides of hills wherever the topography permitted.

"Japanese planning and the means for carrying out the plans were thus deficient for a first-class civilian defense program. In spite of these limitations, such civilian defense measures as they were able to put through contributed substantially in minimizing casualties. School children and other nonessential urban dwellers were evacuated to the country. Those who remained were organized to combat fires and to provide mutual assistance. The air raid warning system was generally efficient. The weight of the individual attacks was, however, far heavier than the Japanese had envisaged or were able to cope with. In the major fire attacks, the civilian defense organizations were simply overwhelmed.

"The growing food shortage was the principal factor affecting the health and vigor of the Japanese people. Prior to Pearl Harbor the average per capita caloric intake of the Japanese people was about 2,000 calories as against 3,400 in the United States. The acreage of arable land in Japan is only three per cent of that of the United States to support a population over half as large. In order to provide the pre-

war diet, this arable acreage was more intensively cultivated, using more manpower and larger quantities of fertilizer, than in any other country in the world; fishing was developed into a major industry; and rice, soybeans and other foodstuffs amounting to 19 per cent of the caloric intake were imported. Despite the rationing of food beginning in April 1941, the food situation became critical. As the war progressed, imports became more and more difficult, the waters available to the fishing fleet and the ships and fuel oil for its use became increasingly restricted. Domestic food production itself was affected by the drafting of the younger males and by an increasing shortage of fertilizers.

"By 1944, the average per capita caloric intake had declined to approximately 1,900 calories. By the summer of 1945, it was about 1,680 calories per capita. Coal miners and heavy industrial workers received higher-than-average rations, the remaining populace, less. The average diet suffered even more drastically from reductions in fats, vitamins and minerals required for balance and adversely affected rates of recovery and mortality from disease and bomb injuries.

"Undernourishment produced a major increase in the incidence of beriberi and tuberculosis. It also had an important effect on the efficiency and morale of the people, and contributed to absenteeism among workers. Survey interrogation of a scientifically designed cross-section sample of the Japanese civilian population revealed a high degree of uniformity as between city and rural sectors of the population and as between various economic and social strata in their psychological reaction to the war. A uniformly high percentage considered Japan's greatest weaknesses to have been in the material realm, either lack of resources, productive plant or modern weapons, and her greatest strength to have been in the Yamato spirit of the Japanese people, their willingness to make every personal sacrifice, including that of life itself, for the Emperor or Japan.

"The Japanese people reacted to news of the attack against the United States and its Allies with mingled feelings of fear, insecurity and hope. To a people wearied by 10 years of war in China, it was clear that this would be a major war and not an 'incident.' The early Japanese military successes, particularly the capture of Singapore and the southern regions, were followed by a wave of optimism and high confidence. Subsequent defeats were studiously withheld from the people or disguised as strategic withdrawals. Prior to the loss of Saipan confidence in eventual victory remained high in spite of exhausting work, poor nutrition and rising black market prices. In June 1944, approximately two per cent of the population believed that Japan faced

the probability of defeat. The fall of Saipan could not be kept from the Japanese people. Even though the psychological effect of this disaster was far greater on the Japanese leaders and intellectuals than on the mass of the population, all indices of Japanese morale began thereafter to decline. By December 1944, air attacks from the Marianas against the home islands had begun, defeats in the Philippines had been suffered, and the food situation had deteriorated; 10 per cent of the people believed Japan could not achieve victory. By March 1945, when the night incendiary attacks began and the food ration was reduced, this percentage had risen to 19 per cent. In June it was 46 per cent, and just prior to surrender, 68 per cent. Of those who had come to this belief over one-half attributed the principal cause to air attacks, other than the atomic bombing attacks, and one-third to military defeats. Sixty-four per cent of the population stated that they had reached a point prior to surrender where they felt personally unable to go on with the war. Of these, less than one-tenth attributed the cause to military defeats, one-quarter attributed the cause to shortages of food and civilian supplies, the largest part to air attack.

"A striking aspect of the air attack was the pervasiveness with which its impact on morale blanketed Japan. Roughly one-quarter of all people in cities fled or were evacuated, and these evacuees, who themselves were of singularly low morale, helped spread discouragement and disaffection for the war throughout the islands. This mass migration from the cities included an estimated 8,500,000 persons. Throughout the Japanese islands, whose people had always thought themselves remote from attack, United States planes crisscrossed the skies with no effective Japanese air or anti-aircraft opposition. That this was an indication of impending defeat became as obvious to the rural as to the urban population.

"Progressively lowered morale was characterized by loss of faith in both military and civilian leaders, loss of confidence in Japan's military might and increasing distrust of government news releases and propaganda. People became short-tempered and more outspoken in their criticism of the government, the war and affairs in general. Until the end, however, national traditions of obedience and conformity, reinforced by the police organization, remained effective in controlling the behavior of the population. The Emperor largely escaped the criticism which was directed at other leaders, and retained the people's faith in him. It is probable that most Japanese would have passively faced death in a continuation of the hopeless struggle, had the Emperor so ordered. When the Emperor announced the unconditional sur-

render the first reaction of the people was one of regret and surprise, followed shortly by relief.

"The interrelation of military, economic and morale factors was complex. To a certain extent each reacted on the other. In the final analysis the Japanese military machine had lost its purpose when it could no longer protect the Japanese people from destruction by air attack. General Takashima, when asked by the Survey as to his reaction to the Imperial Rescript, stated that surrender had become unavoidable; the Army, even should it repel invasion, could no longer protect the Japanese people from extermination.



U. S. Army photo

### ATOMIC BOMB RESULTS AT HIROSHIMA

"On August 6 and 9, 1945, the first two atomic bombs to be used for military purposes were dropped on Hiroshima and Nagasaki respectively. One hundred thousand people were killed, six square miles or over 50 per cent of the built-up areas of the two cities were destroyed. The first and crucial question about the atomic bomb thus was answered practically and conclusively; atomic energy had been mastered for military purposes and the overwhelming scale of its possibilities had been demonstrated. A detailed examination of the physical, economic, and morale effects of the atomic bombs occupied the attention of a major portion of the Survey's staff in Japan in order to arrive at a more precise definition of the present capabilities and limitations of this radically new weapon of destruction.

"Eyewitness accounts of the explosion all describe similar pictures. The bombs exploded with a tremendous flash of blue-white light, like a giant magnesium flare. The flash was of short duration and accompanied by intense glare and heat. It was followed by a tremendous pressure wave and the rumbling sound of the explosion. This sound is not clearly recollected by those who survived near the center of the explosion, although it was clearly heard by others as much as fifteen miles away. A huge snow-white cloud shot rapidly into the sky and the scene on the ground was obscured first by a bluish haze and then by a purple-brown cloud of dust and smoke.

"Such eyewitness accounts reveal the sequence of events. At the time of the explosion, energy was given off in the forms of light, heat, radiation, and pressure. The complete band of radiations, from X- and gamma-rays, through ultraviolet and light rays to the radiant heat of infra-red rays, traveled with the speed of light. The shock wave created by the enormous pressures built up almost instantaneously at the point of explosion but moved out more slowly, that is at about the speed of sound. The superheated gases constituting the original fire ball expanded outward and upward at a slower rate.

"The light and radiant heat rays accompanying the flash traveled in a straight line and any opaque object, even a single leaf of a vine, shielded objects lying behind it. The duration of the flash was only a fraction of a second, but it was sufficiently intense to cause third degree burns to exposed human skin up to a distance of a mile. Clothing ignited, though it could be quickly beaten out, telephone poles charred, thatched houses caught fire. Black or other dark-colored surfaces of combustible material absorbed the heat and immediately charred or burst into flames; white or light-colored surfaces reflected a substantial portion of the rays and were not consumed. The heavy black clay tiles which are an almost universal feature of the roofs of Japanese

houses bubbled at distances up to a mile. Test of samples of this tile by the National Bureau of Standards in Washington indicates that temperatures in excess of  $1,800^{\circ}$  C. must have been generated in the surface of the tile to produce such an effect. The surfaces of granite blocks exposed to the flash scarred and spalled at distances up to almost a mile. In the immediate area of ground zero (the point on the ground immediately below the explosion), the heat charred corpses beyond recognition.

"Penetrating rays such as gamma-rays exposed X-ray films stored in the basement of a concrete hospital almost a mile from ground zero. Symptoms of their effect on human beings close to the center of the explosion, who survived other effects thereof, were generally delayed for two or three days. The bone marrow and as a result the process of blood formation were affected. The white corpuscle count went down and the human processes of resisting infection were destroyed. Death generally followed shortly thereafter.

"The majority of radiation cases who were at greater distances did not show severe symptoms until one to four weeks after the explosion. The first symptoms were loss of appetite, lassitude and general discomfort. Within 12 to 48 hours, fever became evident in many cases, going as high as  $104^{\circ}$  to  $105^{\circ}$  F., which in fatal cases continued until death. If the fever subsided, the patient usually showed a rapid disappearance of other symptoms and soon regained his feeling of good health. Other symptoms were loss of white blood corpuscles, loss of hair, and decrease in sperm count.

"Even though rays of this nature have great powers of penetration, intervening substances filter out portions of them. As the weight of the intervening material increases the percentage of the rays penetrating goes down. It appears that a few feet of concrete, or a somewhat greater thickness of earth, furnished sufficient protection to humans, even those close to ground zero, to prevent serious after effects from radiation.

"The blast wave which followed the flash was of sufficient force to press in the roofs of reinforced-concrete structures and to flatten completely all less sturdy structures. Due to the height of the explosion, the peak pressure of the wave at ground zero was no higher than that produced by a near-miss of a high-explosive bomb, and decreased at greater distances from ground zero. Reflection and shielding by intervening hills and structures produced some unevenness in the pattern. The blast wave, however, was of far greater extent and duration than that of a high-explosive bomb and most reinforced-concrete structures suffered structural damage or collapse up to 700 feet at Hiroshima and

2,000 feet at Nagasaki. Brick buildings were flattened up to 7,300 feet at Hiroshima and 8,500 feet at Nagasaki. Typical Japanese houses of wood construction suffered total collapse up to approximately 7,300 feet at Hiroshima and 8,200 feet at Nagasaki. Beyond these distances structures received less serious damage to roofs, wall partitions, and the like. Glass windows were blown out at distances up to five miles. The blast wave, being of longer duration than that caused by high-explosive detonations, was accompanied by more flying debris. Window frames, doors, and partitions which would have been shaken down by a near-miss of a high-explosive bomb were hurled at high velocity through those buildings which did not collapse. Machine tools and most other production equipment in industrial plants were not directly damaged by the blast wave, but were damaged by collapsing buildings or ensuing general fires.

"The above description mentions all the categories of the destructive action by the atomic-bomb explosions at Hiroshima and Nagasaki. There were no other types of action. Nothing was vaporized or disintegrated; vegetation is growing again immediately under the center of the explosions; there are no indications that radio-activity continued after the explosion to a sufficient degree to harm human beings.

"Let us consider, however, the effect of these various types of destructive action on the cities of Hiroshima and Nagasaki and their inhabitants. Hiroshima is built on a broad river delta; it is flat and little above sea level. The total city area is 26 square miles but only seven square miles at the center were densely built up. The principal industries, which had been greatly expanded during the war, were located on the periphery of the city. The population of the city had been reduced from approximately 340,000 to 245,000 as a result of a civilian defense evacuation program. The explosion caught the city by surprise. An alert had been sounded but in view of the small number of planes the all-clear had been given. Consequently, the population had not taken shelter. The bomb exploded a little northwest of the center of the built-up area. Everyone who was out in the open and was exposed to the initial flash suffered serious burns where not protected by clothing. Over 4 square miles in the center of the city were flattened to the ground with the exception of some 50 reinforced concrete buildings, most of which were internally gutted and many of which suffered structural damage. Most of the people in the flattened area were crushed or pinned down by the collapsing buildings or flying debris. Shortly thereafter, numerous fires started, a few from the direct heat of the flash, but most from overturned charcoal cooking stoves or other

secondary causes. These fires grew in size, merging into a general conflagration fanned by a wind sucked into the center of the city by the rising heat. The civilian-defense organization was overwhelmed by the completeness of the destruction, and the spread of fire was halted more by the air rushing toward the center of the conflagration than by efforts of the fire-fighting organization.

"Approximately 60,000 to 70,000 people were killed, and 50,000 were injured. Of approximately 90,000 buildings in the city, 65,000 were rendered unusable and almost all the remainder received at least light superficial damage. The underground utilities of the city were undamaged except where they crossed bridges over the rivers cutting through the city. All of the small factories in the center of the city were destroyed. However, the big plants on the periphery of the city were almost completely undamaged and 94 per cent of their workers unhurt. These factories accounted for 74 per cent of the industrial production of the city. It is estimated that they could have resumed substantially normal production within 30 days of the bombing, had the war continued. The railroads running through the city were repaired for the resumption of through traffic on August 8, two days after the attack.

"Nagasaki was a highly congested city built around the harbor and up into the ravines and river valleys of the surrounding hills. Spurs of these hills coming down close to the head of the bay divide the city roughly into two basins. The built-up area was 3.4 square miles of which 0.6 square miles was given over to industry. The peak wartime population of 285,000 had been reduced to around 230,000 by August 1945, largely by preraid evacuations. Nagasaki had been attacked sporadically prior to August 9 by an aggregate of 136 planes which dropped 270 tons of high explosives and 53 tons of incendiary bombs. Some two per cent of the residential buildings had been destroyed or badly damaged; three of the large industrial plants had received scattered damage. The city was thus comparatively intact at the time of the atomic bombing. The alarm was improperly given and therefore few persons were in shelters. The bomb exploded over the northwest portion of the city; the intervening hills protected a major portion of the city lying in the adjoining valley. The heat radiation and blast actions of the Nagasaki bomb were more intense than those of the bomb dropped over Hiroshima. Reinforced-concrete structures were structurally damaged at greater distances; the heavy steel-frame industrial buildings of the Mitsubishi steel works and the arms plant were pushed at crazy angles away from the center of the explosion.

Contrary to the situation at Hiroshima, the majority of the fires that started immediately after the explosion resulted from direct ignition by the flash.

"Approximately 40,000 persons were killed or missing and a like number injured. Of the 52,000 residential buildings in Nagasaki 14,000 were totally destroyed and a further 5,400 badly damaged. Ninety-six per cent of the industrial output of Nagasaki was concentrated in the large plants of the Mitsubishi Co. which completely dominated the town. The arms plant and the steel works were located within the area of primary damage. It is estimated that 58 per cent of the yen value of the arms plant and 78 per cent of the value of the steel works were destroyed. The main plant of the Mitsubishi electric works was on the periphery of the area of greatest destruction. Approximately 25 per cent of its value was destroyed. The dockyard, the largest industrial establishment in Nagasaki and one of the three plants previously damaged by high-explosive bombs, was located down the bay from the explosion. It suffered virtually no new damage. The Mitsubishi plants were all operating, prior to the attack, at a fraction of their capacity because of a shortage of raw materials. Had the war continued, and had the raw material situation been such as to warrant their restoration, it is estimated that the dockyard could have been in a position to produce at 80 per cent of its full capacity within three to four months; that the steel works would have required a year to get into substantial production; that the electric works could have resumed some production within two months and been back at capacity within six months; and that restoration of the arms plant to 60 to 70 per cent of former capacity would have required 15 months.

"Some 400 persons were in the tunnel shelters in Nagasaki at the time of the explosion. The shelters consisted of rough tunnels dug horizontally into the sides of hills with crude, earth-filled blast walls protecting the entrances. The blast walls were blown in but all the occupants back from the entrances survived, even in those tunnels almost directly under the explosion. Those not in a direct line with the entrance were uninjured. The tunnels had a capacity of roughly 100,000 persons. Had the proper alarm been sounded, and these tunnel shelters been filled to capacity, the loss of life in Nagasaki would have been substantially lower.

"The Survey has estimated that the damage and casualties caused at Hiroshima by the one atomic bomb dropped from a single plane would have required 220 B-29s carrying 1,200 tons of incendiary bombs, 400 tons of high-explosive bombs, and 500 tons of anti-personnel fragmentation bombs, if conventional weapons, rather than an

atomic bomb, had been used. One hundred and twenty-five B-29s carrying 1,200 tons of bombs would have been required to approximate the damage and casualties at Nagasaki. This estimate presupposed bombing under conditions similar to those existing when the atomic bombs were dropped and bombing accuracy equal to the average attained by the Twentieth Air Force during the last three months of the war.

"As might be expected, the primary reaction of the populace to the bomb was fear, uncontrolled terror, strengthened by the sheer horror of the destruction and suffering witnessed and experienced by the survivors. Prior to the dropping of the atomic bombs, the people of the two cities had fewer misgivings about the war than people in other cities and their morale held up after it better than might have been expected. Twenty-nine per cent of the survivors interrogated indicated that after the atomic bomb was dropped they were convinced that victory for Japan was impossible. Twenty-four per cent stated that because of the bomb they felt personally unable to carry on with the war. Some 40 per cent testified to various degrees of defeatism. A greater number (24 per cent) expressed themselves as being impressed with the power and scientific skill which underlay the discovery and production of the atomic bomb than expressed anger at its use (20 per cent). In many instances, the reaction was one of resignation.

"The effect of the atomic bomb on the confidence of the Japanese civilian population outside the two cities was more restricted. This was in part due to the effect of distance, lack of understanding of the nature of atomic energy, and the impact of other demoralizing experiences. The role of the atomic bomb in the surrender must be considered along with all the other forces which bore upon that question with Japan.

"Japan's governmental structure was such that in practice the Emperor merely approved the decisions of his advisers. A consensus among the oligarchy of ruling factions at the top was required before any major question of national policy could be decided. These factions, each of which had a different point of view, included the group around the Emperor of whom Marquis Kido, the Lord Keeper of the Privy Seal, was the most important, the ex-premiers constituting the Jushin or body of senior statesmen, and the cabinet. The Army and Navy named their own cabinet ministers, who, together with the two chiefs of staff, had direct access to the Emperor. The cabinet could perpetuate itself only so long as it was able to absorb or modify the views of the Army and Navy ministers, who, until the end, were strongly influenced by the fanaticism of the Army officers and many of the

younger Navy officers. The ruling oligarchy considered the opinions of the Japanese people as only one among the many factors to be taken into consideration in determining national policy and in no sense as controlling.

"The first definitive break in the political coalition which began the war occurred following our success at Saipan. Ten days thereafter, on July 16, 1944, the cabinet headed by Gen. Tojo fell. This significant turn in the course of Japan's wartime politics was not merely the result of an immediate crisis. Even at that date, elements opposing continuation of the war had found means of applying pressure against the fanatic exponents of Japan's militaristic clique. The original factions who had either opposed war before Pearl Harbor, or gone along, or 'retired' in the first phase of the conflict recognized as early as the spring of 1944 that Japan was facing ultimate defeat. By that time, United States determination to fight and her ability to mount overpowering offensives in the Pacific, even before the opening of the European Second Front, had already been demonstrated to many of those who had access to all the facts. The political problem of those who saw the situation was to circulate among other leaders in retirement or outside the government a true picture of the war and then unseat the Tojo government in favor of one which would bring the war to an end.

"Rear Adm. Takagi of the Navy General Staff made a study between September 20, 1943, and February 1944, of the war's battle lessons up to that time. Based on analysis of air, fleet and merchant ship losses, Japan's inability to import essential materials for production, and the potentiality of air attacks on the home islands, Takagi concluded that Japan could not win and should seek a compromise peace. His study and a similar one made by Sakomizu of the Cabinet Planning Board documented the fears of the Jushin, and through them of Marquis Kido, that all was not well with Tojo's prosecution of the war. With the loss of Saipan, it was possible to build up sufficient pressure to force Tojo's retirement.

"The government of Gen. Koiso, who was chosen by the ever-cautious Kido to head the succeeding cabinet, did not have the strength to stand up to the military and was a disappointment to the more enthusiastic peace makers. In spite of original instructions to give 'fundamental reconsideration' to the problem of continuing the war, his only accomplishment in that direction was the creation of a Supreme War Direction Council, an inner cabinet which supplied the mechanism through which the problem of surrender was eventually resolved.

"The conviction and strength of the peace party was increased by

the continuing Japanese military defeats, and by Japan's helplessness in defending itself against the ever-growing weight of air attack on the home islands. On April 7, 1945, less than a week after United States landings on Okinawa, Koiso was removed and Marquis Kido installed Adm. Suzuki as premier. Kido testified to the Survey that, in his opinion, Suzuki alone had the deep conviction and personal courage to stand up to the military and bring the war to an end. Early in May 1945, the Supreme War Direction Council began active discussion of ways and means to end the war, and talks were initiated with Soviet Russia seeking her intercession as mediator.

"The talks by the Japanese ambassador in Moscow and with the Soviet ambassador in Tokyo did not make progress. On June 20, the Emperor, on his own initiative, called the six members of the Supreme War Direction Council to a conference and said it was necessary to have a plan to close the war at once, as well as a plan to defend the home islands. The timing of the Potsdam Conference interfered with a plan to send Prince Konoye to Moscow as a special emissary with instructions from the cabinet to negotiate for peace on terms less than unconditional surrender, but with private instructions from the Emperor to secure peace at any price. Although the Supreme War Direction Council, in its deliberations on the Potsdam Declaration, was agreed on the advisability of ending the war, three of its members, the Prime Minister, the Foreign Minister and the Navy Minister, were prepared to accept unconditional surrender, while the other three, the Army Minister, and the Chiefs of Staff of both services, favored continued resistance unless certain mitigating conditions were obtained.

"On August 6, the atomic bomb was dropped on Hiroshima, and on August 9, Russia entered the war. In the succeeding meetings of the Supreme War Direction Council, the differences of opinion previously existing as to the Potsdam terms persisted exactly as before. By using the urgency brought about through fear of further atomic bombing attacks, the Prime Minister found it possible to bring the Emperor directly into the discussions of the Potsdam terms. Hirohito, acting as arbiter, resolved the conflict in favor of unconditional surrender. The public admission of defeat by the responsible Japanese leaders, which constituted the political objective of the United States offensive begun in 1943, was thus secured prior to invasion and while Japan was still possessed of some 2,000,000 troops and over 9,000 planes in the home islands. Military defeats in the air, at sea and on the land, destruction of shipping by submarines and by air, and direct air attack with conventional as well as atomic bombs, all contributed to this accomplishment.

"There is little point in attempting precisely to impute Japan's unconditional surrender to any one of the numerous causes which jointly and cumulatively were responsible for Japan's disaster. The time lapse between military impotence and political acceptance of the inevitable might have been shorter had the political structure of Japan permitted a more rapid and decisive determination of national policies. Nevertheless, it seems clear that, even without the atomic bombing attacks, air supremacy over Japan could have exerted sufficient pressure to bring about unconditional surrender and obviate the need for invasion.

"Based on a detailed investigation of all the facts, and supported by the testimony of the surviving Japanese leaders involved, it is the Survey's opinion that certainly prior to December 21, 1945, and in all probability prior to November 1, 1945, Japan would have surrendered even if the atomic bombs had not been dropped, even if Russia had not entered the war, and even if no invasion had been planned or contemplated.

"The foregoing pages tell of the results achieved by air power in each of its several roles in the war in the Pacific, including the effects of the atomic bombs. The Survey has already reported on the results achieved by air power in the European war. It remains to seek out the degree to which the Pacific study modifies, adds to or supports the signposts to the future which were suggested by the European study; to state the extent to which hindsight suggests that air power might have been differently or better employed in the Pacific; to discuss the impact of the existence of atomic bombs on the role of air power; and to state the Survey's recommendations. First, however, it is necessary to point out some of the unique features of the Pacific war which must be borne in mind while considering lessons to be learned from it.

"The Pacific war was unique in many respects, as was the European war, and great reservation should be used in assuming that what was effective or not effective under those circumstances would be similarly effective at other times and under different circumstances. Japan's initial war strategy called for a war of limited objectives. Her capabilities did not permit an attack on our basic supporting strength. She was, however, a fanatically determined enemy, well prepared initially, and the fighting quality of her soldiers, seamen and airmen should not be underestimated.

"Japan's geographical situation determined that the Pacific war should in large measure be a war for control of the sea and to insure control of the sea, for control of the air over it. As a result, attacks against warships and merchant ships and amphibious operations for possession of island positions on which forward bases could be located

were close to the heart of the struggle. Carrier task forces, surface ships to provide logistic support, and submarines therefore assumed roles of unusual importance.

"Japan's industrial potential was approximately 10 per cent of that of the United States. Even though her research and technical design work was not purely imitative, her ability to develop reliable operating equipment in the new fields was low. Her radar and communications equipment was weak. She could not build sufficient ships or escort vessels. She lacked construction equipment to build adequate airfields. She was always hampered by a lack of oil. Her anti-aircraft was outmoded. She could not economically afford to build adequate shelters for her population. She could not both disperse her industry and also repair damaged plants. She chose dispersal rather than repair, but she had insufficient means even to disperse effectively.

"Not only the uniqueness of the Pacific war but new developments in weapons and tactics make it impossible to assert that signposts to the future derived from the Pacific war will apply with equal force to other situations. The Survey believes, however, that the following signposts as to the role of air power should be given thorough consideration by those working out the solutions to new problems arising under differing conditions.

"1. Control of the air was essential to the success of every major military operation. Control of the air enabled surface vessels to sail the seas as far as that control extended, even within range of enemy land-based airplanes. Control of the air permitted amphibious landings at any point where that control could be assured. Control of the air permitted close air support to ground forces, the effectiveness of which was decisive wherever fully employed. Control of the air over lines of communications permitted effective interdiction of them to the enemy and preserved them to ourselves. Control of the air over the Japanese home islands permitted the destruction by long-range bombing of such of her industries and cities as we chose to attack. The first objective of all commanders in the Pacific war, whether ground, sea or air, whether American, Allied, or Japanese, was to assure control of the air.

"2. Control of the air was not easily achieved, and involved the coordinated application of all the resources of the nation. Air power consisted not merely of the planes and pilots that engaged the enemy, but of all the sources of strength that supported, reinforced and exploited control of the air. It was coordinated teamwork of ground, sea and air forces, both ground-based and carrier-based, and their supporting services, backed up by the full effort of all phases of the home

front that enabled us to secure control of the air, at first locally and then more generally, culminating in virtual freedom of the skies over the Japanese home islands themselves.

"3. The limitations of air control deserve special mention. It was never completely possible to deny the air to the enemy. It was considered that we had control of the air when the enemy could not operate in it without prohibitive losses in relation to results achieved, while our own planes could operate in it at will and with acceptable risk of loss. The Japanese increased their ratio of results achieved to losses by adopting Kamikaze tactics. This was a measure of desperation, but the results obtained were considerable and, had they been much greater, might have caused us to withdraw or to modify our strategic plans. The principle involved indicates the degree to which defensive air control must be improved or enemy bases kept beyond the range of enemy suicide planes or guided missiles from such land or sea as we propose to use.

"4. Given air control, there were also limitations as to the specific results which could be achieved in exploiting such control by aircraft carrying conventional high-explosive bombs. Fox holes, underground emplacements and other prepared defenses could not in many cases be reduced, and it was necessary to eliminate remaining ground forces in costly close-range fighting even though these forces were isolated and completely cut off from supplies and reinforcements.

"Weather and darkness limited exploitation of air control, but as the war progressed technical and tactical advances were made which progressively reduced these limitations.

"Combat radius of fighters and time on patrol at maximum radius, although great by previously existing standards, required that airfields or carriers be available within 300 nautical miles or less of the critical areas of surface combat for optimum fighter cover. The effective radius of our longest range bombers was limited to 1,500 miles and bases still closer to Japan were considered essential for emergency landing and fighter support.

"The importance of reducing these limitations of control of the air and its exploitation by the application of research and development work in postwar years is obvious.

"5. The experience of the Pacific war supports the findings of the Survey in Europe that heavy, sustained and accurate attack against carefully selected targets is required to produce decisive results when attacking an enemy's sustaining resources. It further supports the findings in Germany that no nation can long survive the free exploitation of air weapons over its homeland. For the future it is important fully

to grasp the fact that enemy planes enjoying control of the sky over one's head can be as disastrous to one's country as its occupation by physical invasion.

"Hindsight inevitably suggests that in some respects air power might have been differently or better employed. Prior to the European war, we underestimated the predominant role that air power was to play and allocated to it too small a share of even the inadequate resources then available to the Army and Navy. At the outbreak of the Pacific war, our deficiency was particularly great in modern land-based fighters and in carriers. One thousand planes in the Philippines, at least equal in performance to the best then available to the Japanese, including types effective against shipping, well-manned, equipped and supplied, and dispersed on some 50 airfields, would have seriously impeded the original Japanese advance if knowledge of their existence had not entirely dissuaded the Japanese from making the attempt. The loss of relatively antiquated battleships at Pearl Harbor had little effect on the Navy's combat capabilities at that time, while the addition of a few carriers would have enormously increased its capabilities. Larger overall appropriations to the armed forces, beginning at the time of Japanese occupation of Manchuria when the threat to peace in the Far East became evident, might have made war unnecessary and would have paid for itself many times over in reduced casualties and expenditures had war still been unavoidable.

"Upon entering the war, we were deficient not only in numbers, but in quality of many of our aircraft types. We were forced thereafter into hasty and costly modification and technical development programs to raise the performance of our aircraft to acceptable standards. These programs could have been conducted more efficiently and economically during prewar years.

"In the actual conduct of the war we more quickly grasped the strategic revolution brought about by the capabilities of air power than did the Japanese. By the end of 1943, we had achieved through combat and the augmentation of our forces, such clear cut superiority over the Japanese in all elements of air power that eventual victory was assured.

"In exploiting this superiority greater economy of effort was possible. The structure of our prewar military organization provided no means, short of the President, for integrating our armed forces. Under the pressure of war the Joint Chiefs of Staff was the most decisive mechanism then possible to fill this gap. Each of its members had in effect the power of veto and the required unanimity was produced by compromise. It proved impossible to agree on an overall commander



U. S. Army photo

**DESTRUCTION OF OSAKA BY B-29 BOMBERS**

for the Pacific as a whole. Our military and economic strength, however, made it possible to plan and execute a dual line of advance across the Pacific and to mount an air attack of sufficient weight to induce unconditional surrender concurrently with the preparation of a full scale invasion.

“Capture of the Gilbert Islands produced limited strategic results. Attacks on Rabaul and other bypassed positions were continued longer and in greater volume than required. The effectiveness of high-level attack in softening up prepared defenses and in sinking maneuvering ships was overestimated. Prior to the occupation of the Marianas, B-29s could have been more effectively used in coordination with submarines for search, low-level attacks and mining in accelerating the destruction of Japanese shipping, or in destroying oil and metal plants

in the southern areas, than in striking the Japanese 'Inner Zone' from China bases.

"In the final assault on the Japanese home islands we were handicapped by a lack of prewar economic intelligence. Greater economy of effort could have been attained, and much duplicative effort avoided, by extending and accelerating the strangulation of the Japanese economy already taking place as a result of prior attacks on shipping. This could have been done by an earlier commencement of the aerial mining program, concentration of carrier plane attacks in the last months of the war on Japan's remaining merchant shipping rather than on her already immobilized warships, and a coordinated B-29 and carrier attack on Japan's vulnerable railroad system beginning in April 1945.

"We underestimated the ability of our air attack on Japan's home islands, coupled as it was with blockade and previous military defeats, to achieve unconditional surrender without invasion. By July 1945, the weight of our air attack had as yet reached only a fraction of its planned proportion, Japan's industrial potential had been fatally reduced, her civilian population had lost its confidence in victory and was approaching the limit of its endurance, and her leaders, convinced of the inevitability of defeat, were preparing to accept surrender. The only remaining problem was the timing and terms of that surrender. Having entered the war inadequately prepared, we continued all-out mobilization of all resources to bring ever increasing pressure on Japan, beyond the time when this was still reasonably required.

"Does the existence of atomic bombs invalidate all conclusions relative to air power based on pre-atomic experience? It is the Survey's opinion that many of the pre-existing yardsticks are revolutionized, but that certain of the more basic principles and relationships remain. The atomic bomb, in its present state of development, raises the destructive power of a single bomber by a factor of somewhere between 50 and 250 times, depending upon the nature and size of the target. The capacity to destroy, given control of the air and an adequate supply of atomic bombs, is beyond question. Unless both of these conditions are met, however, any attempt to produce war-decisive results through atomic bombing may encounter problems similar to those encountered in conventional bombing.

"The problem of control of the air, primarily of our own air, and should we be attacked, of the enemy's air as well, becomes of even greater significance. The most intense effort must be devoted to perfecting defensive air control both by day and night, through the improvement of early warning and fighter control apparatus, anti-aircraft

ordnance and defensive fighters, not only from the standpoint of technological improvement and volume, but also of disposition and tactics. It would be rash, however, to predict an increase in the effectiveness of defensive control sufficient to insure that not a single enemy plane or guided missile will be able to penetrate. It therefore behooves us to accept the possibility that at least a small number of enemy planes or guided missiles may be able to evade all our defenses and to attack any objective within range. The threat of immediate retaliation with a striking force of our own should deter any aggressor from attacking.

"If we are not to be overwhelmed out of hand, in the event we are nevertheless attacked, we must reduce materially our vulnerability to such attack. The experience of both the Pacific and European wars emphasizes the extent to which civilian and other forms of passive defense can reduce a country's vulnerability to air attack. Civilian injuries and fatalities can be reduced, by presently known techniques, to one-twentieth or less of the casualties which would be suffered were these techniques not employed. This does not involve moving everything underground, but does involve a progressive evacuation, dispersal, warning, air-raid shelter, and postraid emergency assistance program, the foundations for which can only be laid in peacetime. The analysis of the effects of the atomic bombs at Hiroshima and Nagasaki indicates that the above statement is just as true and much more terrifyingly significant in an age of atomic bombs than it was in an age of conventional weapons. Similarly, economic vulnerability can be enormously decreased by a well worked out program of stockpiles, dispersal and special construction of particularly significant segments of industry. Such a program in the economic field can also be worked out satisfactorily only in peacetime.

"In the strictly military field the impact of atomic weapons and guided missiles on strategy and tactics can only be developed by military specialists. It is the Survey's opinion, however, that mature study by such specialists will support the conclusion that dispersal of military forces, and therefore space and distance in which to effect such dispersal, will be significant considerations; that heavy bombers similar to those used in this war will not be able to operate effectively and on a sustained basis much beyond the range of protective fighters, and that newer types of offensive weapons and new tactics must be developed to do so; that forward air bases will have to be defended or more advanced bases acquired step by step in actual combat; and that the basic principles of war, when applied to include the field of the new weapons, will be found to remain. If such be the case, atomic weapons will not have eliminated the need for ground troops, for surface ves-

sels, for air weapons, or for the full coordination among them, the supporting services and the civilian effort, but will have changed the context in which they are employed to such a degree that radically changed equipment, training and tactics will be required.

"Over and above the numerous recommendations scattered throughout preceding sections of this report, of which the recommendation that we develop protection for our civilian population and for our economy is one of the most important, the Survey has been impressed with the need for concrete and prompt action to encourage adequate research and development; to assure adequate intelligence during peacetime; to integrate our military establishments; and to increase the national appreciation of the necessity for continued strength of the United States as a force for peace.

"Research and development—The 'blitzkrieg' technique is of enormous danger. This conclusion, derived initially from the European war, is strongly supported by the Japanese experience. A mobilized and well-trained striking force enjoying a certain technical superiority can overwhelm in short order the forces of a country of far greater basic long-term strength. In the opening phases of the Pacific war the Japanese were able to overrun 130,000,000 people and an area of enormous strategic importance in the space of a few months. This was true in spite of the fact that from the time of the Munich conference in 1938 we had been on notice that aggression against the peace of the world was possible and that the intervening years and the experience of our Allies had been invaluable in permitting us to take the necessary steps to revise our strategic concepts, to apply our advanced scientific and development resources to the improvement of our weapons, and to begin our industrial and military mobilization. The distances of the Pacific fortunately gave us space, and therefore time, in which to absorb the initial blow while our increasing strength and Japan's increasing logistic problems reversed the initial disadvantages facing our advanced forces.

"Science has increased tremendously the destructive capability of modern weapons and promises further developments in the future. Given an adequate supply of atomic bombs, the B-29s based in the Marianas had sufficient strength to have effectively destroyed in a single day every Japanese city with a population in excess of 30,000 people. In the future, national security will depend to a large degree on technical superiority of weapons and on operating and maintenance proficiency of personnel. Peacetime military strategic planning must be pointed to and supported by a vigorous program of scientific research and development. If the United States is not to be forced to

hasty and inadequate mobilization every time the threat of aggression arises in the world, it is essential that in the field of military weapons and tactics we be technically not merely abreast of, but actually ahead of any potential aggressor. It is not generally realized the degree to which basic scientific research was neglected in the United States during the course of the war in order to concentrate on the belated development of the specific weapons immediately required, nor the degree to which we lagged behind Germany in advanced aerodynamics, jet propulsion and the development of guided missiles. In air armament and torpedoes, even the Japanese were ahead of us. One or two years' lag in either basic research or in the development of reliable military application of such research can only be made up with difficulty, if at all. This type of work has become so complex that expenditures for research and development in the order of one billion dollars annually may be required to assure an acceptable degree of national security.

"Intelligence—At the start of the Pacific war our strategic intelligence was highly inadequate, and our overall war plans, insofar as they were based on faulty information and faulty interpretation of accurate information, were unrealistic. After Pearl Harbor the obtaining and analysis of economic and industrial information necessary to the planning of an attack on Japan's sustaining resources required several years of the most strenuous effort and even then substantial gaps remained. If a comparable lack of intelligence should exist at the start of a future national emergency, it might prove disastrous. In the field of operational intelligence considerable forward strides were made during the Pacific war. The requirements in this field for a large volume of minutely detailed and accurate work, for complex analysis geared to rapidly changing capabilities of forces and weapons, and for speed, all place a heavy burden on training, competence and organization. These requirements were not fully met in the Pacific war; the deficiency was at times serious. This was in large measure traceable to a prewar lack of trained and competent operational intelligence officers to provide an adequate nucleus for an expanding organization. The basis for adequate intelligence can only be laid in peacetime. The solution to our problems in this field appears in part to be the greater centralization to be provided by the National Intelligence Authority, particularly in securing more adequate coordination and dissemination. It appears also to lie in close integration into the various operating organizations of appropriate intelligence units, adequate budgets and personnel for intelligence work, and a sufficient increase in the prestige attached to such work to attract the

highest quality of personnel. This latter can only come from increased training in intelligence and active appreciation of its functions on the part of other Army, Navy, and Government officials. The present lack of recognized responsibility for intelligence work by the various operating organizations and the present shortage of trained and competent intelligence personnel give cause for alarm and require correction.

"Integration of our military establishments—Organizational deficiencies in the Japanese Government contributed to Japan's entering a disastrous war and subsequently contributed to the absoluteness of her defeat. The form of her governmental organization provided no means for civilian control of the military or for obtaining effective coordination between the Army and Navy. Military policy was inconsistent with the foreign policy of the cabinet, the Japanese Army and Navy tending to make their own foreign policy in accordance with their individual aims, capabilities and requirements. During the war, bureaucratic rivalry between her Army and Navy impeded coordinated strategic and tactical planning, the proper employment of her air power, the development of adequate logistics and the efficient utilization of her economic resources. The existence of such joint or combined organizations as the Supreme War Council, the Supreme War Direction Council, the Board of Field Marshals and Fleet Admirals, the Imperial General Headquarters served mainly to hide the fact that real unity, integration, and coordination were conspicuously lacking.

"Even though the United States did not achieve unity of command in the Pacific as a whole, each theater commander used the air, ground and sea forces assigned to him as an integrated or coordinated team. Coordination and compromise among theater commanders was largely achieved in all major respects. Such lack of complete integration as existed was in a large measure traceable back through the structure of the Joint Chiefs of Staff to the basic structure of our prewar military organization. The Congress of the United States is today considering legislation for the reorganization and integration of our military establishments. The Survey is of the opinion that the prompt passage of appropriate legislation is in the national interest.

"The lessons of the Pacific war strongly support that form of organization which provides unity of command, capable of clear and effective decision at the top, strengthens civilian control and thus provides closer integration of military policy with foreign and domestic policy, and favors a high degree of coordination in planning, intelligence, and research and development. Such unity of command should, however, decentralize administrative burdens and permit specialized

training and the free development of the component forces, even at the risk of some duplication.

"Within a department of common defense which provides unity of command and is itself oriented toward air and new weapons, the Survey believes that, in addition to the Army and the Navy, there should be an equal and coordinate position for a third establishment. To this establishment should be given primary responsibility for passive and active defense against long range attack on our cities, industries and other sustaining resources; for strategic attack, whether by airplane or guided missile; and for all air units other than carrier air and such land-based air units as can be more effective as component parts of the Army or Navy. The mission of such a new establishment would differ considerably from that of an autonomous air force and would, in certain respects, require additional and broader experience than has heretofore been required by the Army Air Forces alone.

"Strength as a force for peace—The Survey's report on the European war stated that the great lesson to be learned in the battered cities of England and the ruined cities of Germany is that the best way to win a war is to prevent it from occurring. This is fully supported by the example of the devastated cities of Japan and their unhappy and hungry surviving inhabitants. The prevention of war must be the ultimate end to which our best efforts are devoted. It has been suggested, and wisely so, that this objective is well served by insuring the strength and the security of the United States. The United States was founded and has since lived upon principles of tolerance, freedom and good will at home and abroad. Strength based on these principles is no threat to world peace. Prevention of war will not be furthered by neglect of strength or lack of foresight or alertness on our part. Those who contemplate evil and aggression find encouragement in such neglect. Hitler relied heavily upon it. The Japanese would never have attacked Pearl Harbor had they not correctly assessed the weakness of our defenses in the Pacific and had they not incorrectly assessed the fighting determination of the United States when attacked.

"Suggestions for assuring the military strength and security of the United States are by no means intended as a recommendation for a race in arms with other nations; nor do they reflect a lack of confidence in the prospect of international relationships founded upon mutual respect and good will which will themselves be a guarantee against future wars. The development of an intelligent and coordinated approach to American security can and should take place within the framework of the security organization of the United Nations.

"The United States as a member of the United Nations has cove-

nanted not to use force except in defense of law as embodied in the purposes and principles of the United Nations' Charter. As one of the great powers we must be prepared to act in defense of law and to do our share in assuring that other nations live up to their covenant.

"The United States must have the will and the strength to be a force for peace."



U. S. Army photo

ASUKASA SECTION OF TOKYO AFTER FIRE BOMBING

## Flying Facts and Figures

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## SUMMARY OF AIR CARRIER OPERATIONS

By Domestic Air Lines in the United States<sup>1</sup>

Compiled by the Office of Aviation Information, Civil Aeronautics Administration

Calendar Year	Operators	Planes in Service	Revenue Miles Flown	Total Passengers Carried	Total Passenger Miles Flown	Express Carried (pounds)	Mail Ton-Miles Flown <sup>2</sup>
1926	11	N.A.	4,258,771	5,782	N.A.	3,555	N.A.
1927	16	N.A.	5,779,863	8,661	N.A.	45,859	N.A.
1928	31	268	10,400,239	47,840	N.A.	210,404	N.A.
1929	34	442	22,380,020	159,751	N.A.	240,634	N.A.
1930	38	497	31,992,634	374,935	84,014,572	359,523	N.A.
1931	35	490	42,755,417	460,981	106,442,375	788,059	3,140,205
1932	29	456	45,606,354	474,279	127,038,798	1,033,970	2,701,125
1933	21	408	48,771,553	493,141	173,492,119	1,510,215	2,567,949
1934	22	417	40,955,306	461,743	187,858,629	2,133,191	2,401,411
1935	23	356	55,380,353	746,946	313,905,508	3,822,397	4,132,708
1936	21	272	63,777,226	1,020,931	435,740,253	6,958,777	5,741,436
1937	17	282	66,071,507	1,102,707	476,603,165	7,127,369	6,698,230
1938	18	253	69,668,827	1,343,427	557,719,268	7,335,967	7,422,860
1939	17	265	82,571,523	1,876,051	749,787,096	9,514,220	8,584,891
1940	16	358	108,800,430	2,959,480	1,147,444,948	12,506,176	10,035,638
1941	17	359	133,022,679	4,060,545	1,491,734,671	19,209,671	12,900,405
1942	16	179	110,102,860	3,551,833	1,481,976,329	30,968,785	21,066,627
1943	16	194	103,601,443	3,454,040	1,642,596,640	57,543,591	35,927,042
1944	16	279	142,234,034	4,668,466	2,264,282,453	66,011,669	59,922,016
1945	17	411	214,959,855	7,502,538	3,500,102,057	83,024,000	64,955,466
1946	20	676	309,592,647	12,591,251	6,067,108,573	149,118,000	N.A.

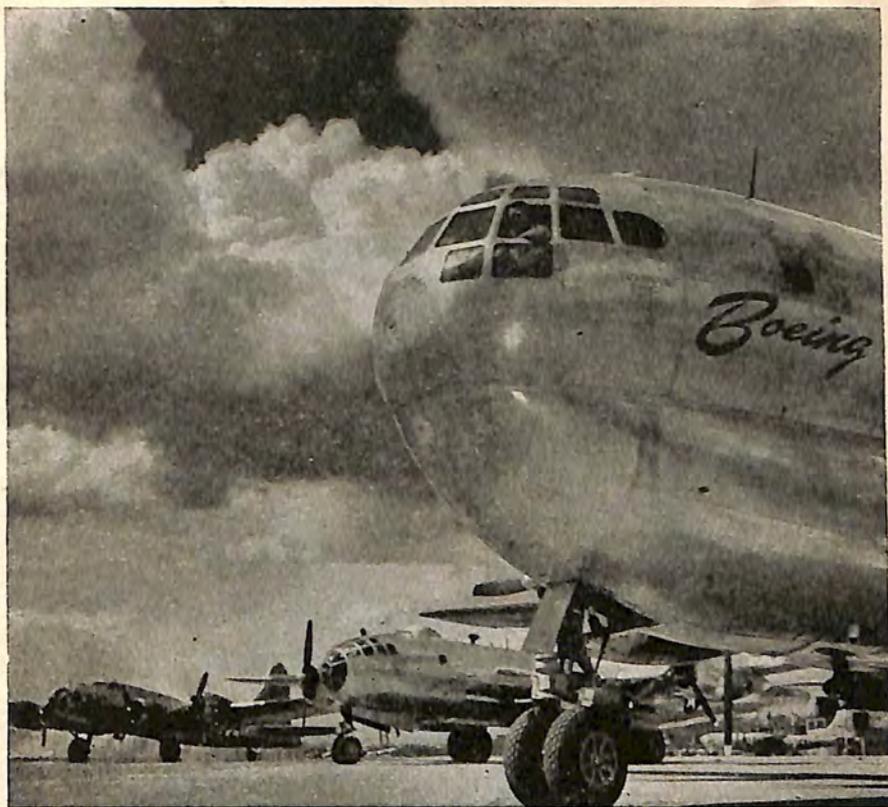
N.A.: Not available.

<sup>1</sup> Does not include charter services or operations to foreign countries.<sup>2</sup> Mail ton-miles flown are for domestic services and Hawaiian Airlines, Ltd., which company holds a domestic air mail contract.

## MILITARY AND NAVAL AIR TRANSPORT

Calendar Year 1946

Operations	U. S. Army Air Forces Air Transport Command	U. S. Navy Air Transport Service
Plane miles flown . . . . .	69,561,060	36,036,402
Passengers carried . . . . .	396,534	429,302
Tons of Cargo and Mail . . . . .	31,408	25,707
Total ton miles . . . . .	203,092,637	121,930,974
Miles of route, peak mo. . . . .	119,071	52,236



## FIRST FAMILY OF THE AIR

Three generations of an illustrious family are represented here.

At left is the durable Boeing B-17 Flying Fortress. Next is the first of the global bombers, the Boeing B-29 Superfortress. And towering over both is the double-decked 80-passenger Boeing Stratocruiser, the world's first true super-transport.

Every aerodynamic advance, achieved by Boeing in 30 years of leadership in building great aircraft, is embodied in the Stratocruiser. It has all the stamina of its fighting predecessors plus matchless spaciousness.

With low direct operating cost, the 340-mile-an-hour Stratocruiser is

designed for ease of servicing and maintenance. Important parts are directly accessible and the four 3500-horsepower engines are interchangeable and quickly replaceable.

The Stratocruiser is remarkably easy to fly because of simplicity of control arrangement. And the control cabin is a pilot's dream—roomy and comfortable, with unequalled visibility. Boeing Airplane Company, Seattle, Washington; Wichita, Kansas.

# BOEING

STRATOCRUISER

**U. S. ARMY AIR FORCES MILITARY PERSONNEL IN  
UNITED STATES AND OVERSEAS**

January 1, 1947

Source: U. S. Army Air Forces Director of Information

	Total	Continental U. S.	Overseas
Officers.....	49,529*	31,497	18,032
Enlisted Personnel.....	291,892	196,551	95,341
Total.....	341,421	228,048	113,373

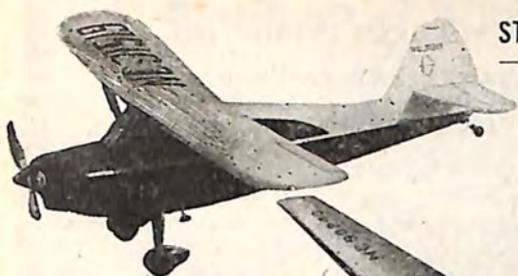
\* Of this number, 24,234 were rated pilots, 6,660 were rated bombardiers, navigators, etc., and 18,635 were non-rated officers.

**U. S. ARMY AIR FORCES MILITARY PERSONNEL  
IN UNITED STATES AND OVERSEAS  
BY TYPE OF PERSONNEL**

August 1945-December 1947

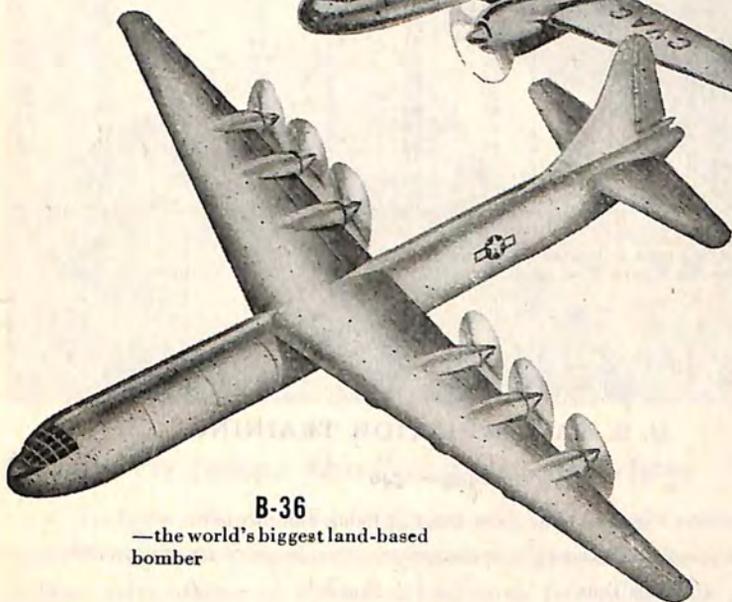
End of Mo.	Total Army Air Forces			Continental U. S.			Overseas		
	Total	Officers	Enlisted Personnel	Total	Officers	Enlisted Personnel	Total	Officers	Enlisted Personnel
1945									
Jan.	2,345,068	377,426	1,967,642	1,165,349	221,180	944,169	1,179,719	156,246	1,023,473
Aug.	2,253,182	368,344	1,884,838	1,253,573	245,511	1,008,062	999,609	122,833	876,776
Dec.	888,769	164,004	724,765	503,234	110,609	392,625	385,535	53,395	332,140
1946									
Dec.	341,413	49,529	291,884	228,048	31,497	196,551	113,365	18,032	95,333

Source: Army Air Forces, Statistical Control Division, Office of Air Comptroller.



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**CONVAIR-240**  
—the world's most modern  
twin-engine airliner



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—the world's biggest land-based  
bomber

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## FLYING FACTS AND FIGURES

**U. S. ARMY AIR FORCES FLYING TIME  
IN UNITED STATES AND OVERSEAS  
BY TYPE OF PLANE**

In Thousands of Hours

1946	Total	Continental U. S.					Overseas Theaters			
		Total	Combat Planes	Trans- ports	Train- ers	Com- muni- cations	Total	Combat Planes	Non- Combat Planes	ATC <sup>1</sup>
Grand Total . . .	3,643	3,483	705	802	892	84	1,160	313	485	362
Jan. . . . .	344	229	67	88	68	6	115	26	39	50
Feb. . . . .	241	166	45	64	52	5	75	18	30	27
Mar. . . . .	274	186	51	62	62	11	88	18	40	30
April. . . . .	322	228	65	70	82	11	94	23	40	31
May. . . . .	316	216	61	69	77	9	100	27	41	32
June. . . . .	336	239	68	74	87	10	97	25	39	33
July. . . . .	319	215	63	69	75	8	104	30	44	30
Aug. . . . .	328	221	66	69	80	6	107	30	46	31
Sept. . . . .	319	214	64	64	81	5	105	31	47	27
Oct. . . . .	337	229	64	69	91	5	108	33	46	29
Nov. . . . .	264	176	49	52	71	4	88	28	39	21
Dec. . . . .	243	164	42	52	66	4	79	24 <sup>2</sup>	34 <sup>2</sup>	21

<sup>1</sup> Air Transport Command.

<sup>2</sup> December flying time estimated for China and Alaska.

Source: Army Air Forces, Statistical Control Division, Office of Air Comptroller.

**U. S. NAVY AVIATION TRAINING**

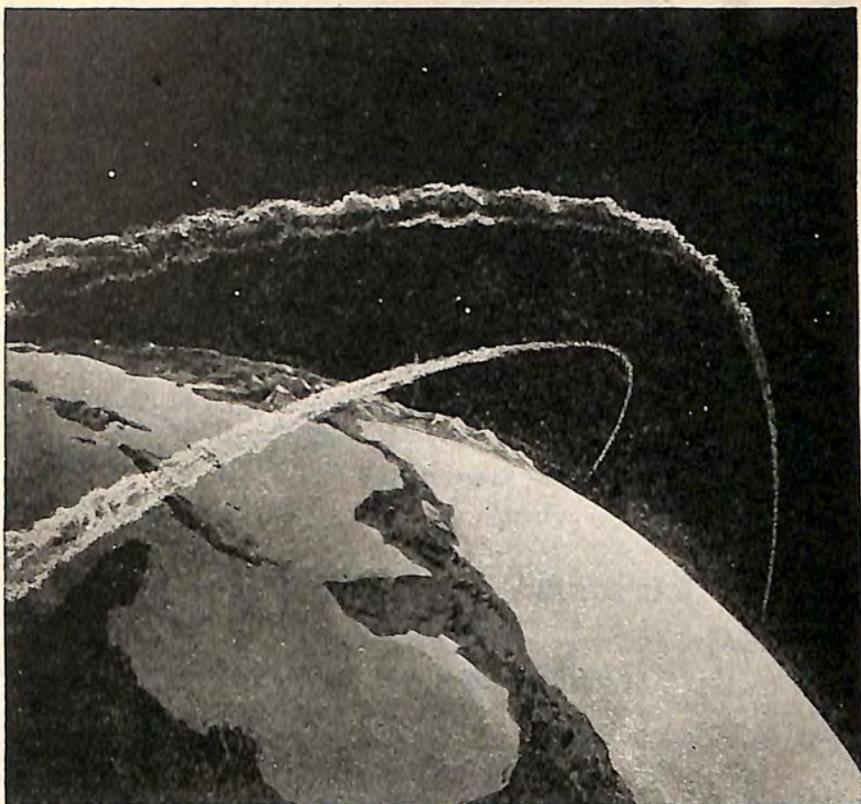
1944—1946

Source: U. S. Navy Office of Public Information

<i>Calendar Year</i>	1944	1945	1946
Pilots trained . . . . .	21,067	7,147 <sup>1</sup>	2,834
Enlisted (includes only trained rated personnel)	72,945	24,490 <sup>2</sup>	16,819

<sup>1</sup> Through August, 1945.

<sup>2</sup> Through October, 1945.



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### U. S. ARMY AIR FORCES AIRPLANES ON HAND, BY MAJOR TYPE

January 1945–December 1946

End of Month	Total	Very Heavy Bombers	Heavy Bombers	Medium Bombers	Light Bombers	Fighters	Reconnaissance	Transports	Trainers	Communications
1945										
Jan.	71,430	1,151	12,844	6,208	2,813	17,332	1,866	10,237	15,840	3,139
Aug.	63,715	2,865	11,065	5,384	3,079	16,799	1,971	9,561	9,558	3,433
Dec.	44,782	2,996	3,005	3,567	2,387	12,596	1,526	7,500	7,617	3,588
1946										
Dec.	30,035	3,006	844	1,877	1,954	8,765	740	4,538	6,297	2,014

Source: Army Air Forces, Statistical Control Division, Office of Air Comptroller.

### U. S. NAVY SERVICE AIRCRAFT

January 1, 1947

#### Including U. S. Marine Corps

Source: U. S. Navy Office of Public Information

Class	Navy	Marine	Reserve	Total
Fighter.....	1,423	665	606	2,088
Attack.....	978	0	414	1,392
Observation.....	110	0	0	110
Patrol (heavy land).....	245	0	0	245
Patrol (medium land).....	100	0	76	176
Patrol (medium sea).....	189	0	0	189
Patrol (amphibious).....	84	0	60	146
Total combat types.....	3,129	665	1,156	4,950
Transport (heavy land).....	79	30	0	109
Transport (medium land).....	143	96	36	275
Transport (heavy sea).....	4	0	0	4
Utility (2-engine).....	277	44	42	363
Utility (1-engine).....	96	0	38	134
Trainer (2-engine).....	354	6	155	515
Trainer (1-engine).....	1,110	71	453	1,643
Rotary Wing.....	17	0	0	17
Total utility types.....	2,089	247	724	3,060
Total aircraft.....	5,218	912	1,880	8,010

Note—Of the total 1,461 are first line combat aircraft.

## 3 "MUSTS"

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- 1 Constant refinement of existing types.
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- 3 Research and design on still later types, probing far into the future of flight.

Only through such a three-fold program of development can America maintain its supremacy in the air. Such leadership is essential to national security and to an ever-expanding era of peacetime trade and commerce.

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Airplanes

**SIKORSKY**  
Helicopters

**U. S. NAVY AIRCRAFT CARRIER  
STRENGTH BY YEARS**

1945—1946

Source: U. S. Navy Office of Public Information

<i>Dec. 31, Each Year</i>	<i>No.</i>	<i>Standard Tonnage</i>	<i>Plane Capacity<sup>1</sup></i>	<i>Active</i>	<i>In Reserve</i>
<b>1945<sup>2</sup></b>					
Large Carriers.....	1	45,000	120	0	0
Carriers.....	23	528,100	2,070	0	0
Light Carriers.....	8	88,000	320	0	0
Escort Carriers.....	72	510,059	1,800	0	0
<b>Total.....</b>	<b>104</b>	<b>1,171,159</b>	<b>4,310</b>	<b>0</b>	<b>0</b>
<b>1946</b>					
Large Carriers.....	3	135,000	360	3	0
Carriers.....	24	551,000	2,160	11	13
Light Carriers.....	8	88,000	320	1	7
Escort Carriers.....	66	407,500	1,650	10	56
<b>Total.....</b>	<b>101</b>	<b>1,241,500</b>	<b>4,490</b>	<b>25</b>	<b>76</b>

<sup>1</sup> Based on average number of planes by carriers.

<sup>2</sup> Through October, 1945.

# "WEEMS"

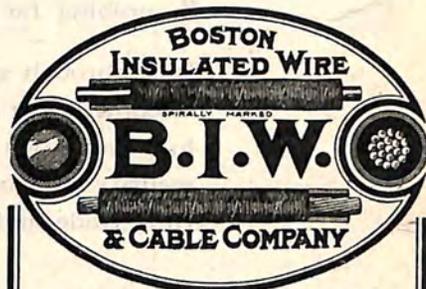
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## 39 Years Ago U. S. Army Bought Its First Airplane

The Army Air Forces celebrated on February 10, 1947, the 39th anniversary of the signing of the first contract to purchase an airplane.

The contract, signed February 10, 1908, called for the purchase of "one heavier-than-air flying machine" for \$25,000, to be delivered on or before August 28 of that year. The document was signed by Capt. Charles S. Wallace, representing the Air Service; Orville Wright, for the Wright brothers of Dayton, Ohio, and Brig. Gen. James Allen, Chief Signal Officer.

Although the contract called for delivery in August, 1908, the actual acceptance flights were not made until almost a year later, due to a plane accident suffered by Orville Wright. On July 27, 1909, however, Orville Wright successfully completed the first of two acceptance flights, staying aloft one hour, 12 minutes, and 40 seconds, thereby fulfilling the condition of the contract which stated that the airplane must fly continuously for one hour. On the initial flight he carried as a passenger Lieut. Frank P. Lahm of the Air Service.

Three days later, before 7,000 spectators, the Wright brothers completed the second acceptance flight with Orville Wright as pilot and Lieut. Benjamin D. Foulois (now Major General Foulois, retired) as passenger. Since the contract called for a sustained flight at a speed of 40 miles an hour, Orville Wright flew a 10-mile cross-country hop from Fort Myer, Virginia, to Shuter Hill at Alexandria. Average speed for the flight was a trifle better than 42 miles an hour.

A clause in the agreement provided for a 10 per cent bonus payment over the \$25,000 contract price for each mile an hour of speed over the specified 40. The Wright brothers, therefore, received \$30,000 for the Nation's first military airplane. Instruction in handling the plane for the flying officers of the Air Service was included in the contract's terms.

In the 39 years since its first airplane acceptance, the AAF has made tremendous aeronautical progress. The Wright brothers' fabric-covered, open-cockpit plane has been replaced by a fleet of new aerial developments.

And not only in military circles has the airplane advanced more rapidly than any other form of transportation ever advanced before. Aviation has now reached the point where Donald W. Douglas refers to it, accurately, as being "essential to civilization."

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### PRODUCTION OF AIRCRAFT IN THE UNITED STATES

From Statistical Service, Aircraft Industries Association of America

Year	Civil	Military	Total
1938.....	1,823	1,800	3,623
1939.....	3,715	2,141	5,856
1940.....	6,785	6,086	12,871
1941.....	6,844	19,290	26,134
1942.....	985	47,873	48,858
1943.....	—	85,046	85,046
1944.....	—	96,360	96,360
1945.....	2,047	46,819	48,866
1946 (11 months).....	32,882	1,217	34,099

Source: 1938-1941—(Civil) U. S. Department of Commerce, "Civil Aeronautics Journal," Vol. 5, No. 1 (figures indicate registrations). 1938-1939—(Military) U. S. War Department, Bureau of Public Relations. 1942—(Civil) Civil Aeronautics Administration, Information Division. 1940-1944—(Military) Aircraft Resources Control Office, Report 15. 1945—Army Air Forces, Office of Plans and Policies. 1946—Bureau of the Census, Facts for Industry, M 42A.

### WAGES AND HOURS IN THE AIRCRAFT INDUSTRY

From Statistical Service, Aircraft Industries Association of America

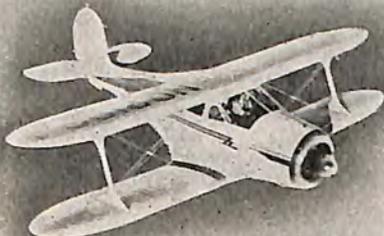
AVERAGE HOURS AND EARNINGS OF WAGE EARNERS IN AIRFRAME AND ENGINE PLANTS

	Average Weekly Hours		Average Weekly Earnings		Average Hourly Earnings	
	Aircraft and Parts excluding Engines	Aircraft Engines	Aircraft and Parts excluding Engines (dollars)	Aircraft Engines (dollars)	Aircraft and Parts excluding Engines (cents)	Aircraft Engines (cents)
1939.....	41.5	44.1	30.34	36.58	74.5	83.5
1940.....	43.2	45.8	31.40	38.50	74.3	84.0
1941.....	45.3	46.9	37.75	47.04	84.0	103.3
1942.....	47.0	48.7	46.21	59.03	98.7	121.2
1943.....	46.4	47.4	49.76	59.81	107.2	126.2
1944.....	47.1	46.6	54.50	61.14	115.9	131.2
1945.....	45.7	44.5	54.37	57.93	119.1	130.1
1946						
Jan.....	40.9	40.9	48.40	51.33	118.4	125.4
Feb.....	40.8	42.1	49.91	53.43	122.2	126.8
Mar.....	41.0	41.9	50.53	52.80	123.3	125.8
Apr.....	41.3	41.8	51.68	54.08	125.3	129.3
May.....	40.7	41.3	51.63	55.26	126.8	133.9
June.....	40.4	41.6	52.55	55.91	130.2	134.3
July.....	40.0	40.6	53.01	54.72	132.5	134.8
Aug.....	40.7	41.4	53.85	56.08	132.3	135.4
Sept.....	40.6	41.9	53.75	56.93	132.5	135.7
Oct. <sup>a</sup> .....	40.5	42.1	53.52	57.46	132.1	136.4

<sup>a</sup> Preliminary.



**Model 18** The Beechcraft seven-to-nine place executive transport is a familiar airplane on airports in all parts of the world. Its sturdy, dependable performance and the flexibility of seating and cargo arrangements make it ideally adaptable for executive personnel or as an air carrier. Design and performance permit operation from small landing fields.



**Model 17** The Beechcraft Model 17 biplane provides the discriminating personal or sportsman pilot an airplane of beauty and speed. Pilot and four passengers are able to ride in roomy comfort at 200 miles an hour. Negative wing stagger, an exclusive Beechcraft feature, affords clear visibility and ready cabin entrance.



**Model 35** The new Beechcraft Bonanza cruises at 175 mph, consumes 10 gallons per hour, carries four people. Its range is 750 miles at 165 mph. It has a direct operating cost of as low as 1 cent per passenger mile. It's delivered complete for day, night and instrument flight.

## PROGRESSIVE

The performance, dependability and ruggedness of Beechcraft products prove the progressive ability of Beechcraft to build airplanes that are outstanding in their class.

Every Beechcraft has been designed to efficiently translate time into distance. Each in its class pays cash dividends by reducing time required for travel and by providing comfortable and relaxing transportation.

For those who wish an unbiased personal evaluation of the merit of Beechcraft products we refer them to any experienced military pilot who served in the Armed Services or to any veteran airline captain.

The Beechcraft Distributor nearest you will be glad to make an analysis of your transportation requirements and furnish you with facts, figures and a demonstration without obligation, or write Beech Aircraft Corporation, Wichita, Kansas.

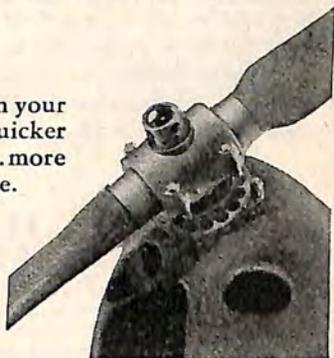
**Beechcraft Propellers.** A Beechcraft Propeller on your airplane means more enjoyable flying . . . quicker take-offs . . . faster climbs . . . faster cruising . . . more miles per gallon . . . less engine maintenance.

# Beech Aircraft

CORPORATION



WICHITA, KANSAS, U. S. A.



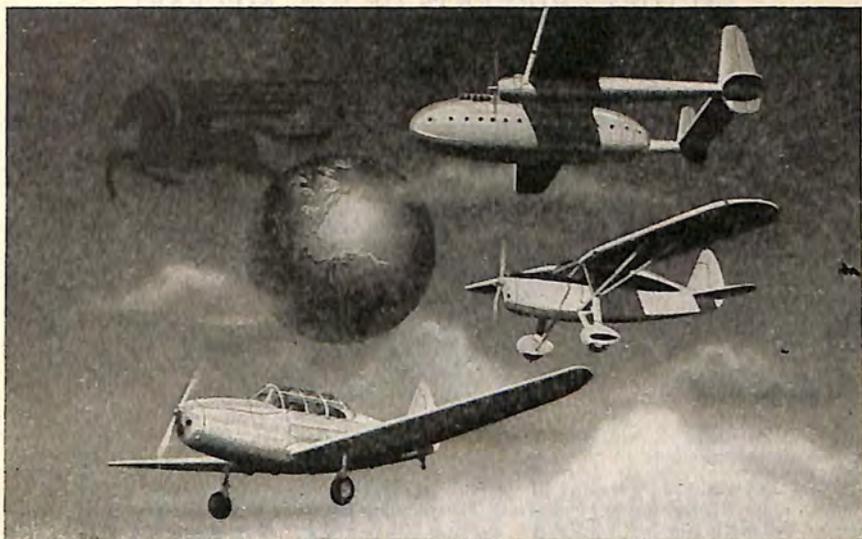
**RECIPIENTS OF U. S. MILITARY AIRPLANES  
FROM ALL FACTORY DELIVERIES**

September 1945–December 1946

Type of Airplane and Recipient	1945			1946	
	Total <sup>1</sup>	Sept.	Dec.	Total	Dec.
<b>Grand Total</b> .....	48,281	1,009	368	1,521	139
<b>Army Air Forces</b> .....	26,254	509	164	669	75
<b>U. S. Navy</b> .....	16,985	500	204	852	64
<b>Combat Airplanes—Total</b> .....	39,922	850	343	1,366	126
Army Air Forces.....	20,366	375	151	534	64
U. S. Navy.....	15,753	475	192	832	62
<b>Very Heavy Bombers</b>					
Army Air Forces.....	2,657	143	4	62	0
<b>Heavy Bombers—Total</b> .....	4,388	58	3	0	0
Army Air Forces.....	3,681	0	0	0	0
U. S. Navy.....	630	58	3	0	0
<b>Medium Bombers—Total</b> .....	2,881	39	132	34	4
Army Air Forces.....	1,432	0	1	0	0
U. S. Navy.....	1,178	39	131	34	4
<b>Light Bombers—Total</b> .....	7,028	217	1	39	8
Army Air Forces.....	1,720	3	1	1	0
U. S. Navy.....	5,115	214	0	38	8
<b>Fighters—Total</b> .....	22,231	367	203	1,100	88
Army Air Forces.....	10,591	229	145	349	38
U. S. Navy.....	8,381	138	58	751	50
<b>Reconnaissance—Total</b> .....	737	26	0	131	26
Army Air Forces.....	285	0	0	122	26
U. S. Navy.....	449	26	0	9	0
<b>Transports—Total</b> .....	4,717	104	14	91	11
Army Air Forces.....	3,043	79	6	87	11
U. S. Navy.....	537	25	8	4	0
<b>Trainers—Total</b> .....	1,352	0	0	0	0
<b>Communications—Total</b> .....	2,290	55	11	64	2
Army Air Forces.....	2,024	55	11	48	0
U. S. Navy.....	235	0	0	16	2

<sup>1</sup> All 1945 totals include planes sent to Allies that year up to VJ-Day.

Source: Army Air Forces, Statistical Control Division, Office of Air Comptroller.



## Advancing the Aeronautical Sciences Through Research and Development

Ever since their first plane made aerial photography a precise function, Fairchild engineers have worked in aviation's future.

Their research gave the Army primary trainers with combat plane characteristics.

They designed and built the cargo-carrying Packet. They created the Fairchild *Twenty-Four*, finest of personal transports.

From Fairchild's Ranger engineers came the famous Ranger inverted, in-line, air-cooled power plants.

Stratos, a Fairchild affiliate, developed air conditioning installations that main-

tain constant, comfortable pressures and temperatures.

Al-Fin, a process that bonds aluminum to steel, was developed in Fairchild laboratories.

So was the Duramold process for the fabrication of plastic-bonded wood aircraft.

With its experience and emphasis on research and development in aviation, Fairchild has been chosen by the U. S. Army Air Forces as the prime contractor for development of atomic energy as a source of aircraft power. The Navy, too, has designated Fairchild in the development of guided missiles.



# FAIRCHILD

## ENGINE AND AIRPLANE CORPORATION

30 ROCKEFELLER PLAZA, NEW YORK 20, N. Y.

Divisions: Fairchild Aircraft, Hagerstown, Md. • Ranger Aircraft Engines, Farmingdale, L. I., N. Y.  
Duramold, Jamestown, N. Y. • Fairchild Personal Planes, Strother Field, Kansas • Fairchild Pilotless Plane, Farmingdale, L. I., N. Y.  
Subsidiary: Al-Fin Corporation, Jamaica, L. I., N. Y. • Affiliate: Stratos Corporation, Babylon, L. I., N. Y.

## FACTORY SHIPMENTS OF U. S. AIRCRAFT

1946

Source: Bureau of the Census, U. S. Department of Commerce

Description	Unit of Measure	Total
Complete aircraft		
Airplanes, total <sup>1</sup> .....	No. of planes	36,204
	Value	\$362,772,192
For U. S. military customers <sup>1</sup> .....	No. of planes	1,330
	Value	\$101,972,255
For all other customers.....	No. of planes	34,874
	Value	\$170,799,937
Gliders.....	Number	( <sup>2</sup> )
Conversions.....	No. of planes	345
	Value	\$40,515,539
Airframe spare parts		
For U. S. military customers.....	Value	\$31,771,480
For all other customers.....	Value	\$17,715,397
All other products		
Modifications.....	Value	\$14,918,256
Aircraft products.....	Value	
Non-aircraft products.....	Value	

NOTE: Data on conversions are incomplete; they include only conversions performed by companies producing complete aircraft. Conversions by commercial airlines, airports, etc., are not included.

<sup>1</sup> Excludes pilotless aircraft, liaison planes, and helicopters, confidential, secret and experimental military aircraft, as well as engines and parts.

<sup>2</sup> Not shown to avoid disclosing the operations of individual companies.

## SHIPMENTS FOR U. S. MILITARY SERVICES

Total.....	1,330 <sup>1</sup>
Bombers and heavy transports.....	189
Fighters, reconnaissance, and photographic.....	1,141

<sup>1</sup> Includes a small number of reconnaissance and photographic planes, but excludes pilotless aircraft, liaison planes and helicopters.

## SHIPMENTS TO NON-MILITARY CUSTOMERS

NUMBER OF PLANES		
Total (including helicopters).....		34,874
Classification by number of places		
2-places.....		30,639
3- and 4-places.....	}	4,235
5 and more places.....		
Classification by number of engines		
1 engine.....		34,407
2 and 4 engines.....		467
Classification by total rated horsepower (all engines) (maximum except takeoff)		
1-74 h.p.....	}	20,489
75-99 h.p.....		13,901
100-399 h.p.....		
400 h.p. and over.....		484
AIRFRAME WEIGHT		
Total (including helicopters).....		25,607,671
Classification by number of places		
2-places.....	}	16,944,632
3- and 4-places.....		8,663,039
5 and more places.....		
Classification by number of engines		
1 engine.....		20,058,625
2 and 4 engines.....		5,549,046
Classification by total rated horsepower (all engines) (maximum except takeoff)		
1-74 h.p.....	}	10,956,934
75-99 h.p.....		9,070,729
100-399 h.p.....		
400 h.p. and over.....		5,580,008



# Twenty billion leagues over the world !

Logging billions of air miles since 1921, Douglas-built aircraft have set unequalled records for *dependable* flight. This same dependability characterizes the great, even swifter air giants now being delivered by Douglas.

Since the famous Douglas DC-3 first made possible modern air travel in 1934, Douglas planes have flown millions upon millions of people everywhere in the world.

Today—over 90% of all airline transportation is provided by Douglas airplanes. Throughout the world this percentage holds. And, as you have come to expect, air travel on Douglas planes is *right*—in comfort, in speed, in reliability.

Soon even faster and more commodious aircraft—all bearing the stamp of Douglas integrity—will take over on the leading airlines of the world.

**MORE PEOPLE FLY MORE PLACES BY DOUGLAS**

**REGISTERED CIVIL AIRCRAFT IN THE UNITED STATES  
BY RATED HORSEPOWER**

September 1, 1946

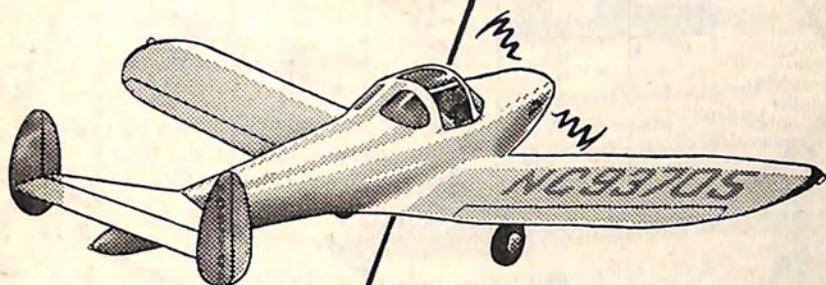
Compiled by Information and Statistics Service, Civil Aeronautics Administration

	Total Rated Horsepower	Number of Aircraft <sup>1</sup>
Grand Total.....		67,028
Single Engine—Total.....		60,898
	16- 65	30,812
	66- 84	5,253
	85- 99	4,385
	100- 144	2,547
	145- 199	6,990
	200- 299	6,132
	300- 499	3,915
	500- 999	819
	1,000-3,000	37
Two Engine—Total.....		3,527
	130- 450	1,718
	500- 999	423
	1,000-1,999	180
	2,000-2,999	1,198
	3,000-4,000	8
Three Engine—Total.....		41
	300-1,575	41
Four Engine—Total.....		439
	2,800-6,000	385
	6,001-8,000	54

<sup>1</sup> Not included above are gliders, free balloons, etc. Registered aircraft as of September 1, 1946, total 67,028.

FOR PLEASURE, FOR PROFIT, FLY **ERCOUPE**

*the plane that ranks  
first in sales to  
individuals*



**WORLD'S SAFEST PLANE  
GUARANTEED SPIN-PROOF  
SIMPLIFIED OPERATION  
ALL-METAL STRUCTURE  
TRICYCLE LANDING GEAR**

Engineering & Research Corporation, Riverdale, Md.

**EXPORT OF AIRCRAFT EQUIPMENT FROM THE  
UNITED STATES**

1946

Source: Bureau of the Census

1946	Aircraft (landplanes and seaplanes powered and without engines)		Aircraft Engines		Parts and Accessories
	Number	Value (millions)	Number	Value (millions)	Value (millions)
January.....	96	\$ .9	59	\$ .3	\$ 2.2
February.....	89	1.5	72	.5	2.1
March.....	117	3.5	200	1.1	3.0
April.....	160	5.5	102	.8	2.7
May.....	178	10.4	261	1.6	3.8
June.....	202	10.6	177	1.3	3.3
July.....	213	4.7	228	.6	3.0
August.....	215	4.7	352	1.6	3.7
September.....	206	7.2	144	.5	2.8
October.....	238	5.0	199	1.0	2.5
November.....	—	—	—	—	—
December.....	—	—	—	—	—
Total.....	—	—	—	—	—

**COUNTRY OF DESTINATION**

First 10 Months of 1946

**CIVIL AIRCRAFT**

Country of Destination	Units	Value (thousands of dollars)	Shipping Weight (pounds in thousands)
Total Aircraft.....	1,714	\$53,984	12,896
North America—Total.....	656	\$ 6,452	2,900
Iceland.....	8	121	54
Canada.....	286	2,152	1,131
Newfoundland.....	2	410	43
Mexico.....	360	3,760	1,762
Central America—Total.....	150	\$ 2,653	1,089
Guatemala.....	7	60	39
Salvador.....	4	83	54
Honduras.....	24	216	153
Nicaragua.....	6	93	81
Costa Rica.....	15	135	100
Panama.....	14	34	15
Bahamas.....	1	3	2
Cuba.....	41	636	274
Jamaica.....	3	3	12
Haiti.....	1	2	4
Dominican Republic.....	19	108	126
Trinidad.....	3	234	39
Curacao.....	8	1,039	167
French West Indies.....	4	7	23



# What is Leadership?

Leadership Is Building the Best: the fastest, the farthest, the largest. Superlatives? Yes... but accurate descriptions of Lockheed's products today. *Here they are:*



**THE FASTEST**—Lockheed's SHOOTING STAR, world's fastest fighter. That's leadership.



**THE FARTHEST**—Lockheed's NEPTUNE, world's farthest flier. That's leadership.



**THE LARGEST**—Lockheed's CONSTITUTION, world's largest transport. That's leadership.



**LOCKHEED'S CONSTELLATION**, the most popular transport flying today, brings this leadership to the travelers of the world.



**LEADERSHIP MUST BE MAINTAINED.** In wind tunnel and research laboratory, Lockheed leaders of tomorrow are now taking form.

*Look to Lockheed for Leadership*

LOCKHEED AIRCRAFT CORPORATION • BURBANK, CALIFORNIA

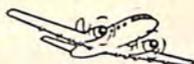
## Export of Aircraft Equipment from the United States (1946)—Continued

Country of Destination	Units	Value (thousands of dollars)	Shipping Weight (pounds in thousands)
South America—Total.....	568	\$12,257	4,758
Colombia.....	58	1,786	960
Venezuela.....	54	2,795	831
Ecuador.....	17	853	243
Peru.....	46	1,055	356
Bolivia.....	13	153	196
Chile.....	41	398	222
Brazil.....	108	3,441	894
Paraguay.....	1	2	3
Uruguay.....	39	97	114
Argentina.....	191	1,707	939
Europe—Total.....	167	\$26,579	2,976
Sweden.....	18	2,573	296
Norway.....	3	823	86
Denmark.....	3	651	97
United Kingdom.....	6	3,710	265
Eire.....	3	239	58
Netherlands.....	32	6,281	638
Belgium.....	43	2,139	360
France.....	24	8,266	811
Switzerland.....	5	251	44
Spain.....	4	1,363	141
Portugal.....	13	228	105
Yugoslavia.....	4	5	19
Albania.....	3	7	14
Greece.....	6	43	42
Rest of World—Total.....	173	\$ 6,043	1,083
Turkey.....	3	495	55
Syria.....	6	12	15
Iraq.....	1	3	4
Philippine Republic.....	3	153	76
Australia.....	12	3,587	382
Egypt.....	4	247	36
Other Portuguese Africa.....	8	64	51
Liberia.....	2	5	6
Belgian Congo.....	6	14	17
Union of South Africa.....	126	1,459	436
South Rhodesia.....	2	4	5

## AIRCRAFT ENGINES

First 10 Months of 1946

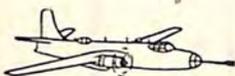
Country of Destination	Units	Value (thousands of dollars)	Shipping Weight (pounds in thousands)
Total Engines.....	1,794	\$ 9,301	3,120
North America—Total.....	537	\$ 1,737	621
Iceland.....	2	16	2
Canada.....	351	1,216	301
Newfoundland.....	8	166	25
Mexico.....	176	339	293



**DE LUXE AIRLINERS . . .**  
 Hundreds of advanced new Martin passenger and cargo planes are being built for the airlines with further sales pending. Martin 2-0-2 and 3-0-3 transports are becoming standard equipment for leading airlines everywhere.



**TOPS AMONG AIRLINERS . . .** The Martin 2-0-2 is the standard on leading airlines of the world. Its exceptional performance and advanced design have met the most demanding specifications of the airline industry.



**NEW MILITARY CRAFT . . .**  
 For the Navy Martin is building the XP4M-1 reconnaissance plane (shown above)—the PBM-5 Mariner—the JRM Mars—the XPBM-5A amphibian—the AM-1 Mauler dive bomber. For the Army Air Forces: the XB-48 jet bomber.



**AIRCRAFT GUN TURRETS . . .**  
 During the war, Martin developed two of the nation's most effective aerial gun turrets—became a leading manufacturer of this type of equipment. Today, turret production is an integral part of the overall Martin operation.



**PLASTICS . . .** Marvinol, highly versatile Martin plastic raw material, has wide uses. Martin is completing construction of factory for large-scale production of this new resin. Other Martin-developed products are being manufactured under license.



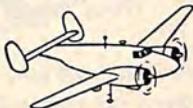
**NEW CONSTRUCTION MATERIALS . . .** Honeycomb, developed by Martin Research, combines great strength with extreme lightness. To be used in new Martin planes, it holds interesting possibilities in many diverse fields.



**MARTIN GROUND EQUIPMENT . . .** Designed for handling, serving and loading new commercial transports. Complete line includes passenger ramps, cargo loaders, service stands, tow-bars, etc. Substantial orders have been filled for many leading airlines.



**FLEXIBLE FUEL TANKS . . .**  
 Reducing maintenance and increasing dependability of aircraft are Mareng (from the words, Martin Engineering) fuel tanks. These flexible fuel tanks will not crack open under stress—may be replaced without dismantling plane.



**TELEVISION EQUIPMENT . . .**  
 Stratovision, developed jointly by Martin and Westinghouse, may revolutionize television and FM. Martin aircraft, re-broadcasting from miles above earth, will end need for costly cables or relay stations.



**LARGE CONTRACTS** have been awarded Martin for research work on guided missiles, advanced forms of propulsion, electronics, super-sonic speeds, new materials, other important military projects. Martin now holds 223 patents with others pending.

*New Planes . . . Plastics  
 . . . Other Products*

**MADE BY MARTIN**

Pictured on this page are some of the new commercial and military aircraft being built by Martin for the airlines and for the military services. From Martin laboratories have come new plastics, construction materials, other products in many fields to help assure America of a more abundant life. For startling new developments in guided missiles, electronics, other fields . . . look to Martin

Research and let "Made by Martin" be your guarantee of topmost quality. THE GLENN L. MARTIN COMPANY, BALTIMORE 3, MARYLAND.



Builders of Dependable Aircraft Since 1909

## Export of Aircraft Equipment from the United States (1946)—Continued

Country of Destination	Units	Value (thousands of dollars)	Shipping Weight (pounds in thousands)
Central America—Total.....	153	\$ 730	299
Guatemala.....	4	6	7
Honduras.....	10	28	13
Nicaragua.....	4	7	7
Costa Rica.....	21	113	33
Canal Zone.....	16	65	35
Bahamas.....	3	5	5
Bermuda.....	3	21	6
Cuba.....	53	177	118
Jamaica.....	1	3	2
Haiti.....	1	18	2
Dominican Republic.....	4	5	8
Barbados.....	1	3	2
Trinidad.....	19	193	40
Curacao.....	9	86	20
French West Indies.....	4	( <sup>a</sup> )	1
South America—Total.....	527	\$ 1,659	947
Colombia.....	118	216	260
Venezuela.....	42	144	79
French Guiana.....	1	2	2
Ecuador.....	8	28	11
Peru.....	21	55	55
Bolivia.....	8	20	28
Chile.....	11	54	17
Brazil.....	243	680	388
Uruguay.....	6	8	14
Argentina.....	69	443	93
Europe—Total.....	463	\$ 4,334	908
Sweden.....	50	648	111
Norway.....	28	232	84
Denmark.....	18	162	37
United Kingdom.....	90	282	114
Eire.....	17	194	44
Netherlands.....	100	781	219
Belgium.....	19	292	46
France.....	90	1,083	230
Austria.....	1	25	4
Czechoslovakia.....	1	25	4
Switzerland.....	8	126	20
Spain.....	13	183	30
Portugal.....	23	236	42
Italy.....	2	39	6
Greece.....	3	26	7
Rest of World—Total.....	114	\$ 841	255
Saudi Arabia.....	1	18	3
Philippine Republic.....	52	113	111
China.....	6	31	14
Australia.....	14	214	30
New Zealand.....	1	12	2
Other British Oceania.....	1	12	3
Egypt.....	25	222	61
Other Portuguese Africa.....	1	2	1
French West Africa.....	1	25	3
Liberia.....	2	40	5
Belgian Congo.....	1	25	3
Union of South Africa.....	8	112	16
Libya.....	1	15	3

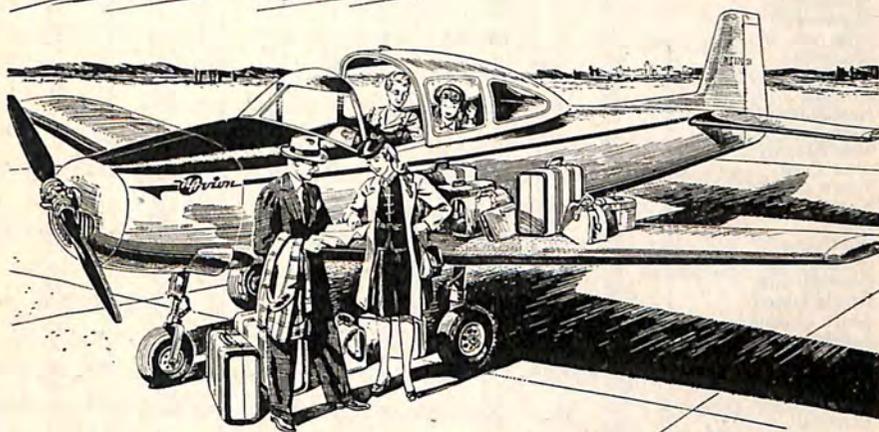
<sup>a</sup> Less than \$500.



# Avion

## THE PRACTICAL 4-PLACE PLANE

All metal construction... 185 h.p. Continental engine... variable pitch propeller... power-retractable tricycle landing gear... hydraulically operated landing flaps. CAA Approved Type Certificate No. 782.



For more details write Dept. U, North American Aviation, Inc.,  
Municipal Airport, Los Angeles 45, California

### NORTH AMERICAN AVIATION INC.



CREATORS OF P-51 MUSTANG AND  
ADVANCED MILITARY AIRCRAFT

### AIRPORTS AND LANDING FIELDS IN THE UNITED STATES

January 1, 1947

Compiled by Information and Statistics Service, Civil Aeronautics Administration

State	Total <sup>1</sup>	Commer- cial	Municipal	CAA Inter- mediate	All Others <sup>2</sup>	Total Lighted
Total.....	4,490	1,920	1,424	201	936	1,015
Alabama.....	75	21	16	2	36	20
Arizona.....	104	33	26	10	35	32
Arkansas.....	68	36	15	1	16	9
California.....	356	156	86	11	103	93
Colorado.....	80	33	34	2	11	13
Connecticut.....	25	15	9	1	0	7
Delaware.....	12	8	2	0	2	3
District of Columbia.....	3	0	0	0	3	3
Florida.....	204	29	45	3	127	51
Georgia.....	103	30	26	9	38	40
Idaho.....	67	13	37	4	13	15
Illinois.....	130	76	19	5	30	21
Indiana.....	103	54	10	2	28	18
Iowa.....	105	64	34	4	3	15
Kansas.....	149	58	56	3	32	24
Kentucky.....	23	9	8	2	4	9
Louisiana.....	57	17	18	4	18	23
Maine.....	47	21	20	0	6	18
Maryland.....	39	24	5	1	9	5
Massachusetts.....	60	37	15	0	8	11
Michigan.....	163	52	95	0	16	21
Minnesota.....	75	31	43	1	0	9
Mississippi.....	61	17	23	6	15	18
Missouri.....	99	45	29	8	17	19
Montana.....	95	15	53	12	15	27
Nebraska.....	73	26	29	5	13	16
Nevada.....	46	15	9	9	13	19
New Hampshire.....	23	10	12	0	1	6
New Jersey.....	63	45	9	0	9	11
New Mexico.....	86	29	26	10	21	24
New York.....	199	136	40	4	19	34
North Carolina.....	133	84	23	1	25	16
North Dakota.....	47	11	30	6	0	13
Ohio.....	145	100	31	6	8	25
Oklahoma.....	149	61	50	3	35	28
Oregon.....	86	36	37	5	8	25
Pennsylvania.....	158	108	37	3	10	30
Rhode Island.....	8	4	1	0	3	2
South Carolina.....	61	15	22	2	22	15
South Dakota.....	47	16	25	1	5	6
Tennessee.....	38	12	14	7	5	18
Texas.....	417	172	123	23	99	100
Utah.....	41	6	22	8	5	18
Vermont.....	12	3	9	0	0	4
Virginia.....	82	40	20	3	19	18
Washington.....	111	36	49	3	23	29
West Virginia.....	33	20	10	2	1	7
Wisconsin.....	83	42	38	2	1	11
Wyoming.....	46	8	25	7	6	16

<sup>1</sup> Total includes 1,396 Class I airports for private owners of smaller type aircraft, 509 airports which do not meet Class I standards, 1,249 Class II airports for private owners of largest type aircraft and feeder line aircraft, 485 Class III airports for present-day transport aircraft, and 851 Class IV and V airports for largest aircraft in use or planned for immediate future.

<sup>2</sup> Indicates Army, Navy, Army operated and Navy Operated (latter two are municipal or commercial airports temporarily taken over by Army or Navy), C. A. P., miscellaneous Government and private.



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A handwritten signature in cursive script that reads "W. T. Piper". The signature is written in dark ink and is positioned at the bottom right of the page, below the main text.

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## U. S. ARMY AIR FORCES

Washington, D. C.

February 1, 1947

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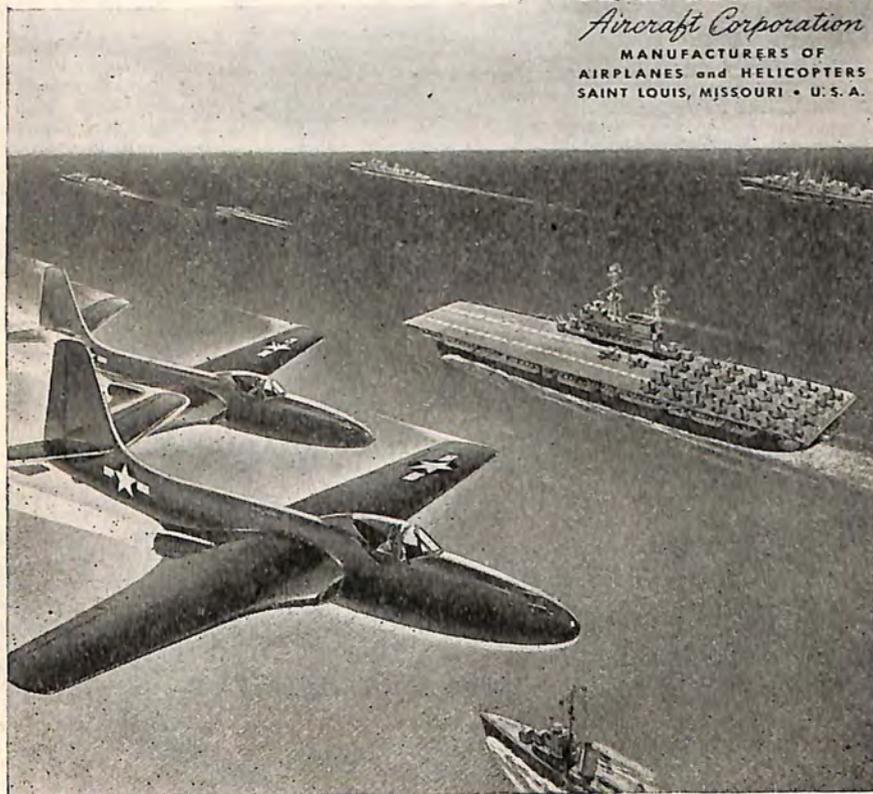
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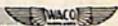
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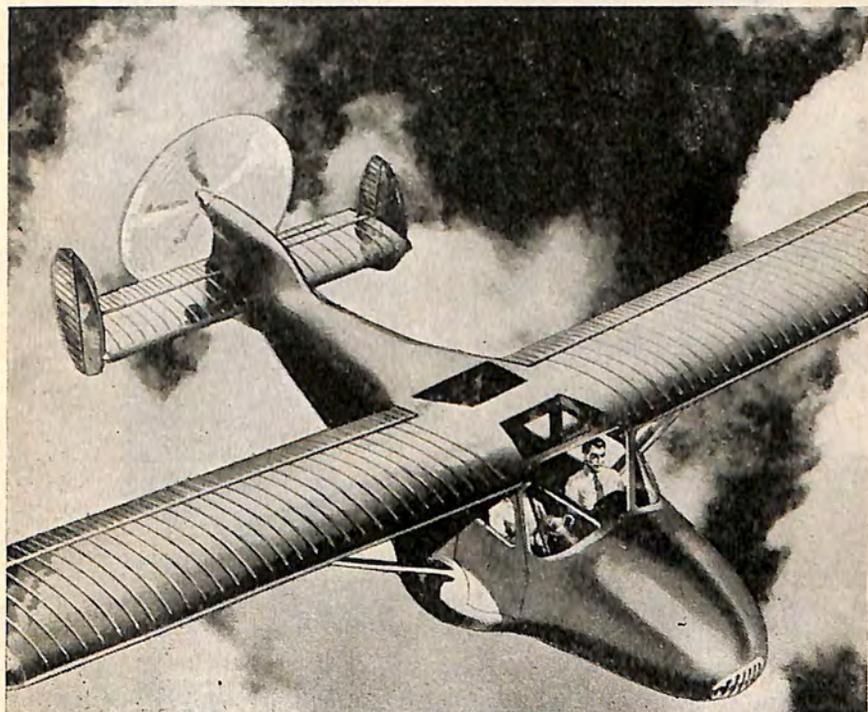
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 Joseph C. O'Mahoney, Wyo.  
 Theodore Francis Green, R. I.

## Armed Services

(Committee on Armed Services consolidates the former Committee on Naval Affairs and the Committee on Military Affairs.)

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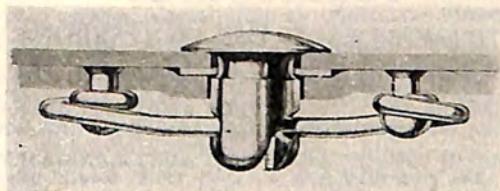
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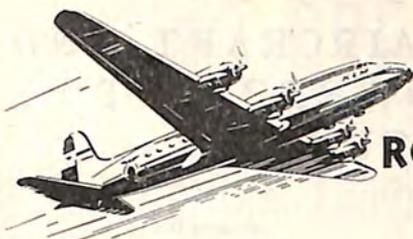
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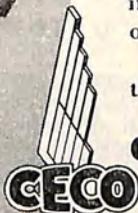
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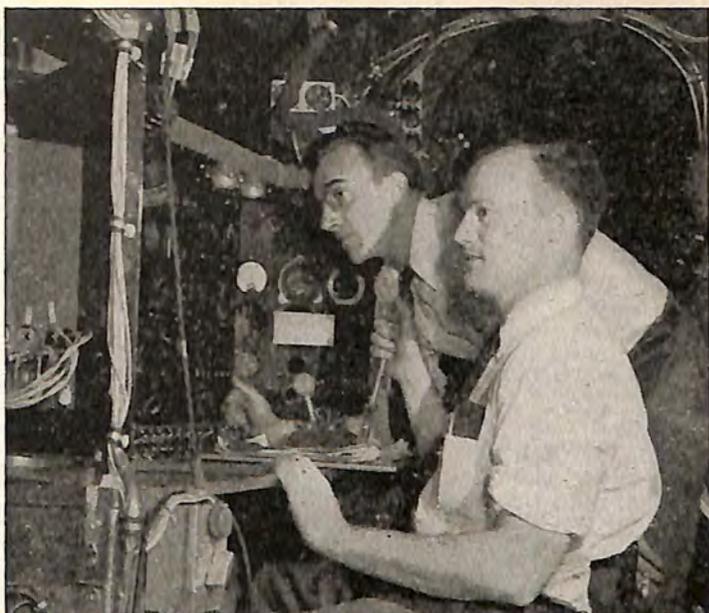
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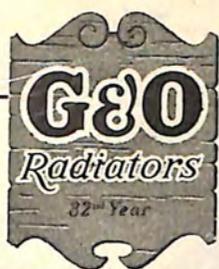
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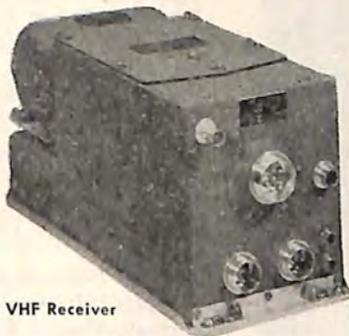
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C-15 Control Unit

A-12 Antenna Unit

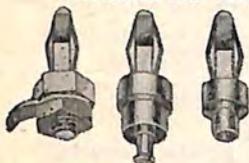
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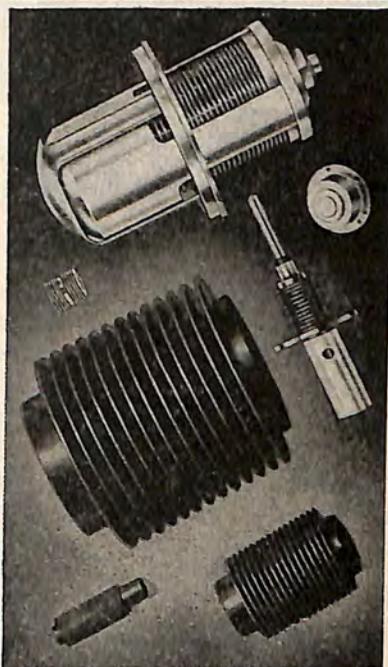
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EQUIPMENT**

Cardox Corp.  
Fenwal, Inc.  
Walter Kidde & Co., Inc.  
Pyrene Manufacturing Co.  
Scott Aviation Corp.  
United States Rubber Co.

**FITTINGS**

Aeroquip Corp.  
Air Associates Inc.  
Aircraft Hardware Mfg. Co.  
Breeze Corporations, Inc.  
Commercial Plastics Co.  
Downs Smith Brass & Copper Co. Inc.  
Durham Aircraft Service, Inc.  
Farmingdale Aircraftsmen Manufac-  
turing Corp.  
Liberty Aircraft Products Corp.  
Parker Appliance Co.  
Tube Turns, Inc.  
Weatherhead Co.

**FLARES & SIGNALS**

Kilgore Manufacturing Co.

**FLOATS, SKIIS**

Heath Co.  
Liberty Aircraft Products Corp.  
Mercury Aircraft Inc.

**FORGINGS**

Airchox Co.  
Aircraft Mechanics, Inc.  
Aluminum Company of America  
Chambersburg Engineering Co.  
Dow Chemical Co.  
Evans Products Co., Sky Products Div.  
Revere Copper & Brass Inc.  
Transue & Williams Steel Forging  
Corp.  
Tube Turns, Inc.  
Weatherhead Co.

**FUEL PUMPS &  
SYSTEMS—AIRCRAFT**

Aircraft Components Corp.  
Aircraft Hardware Mfg. Co.  
American Bosch Corp.  
Bendix Aviation Corp.  
Chandler-Evans Corp.  
Durham Aircraft Service, Inc.  
Thompson Products, Inc.  
United Aircraft Products, Inc.

**FUEL SYSTEMS—  
AIRPORT**

Socony-Vacuum Oil Co., Inc.

**FUELS**

Intava Inc.  
Shell Oil Co., Inc.  
Sinclair Refining Co.  
Socony-Vacuum Oil Co., Inc.  
Standard Oil Co. of California  
Texas Co.

**GASKETS**

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American Flange & Manufacturing  
Co., Inc.  
B G Corp.  
Durham Aircraft Service, Inc.

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TO YOU!



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 Hewitt Rubber of Buffalo  
 Johns-Manville  
 United States Rubber Co.

**GAUGES****(See also Instruments)**

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 Durham Aircraft Service, Inc.  
 Eclipse-Pioneer Div., Bendix Aviation Corp.  
 Minneapolis-Honeywell Regulator Co.,  
 Aeronautical Div.  
 Sheffield Corp.  
 Simmonds Aerocessories, Inc.  
 Weston Electrical Instrument Corp.

**GEARS**

Aircraft Hardware Mfg. Co.  
 Fairchild Engine & Airplane Corp.  
 Liberty Aircraft Products Corp.  
 Steel Products Engineering Co.  
 Westinghouse Electric Corp.

**GRASS SEED**

Associated Seed Growers Inc.  
 O. M. Scott & Sons Co.  
 F. H. Woodruff & Sons, Inc.

**GLUES & ADHESIVES**

United States Plywood Corp.  
 United States Rubber Co.

**GROMMETS**

Aircraft Hardware Mfg. Co.  
 Durham Aircraft Service, Inc.  
 Garlock Packing Co.  
 B. F. Goodrich Co.  
 Heath Co.  
 Schweizer Aircraft Corp.  
 Stronghold Screw Products Inc.  
 United States Rubber Co.

**HARDWARE  
(MISCELLANEOUS)**

Acromark Co.  
 Air Associates Inc.  
 Aircraft Hardware Mfg. Co.

Burklyn Co.  
 Downs Smith Brass & Copper Co. Inc.  
 Durham Aircraft Service, Inc.  
 Farmingdale Aircraftsmen Manufacturing Corp.  
 United Aircraft Products, Inc.  
 Weatherhead Co.

**HEATERS**

Aircraft Hardware Mfg. Co.  
 General Electric Co.  
 Liberty Aircraft Products Corp.  
 Solar Aircraft Co.  
 Surface Combustion Corp.  
 Young Radiator Co.

**HOISTS, CRANES,  
LIFTS, ETC.**

Pacific Aviation Inc.

**HOSE-RUBBER  
& SYNTHETIC**

Aeroquip Corp.  
 Aircraft Hardware Mfg. Co.  
 Durham Aircraft Service, Inc.  
 B. F. Goodrich Co.  
 Hewitt Rubber of Buffalo  
 Resistoflex Corp.  
 United States Rubber Co.  
 Weatherhead Co.

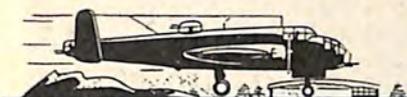
**HOSE CLAMPS &  
HOSE FITTINGS**

Actus Corp.  
 Aeroquip Corp.  
 Air Associates Inc.  
 Aircraft Hardware Mfg. Co.  
 Aircraft Standard Parts Co., Inc.  
 Durham Aircraft Service, Inc.  
 B. F. Goodrich Co.  
 Hansen Manufacturing Co.  
 Hewitt Rubber of Buffalo  
 Resistoflex Corp.  
 Schweizer Aircraft Corp.  
 United States Rubber Co.  
 Weatherhead Co.

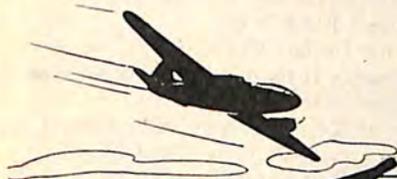
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& ASSEMBLIES**

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 Aeronautical Manufacturing Corp.  
 Aeroquip Corp.

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*The 100,000 Btu heater package including controls and blowers for installation in D.C.-3 class airplanes.*

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 Cleveland Pneumatic Tool Co.  
 Durham Aircraft Service, Inc.  
 Eclipse-Pioneer Div., Bendix Aviation Corp.  
 Ex-Cell-O Corp.  
 General Controls Co.  
 Liberty Aircraft Products Corp.  
 Pacific Aviation Inc.  
 Saval Co.  
 Sperry Gyroscope Co., Inc.  
 Sperry Products, Inc.  
 Thompson Products, Inc.  
 United Aircraft Products, Inc.  
 Warner Aircraft Corp.  
 Weatherhead Co.

**HYDRAULIC FLUIDS**

Bell Co. Inc.  
 Intava Inc.  
 Shell Oil Co., Inc.  
 Socony-Vacuum Oil Co., Inc.  
 Standard Oil Co. of California

**INSTRUMENTS****Aircraft**

Aircraft Hardware Mfg. Co.  
 American Paulin System  
 Bendix Aviation Corp.  
 Durham Aircraft Service, Inc.  
 General Electric Co.  
 Kollsman Instrument Div. of Square D Co.  
 McDonnell Aircraft Corp. Inc.  
 Sperry Gyroscope Co., Inc.  
 Weems System of Navigation  
 Westinghouse Electric Corp.  
 Weston Electrical Instrument Corp.

**Engine**

Aircraft Hardware Mfg. Co.  
 Bendix Aviation Corp.  
 Durham Aircraft Service, Inc.  
 General Electric Co.  
 Kollsman Instrument Div. of Square D Co.  
 McDonnell Aircraft Corp. Inc.  
 Minneapolis-Honeywell Regulator Co.,  
 Aeronautical Div.

Scott Aviation Corp.  
 Sperry Gyroscope Co., Inc.  
 Weston Electrical Instrument Corp.

**Flight**

Aircraft Hardware Mfg. Co.  
 American Paulin System  
 Bendix Aviation Corp.  
 Chicago Aerial Survey Co.  
 Durham Aircraft Service, Inc.  
 General Electric Co.  
 Jardur Import Co.  
 Kollsman Instrument Div. of Square D Co.  
 Minneapolis-Honeywell Regulator Co.,  
 Aeronautical Div.  
 Sperry Gyroscope Co., Inc.  
 Weems System of Navigation  
 Weston Electrical Instrument Corp.

**Ground**

American Paulin System  
 Bendix Aviation Corp.  
 Friez Instrument Div., Bendix Aviation Corp.  
 Sperry Gyroscope Co., Inc.  
 Weston Electrical Instrument Corp.

**Shop**

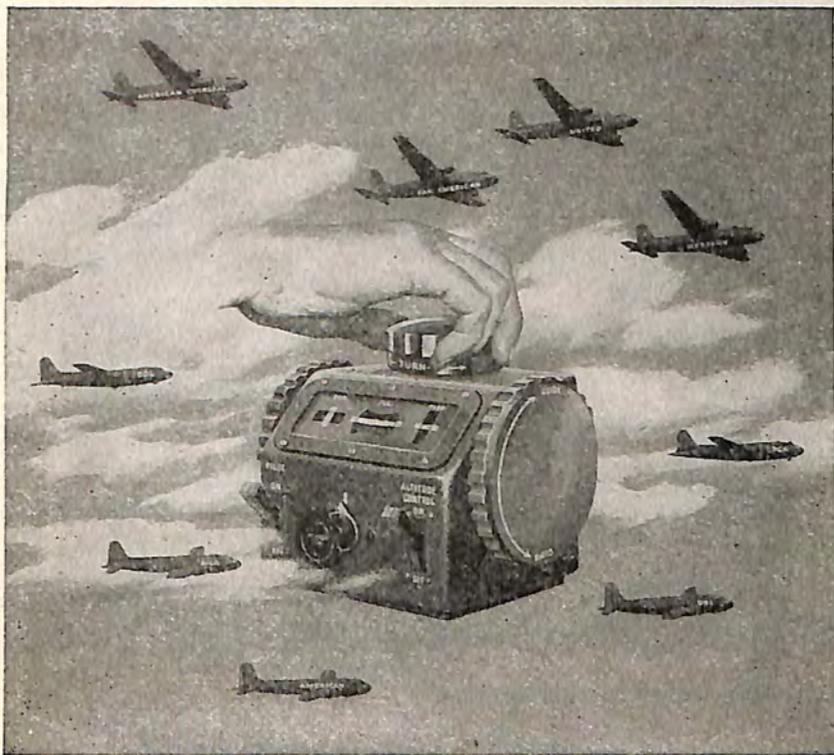
Bendix Aviation Corp.  
 Gaertner Scientific Corp.  
 General Electric Co.  
 Sperry Gyroscope Co., Inc.  
 Westinghouse Electric Corp.  
 Weston Electrical Instrument Corp.

**Testing & Measuring**

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 Bendix Aviation Corp.  
 Gaertner Scientific Corp.  
 General Electric Co.  
 Magnaflux Corp.  
 Scintilla Magneto Div., Bendix Aviation Corp.  
 Sheffield Corp.  
 Sperry Gyroscope Co., Inc.  
 Westinghouse Electric Corp.  
 Weston Electrical Instrument Corp.

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**(Insulating Materials) Continued**

Seaman Products Div., Seaman Paper Co.  
 United States Rubber Co.  
 Westinghouse Electric Corp.

**JET & GAS TURBINE PARTS**

Thompson Products, Inc.

**JOINTS & COUPLINGS**

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 Baldwin-Duckworth Div., Chain Belt Co.  
 Bendix Aviation Corp.  
 Burklyn Co.  
 Durham Aircraft Service, Inc.  
 Hansen Manufacturing Co.  
 Lord Manufacturing Co.  
 Parker Appliance Co.  
 Solar Aircraft Co.  
 Thompson Products, Inc.  
 United States Rubber Co.

**LANDING GEAR**

Bendix Products Div., Bendix Aviation Corp.

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Adel Precision Products Corp.  
 Aircraft Mechanics, Inc.  
 Bendix Aviation Corp.  
 Cleveland Pneumatic Tool Co.  
 Fairchild Engine & Airplane Corp.  
 Liberty Aircraft Products Corp.  
 Menasco Manufacturing Co.  
 Meyers Aircraft Co.  
 Pacific Aviation Inc.  
 United Aircraft Products, Inc.

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Adel Precision Products Corp.  
 Aircraft Mechanics, Inc.  
 Bendix Aviation Corp.  
 Cleveland Pneumatic Tool Co.  
 Firestone Aircraft Co. of Pennsylvania  
 Liberty Aircraft Products Corp.  
 Menasco Manufacturing Co.  
 Meyers Aircraft Co.  
 Pacific Aviation Inc.  
 Scott Aviation Corp.  
 United Aircraft Products, Inc.

**Shock Struts—Hydraulic**

Adel Precision Products Corp.  
 Bendix Aviation Corp.  
 Bendix Products Div., Bendix Aviation Corp.  
 Cleveland Pneumatic Tool Co.  
 Ex-Cell-O Corp.  
 Firestone Aircraft Co. of Pennsylvania  
 Liberty Aircraft Products Corp.  
 Menasco Manufacturing Co.  
 Meyers Aircraft Co.  
 Pacific Aviation Inc.  
 Scott Aviation Corp.  
 United Aircraft Products, Inc.

**Tail Wheel Assemblies**

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 Bendix Aviation Corp.  
 Cleveland Pneumatic Tool Co.  
 Firestone Aircraft Co. of Pennsylvania  
 Heath Co.  
 Liberty Aircraft Products Corp.  
 Menasco Manufacturing Co.  
 Meyers Aircraft Co.  
 Scott Aviation Corp.  
 United Aircraft Products, Inc.

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Bendix Aviation Corp.  
 B. F. Goodrich Co.  
 Walter Kidde & Co., Inc.  
 Skilsaw, Inc.  
 United States Rubber Co.

**LIGHTING EQUIPMENT****Aircraft**

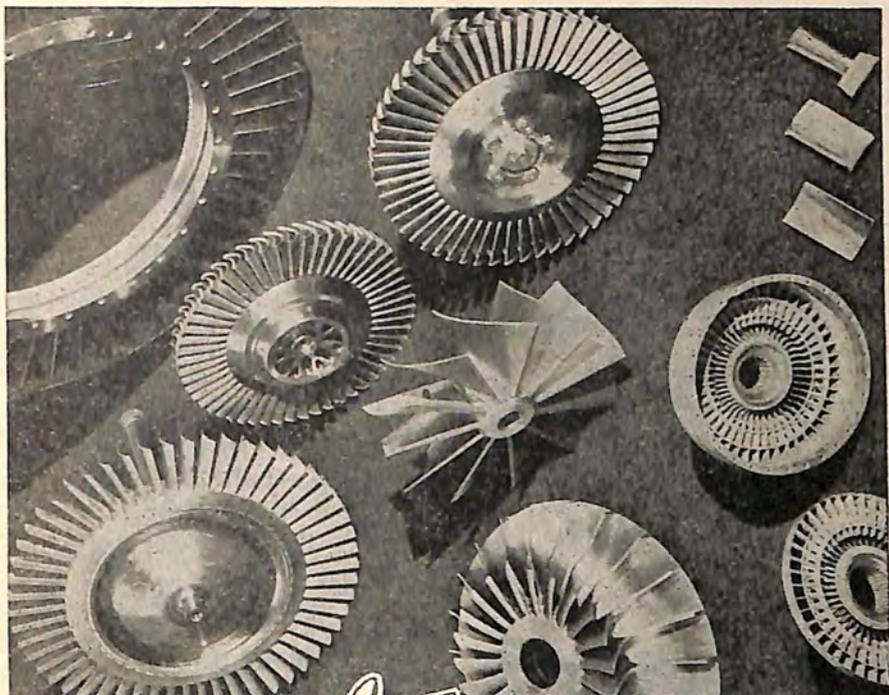
Aircraft Hardware Mfg. Co.  
 Bendix Aviation Corp.  
 Eclipse-Pioneer Div., Bendix Aviation Corp.  
 General Electric Co.  
 Grimes Mfg. Co.  
 Westinghouse Electric Corp.

**Airport**

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**Shop**

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and supercharging call for a wide variety of many-bladed wheels to pack air and power into modern aircraft engines. Such wheels are manufactured to extremely close tolerances and must withstand severe heat and centrifugal strains. Building them is a new, highly specialized metallurgical and engineering science.

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 Sinclair Refining Co.  
 Socony-Vacuum Oil Co., Inc.  
 Standard Oil Co. of California  
 Texas Co.

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 Aro Equipment Corp.  
 Chambersburg Engineering Co.  
 Ex-Cell-O Corp.  
 Farmingdale Aircraftmen Manufacturing Corp.  
 Sheffield Corp.  
 Standard Machine Tool Co.  
 Thomson Industries Inc.  
 Topflight Tool Co., Inc.  
 Walker-Turner Co., Inc.

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 Ex-Cell-O Corp.  
 Liberty Aircraft Products Corp.  
 Pacific Aviation Inc.  
 Sheffield Corp.  
 Skilsaw, Inc.  
 Steel Products Engineering Co.

**MANIFOLDS**

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 B. H. Aircraft Co., Inc.  
 Rohr Aircraft Corp.  
 Ryan Aeronautical Co.  
 Solar Aircraft Co.

**OIL SEALS**

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 Garlock Packing Co.  
 Johns-Manville

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FLIGHT**

Aro Equipment Corp.  
 Bendix Aviation Corp.  
 Chicago Metal Hose Corp.  
 Durham Aircraft Service, Inc.

Eclipse-Pioneer Div., Bendix Aviation Corp.  
 Walter Kidde & Co., Inc.  
 Scott Aviation Corp.

**PANELS**

Acromark Co.  
 Bendix Aviation Corp.  
 Eclipse-Pioneer Div., Bendix Aviation Corp.  
 Farmingdale Aircraftmen Manufacturing Corp.  
 Schweizer Aircraft Corp.  
 United States Plywood Corp.  
 Westinghouse Electric Corp.

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AND HARDWARE**

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 Bendix Aviation Corp.  
 Irving Air Chute Co., Inc.  
 Pioneer Parachute Co. Inc.

**PARACHUTES**

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 Irving Air Chute Co., Inc.  
 Pioneer Parachute Co. Inc.

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 Celanese Plastics Corp.  
 Commercial Plastics Co.  
 E. I. du Pont de Nemours & Co., Inc.  
 Formica Insulation Co.  
 General Electric Co.  
 Heath Co.  
 Scintilla Magneto Div., Bendix Aviation Corp.  
 Westinghouse Electric Corp.

**PRIMERS (ENGINE)**

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 Chandler-Evans Corp.  
 Parker Appliance Co.

**PROPELLER PARTS**

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 Aircraft Components Corp.  
 Aro Equipment Corp.  
 B. H. Aircraft Co., Inc.

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 B. F. Goodrich Co.  
 Hartzell Propeller Co.  
 Koppers Co., Inc., Aeromatic Propeller Dept.  
 Moore-Eastwood & Co.  
 Republic Aircraft Products Div., The Aviation Corp.  
 Steel Products Engineering Co.  
 Thompson Products, Inc.  
 Wyman-Gordon Co.

**PROPELLERS**

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 Aircraft Components Corp.  
 Beech Aircraft Corp.  
 Curtiss-Wright Corp., Propeller Div.  
 Flottorp Mfg. Co.  
 Hamilton Standard Propellers Div., United Aircraft Corp.  
 Hartzell Propeller Co.  
 Koppers Co., Inc., Aeromatic Propeller Dept.  
 McCauley Corp.  
 Republic Aircraft Products Div., The Aviation Corp.  
 Thomson Industries Inc.  
 Wyman-Gordon Co.

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 Durham Aircraft Service, Inc.  
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 Formica Insulation Co.  
 Scott Aviation Corp.  
 Westinghouse Electric Corp.

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 Aircraft Hardware Mfg. Co.  
 Aro Equipment Corp.  
 Bendix Aviation Corp.  
 Chandler-Evans Corp.  
 Durham Aircraft Service, Inc.  
 Eclipse-Pioneer Div., Bendix Aviation Corp.  
 Liberty Aircraft Products Corp.  
 Pacific Aviation Inc.

Scintilla Magneto Div., Bendix Aviation Corp.  
 Sperry Gyroscope Co., Inc.  
 United Aircraft Products, Inc.

**RADIATORS**

Clifford Manufacturing Co.  
 G & O Manufacturing Co.  
 Standard Machine Tool Co.  
 United Aircraft Products, Inc.  
 Young Radiator Co.

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Air Associates Inc.  
 Airadio, Inc.  
 Bendix Aviation Corp.  
 Bendix Radio Div., Bendix Aviation Corp.  
 Chicago Metal Hose Corp.  
 Collins Radio Co.  
 Communications Co., Inc.  
 Doolittle Radio Inc.  
 General Electric Co.  
 Harvey Radio Laboratories, Inc.  
 Heath Co.  
 Lord Manufacturing Co.  
 Permoflux Corp.  
 Philco Corp.  
 Sperry Gyroscope Co., Inc.  
 Western Electric Co., Inc., Radio Div.  
 Westinghouse Electric Corp.

**RADIO COMPASSES**

Bendix Aviation Corp.  
 Bendix Radio Div., Bendix Aviation Corp.  
 Collins Radio Co.  
 Fairchild Camera & Instrument Corp.  
 Sperry Gyroscope Co., Inc.  
 Western Electrical Instrument Corp.

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Air Associates Inc.  
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 Aircraft Radio Corp.  
 Bendix Aviation Corp.  
 Bendix Radio Div., Bendix Aviation Corp.  
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Westinghouse Electric Corp.

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Downs Smith Brass & Copper Co. Inc.  
Durham Aircraft Service, Inc.  
Stronghold Screw Products Inc.

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Airchox Co.  
Aircraft Hardware Mfg. Co.  
B. F. Goodrich Co.

**SEATS**

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Evans Products Co., Sky Products Div.  
Schweizer Aircraft Corp.  
United States Rubber Co.  
Weber Showcase & Fixture Co., Inc.,  
Aircraft Div.

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(RADIO & IGNITION)**

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Aircraft Hardware Mfg. Co.  
B G Corp.  
Belden Manufacturing Co.  
Bendix Aviation Corp.  
Breeze Corporations, Inc.  
Chicago Metal Hose Corp.  
Durham Aircraft Service, Inc.  
General Electric Co.  
Scintilla Magneto Div., Bendix Aviation Corp.

**SHOCK ABSORBERS**

Adel Precision Products Corp.  
Bendix Aviation Corp.  
Cleveland Pneumatic Tool Co.  
Lord Manufacturing Co.  
Pacific Aviation Inc.  
Scott Aviation Corp.

**SHOP EQUIPMENT**

Aircraft Screw Products Co., Inc.  
Aro Equipment Corp.

Burklyn Co.  
Sheffield Corp.  
Skilshaw, Inc.

**SPARK PLUGS**

Aircraft Components Corp.  
Aircraft Hardware Mfg. Co.  
B G Corp.  
Bendix Aviation Corp.  
Champion Spark Plug Co.  
Durham Aircraft Service, Inc.  
Scintilla Magneto Div., Bendix Aviation Corp.  
Simmonds Aeroaccessories, Inc.

**SPRINGS**

Downs Smith Brass & Copper Co. Inc.  
Eaton Manufacturing Co.

**STAMPINGS**

Acromark Co.  
Adel Precision Products Corp.  
B. H. Aircraft Co., Inc.  
Downs Smith Brass & Copper Co. Inc.  
Eaton Manufacturing Co.  
Farmingdale Aircraftmen Manufacturing Corp.  
Liberty Aircraft Products Corp.  
Republic Steel Corp.  
Revere Copper & Brass Inc.  
Ryan Aeronautical Co.  
Stronghold Screw Products Inc.  
Transue & Williams Steel Forging Corp.  
Weatherhead Co.

**STANDS (ENGINE,  
PROPELLER,  
SERVICING)**

Aircraft Mechanics, Inc.  
Liberty Aircraft Products Corp.  
United Aircraft Products, Inc.  
Whiting Corp.

**STARTERS**

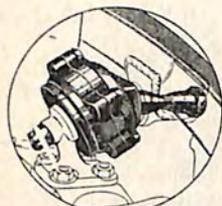
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Bendix Aviation Corp.  
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Eclipse-Pioneer Div., Bendix Aviation Corp.  
Westinghouse Electric Corp.

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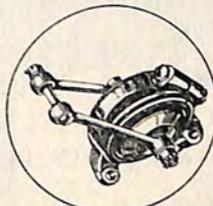
Throughout



**MR-26 ASSEMBLY**

Consists of eight MR-26-SA sub-assemblies

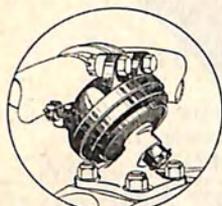
For DOUGLAS DC-4 (C-54)  
Using Pratt & Whitney R-2000 Series Engines



**RL-35 ASSEMBLY**

Consists of nine RL-35-SA sub-assemblies

For LOCKHEED "CONSTELLATION"  
Using Wright R-3350 A & B Series Engines



**MR-36 and MR-36F ASSEMBLIES**

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For CURTISS CW-20 (C-46)  
FAIRCHILD "PACKET" (C-82)  
MARTIN 202  
DOUGLAS DC-6 (C-112)  
Using Pratt & Whitney R-2800 A & B Series Engines, use MR-36  
Pratt & Whitney R-2800 C Series Engines, use MR-36F



**LORD ENGINE MOUNTINGS FOR DC-3**

Item	P & W 1830 Series		Wright 1820 Series	
	Quantity Per Plane	Part Number	Quantity Per Plane	Part Number
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Insert	16	J1789-1	18	SK1923-1
Sandwich	32	SK1292-1	36	SK1292-2

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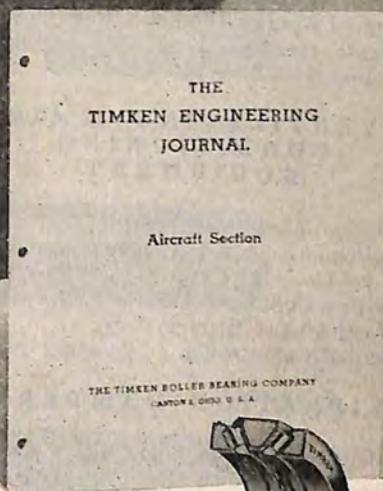
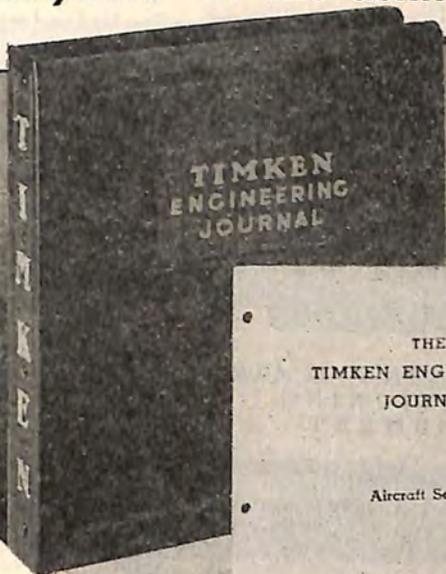
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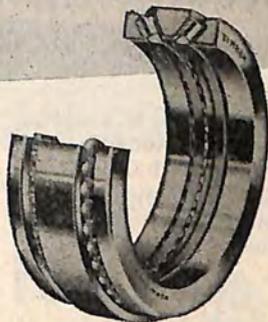
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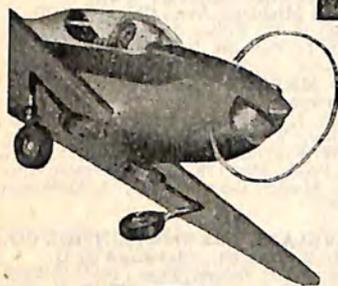
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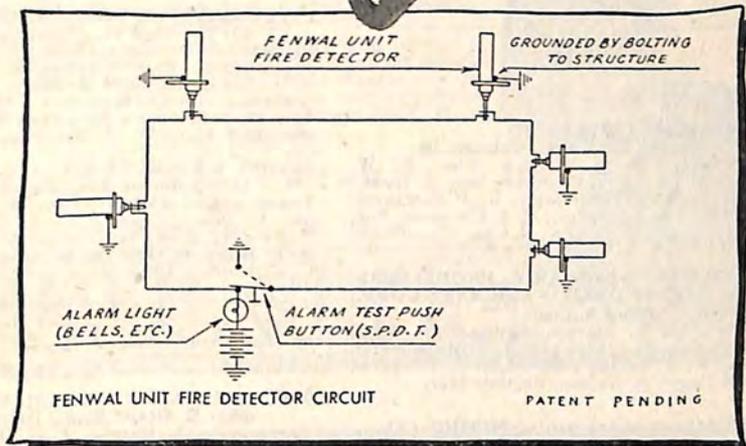
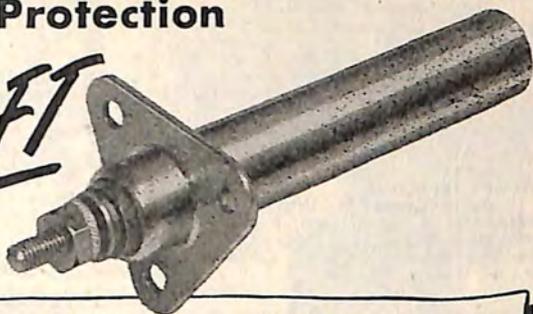
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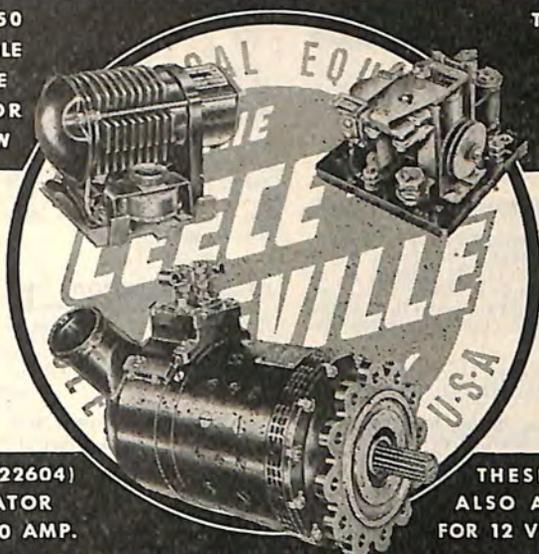
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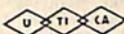
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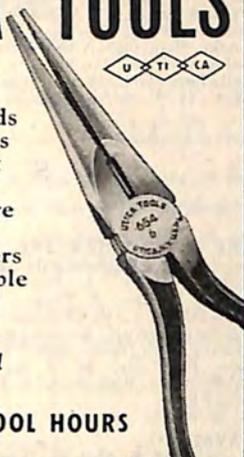
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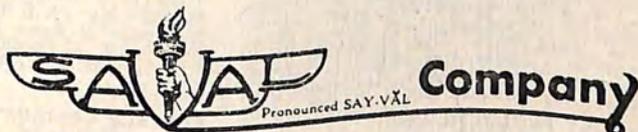
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