# *The*
# AIRCRAFT YEAR BOOK

## *For 1946*

AIRCRAFT YEAR BOOK FOR 1946

U. S. Army photo

BROKEN HEART OF GERMAN AIR POWER

The great Air Ministry in Berlin where the destruction of many nations was plotted by the leaders of the German air forces. Allied bombers knocked it into ruins, and it became a symbol of the complete devastation that followed.

# *The* AIRCRAFT YEAR BOOK

*(Registered U. S. Patent Office)*

# *For 1946*

TWENTY-EIGHTH ANNUAL EDITION

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Editor

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U. S. Army photo

TOKYO'S FIFTH AVENUE

After raids by American bombers. The capital was 50 per cent destroyed before Japan surrendered.

# CHAPTER I

## AIR POWER—PEACE POWER

Victory Determined by the War in the Air—Our Air Forces Play Decisive Role in Defeat of the Enemy—We Emerge from the War With the World's Greatest Air Power—Its Ability to Maintain Peace—Superiority in Numbers and Performance of American Aircraft—The High Cost of Victory—The Need for Continuous Progress—The Five Essentials of Air Power—Our Postwar Air Forces—Developments in Civilian Aviation.

IF the great war which ended with the defeat of Germany and Japan taught the human race anything at all, aside from the fact that modern warfare is unprofitable even to the victors, then it proved conclusively, that air power can keep the peace in an uneasy world just as a police force maintains law and order in a restless city. For the second time in a generation we had been forced into a war because our enemies believed we were not prepared; and they discounted some of the advantages in our favor. Britain held Germany at arm's length, and the enemy in Europe had to wait until we were ready. But in the Pacific nobody was ready, except the Japanese, and they did not wait. They fell upon us at Pearl Harbor and in the Philippines, and upon our friends in Singapore, Burma and in Java, like gangsters raiding a town with its police force away on a picnic. Still some of the advantages were with us. While vast distances kept us from getting at the enemy in sufficient strength at first, those same vast distances kept the enemy from reaching us—our arsenals, our other resources and our homes—until we were ready to return the holocaust, which we did. But even as we mobilized our armies and trained them and sent them overseas, built up our huge fleets and launched them against the distant bases of the foe and hurled our great aerial armadas over all the world's battlefronts, it was apparent that this would be our last chance to hold an enemy at bay while we took our time to acquire the strength necessary to dispatch him. The devilish weapons forged in the fires of this man-made hell and all the different and ghastly new techniques of war would surely bring disaster to that country first attacked, with the attack being more sudden than that of the Japs at Pearl Harbor on December 7, 1941, and the end far more catastrophic for the vanquished than it was for Germany on May 8, 1945, and for Japan on August 14, the same year.

U. S. Army pnoto

ALLIED BOMB DESTRUCTION IN GERMANY

This is Duren, an example of air attacks which knocked out enough of German resistance to make the path of conquest easier for the Allied ground forces.

Everything about this war proved that the United States must keep its air power ready to meet any foe without notice, meet him more than halfway if possible, and prevent him reaching us. The war taught us even more than that. It showed us, and the facts to prove it are in the pages of this book from cover to cover for all to read and understand, that the best thing for the United States to do is to maintain its air power in position to discourage anybody from even thinking of attacking us. In the last war we were spared the attacks on our homeland which we made on the enemy. But new weapons surely will let an enemy reach even the heart of this continent with lightning swiftness in the not so distant future, and with the certainty of more destruction than any that could be caused by lightning. The best way is to prevent any next war, because it would be too costly for us, even if we won. The last war cost too much. It hurt us in many ways as much as it hurt our enemies, and we hurt them grievously.

While the armies and surface fleets and all the might of allied nations could claim a fair share of the final victories against our foes in Europe and in the far Pacific, it was air power that hurt them most. In the European war, allied air power was mainly American and British, and during the great offensive our Army Air Forces were predominantly the largest. Teamed with the gallant Royal Air Force which had saved England during the German blitz, this allied air power paved the way for the armies, and it reduced Germany to ruins for the soldiers to overrun.

In Germany, according to the report of the Strategic Bombing Survey in Chapter III, 3,600,000 dwellings, about 20 per cent of the total, were destroyed or heavily damaged, seven and a half millions rendered homeless, the principal German cities largely reduced to hollow walls and piles of rubble. German industry "was bruised and temporarily paralyzed," this last a very conservative statement, because most of the German factories were badly damaged; for example, only five per cent of the German gasoline and oil production capacity remained, and the transportation system was knocked out for all practical use. But it was a tough campaign, as shown by the facts in Chapter III and the complete statistical tables on our AAF casualties and losses in equipment, along with what the enemy received, which will be found in the section Flying Facts and Figures.

Among the Allies, our American forces waged most of the air war against Japan, and as the statistics show, Japan was as badly

U. S. Army photo

THE ASUKASA SECTION OF TOKYO

After our Army Air Forces had drenched it with fire bombs.

U. S. Army photo

TOKYO'S BUSINESS DISTRICT

Showing what had been accomplished by American bombers toward total destruction of the Japanese capital.

hurt as Germany. The Japanese cities were bombed and burned to rubble. The munitions plants were ruined. Transportation was torn up. Millions lost their homes. Like the Germans, the Japs were badly beaten by air power, and they knew it months before they surrendered. They hoped to save face by killing off several thousand Americans if they invaded Japan; but the atomic bombs on Hiroshima and Nagasaki gave them a perfect excuse to surrender immediately thereafter in order to save their own lives. Here too, air power was required to put the atomic bombs into Japan.

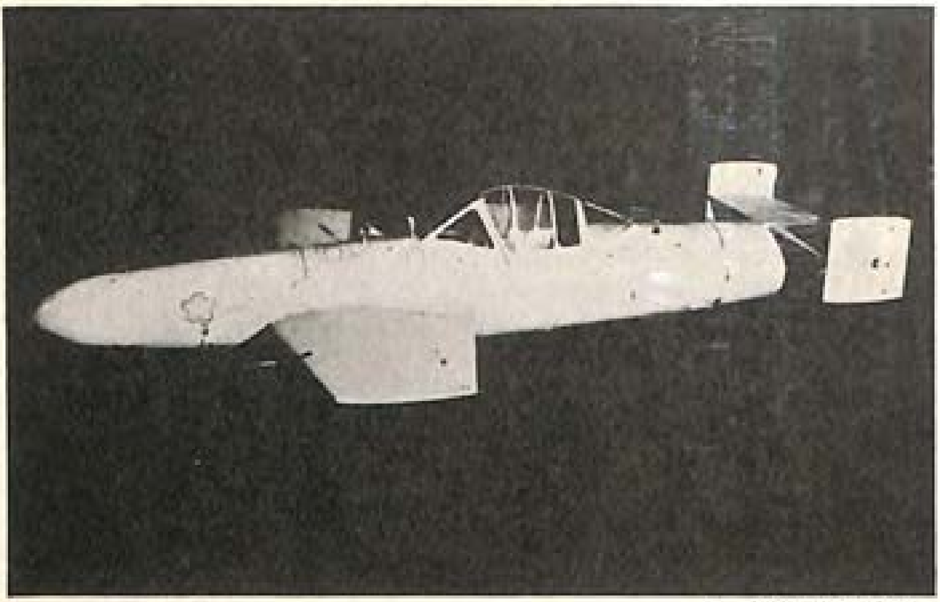
We came out of the total war with great losses, the official records show, but they were nowhere near as great as they would have been had we not been spared the time to prepare for the campaigns which we won. We had the time to build up the equipment and train our people to use it effectively. While the atomic bomb was the most spectacular of the new and terrible weapons developed during the war, there were many others which were used against our enemies, and they are fully described in the following chapters. On the other hand, there were many new weapons which did not get into action, some of which remained on the secret list months after the war. That was one of our heritages, the development of superior weapons, and for the time-being, say for two or three years, we could maintain this scientific lead over potential enemies anywhere. But that would avail us nothing if the others should catch up with us in the scientific race; if for example, they too should succeed in developing atomic bombs. It was known that hundreds of German scientists and technicians were dispersed in other countries where they were encouraged to resume work interrupted by the defeat of Germany, and Germany had been working hard for years to develop aircraft, guided missiles and other weapons capable of striking targets thousands of miles away. Her buzz bombs and rocket projectiles that hurt England badly were only the beginning of things to come had our air power not put an end to her program.

Unlike all the other nations, with the possible exception of Russia, we came out of the war much stronger than when we entered it. We had better armies in the sense that they were the best equipped of any in the world. We had by far the world's greatest navy in size and strength. We had the world's largest and most effective air forces and

U. S. Army photo

DESTRUCTION OF OSAKA, JAPAN

This waterfront area of Osaka offers a sample of what our B-29 Superfortresses did to Japan's key cities during five months of heavy raids before the surrender.



U. S. Navy photo

JAP SUICIDE BAKA BOMB

This was the Jap's latest weapon against our advance. An explosive charge filled the nose and was discharged upon impact. A suicide pilot controlled the craft. Rockets in the tail section supplied propulsion. The bomb was launched from a medium bomber.

all the other essentials to dominant air power which could make those forces continue to grow in size and strength. In brief, we emerged victors from the greatest war in history capable of putting still greater air power against anybody foolish enough to start trouble.

We still had more than 220,000 pilots in our Army and Navy air forces after Japan surrendered. We had nearly 3,000,000 trained air force personnel skilled in the new things, hundreds of new things from flying machines to radar and atomic bomb technique. We still had more than 80,000 first class warplanes, including more than 15,000 transports, and more than 100 aircraft carriers loaded with over 4,000 combat planes. We had left more bombers of every type and more first class fighters than all the rest of the world combined. We had possession of sufficient auxiliaries, too, such as munitions, food and clothing supplies, gasoline and machines—all this at a time when the rest of the world was short of everything.

We came out of the war with the experience and knowledge born of 2,646,555 sorties made by our Army and Navy air forces during which they had dropped more than two million tons of bombs on enemy targets and had destroyed more than 55,000 enemy planes in combat operations—nearly 30,000 in the European war and over 25,000 in the war against Japan.

We came out of the war knowing that we could have accomplished even more in some respects, such as putting stronger air power into the early stages of the Pacific campaign, if overall strategy had not called for our sending huge quantities of equipment and supplies to our allies, notably Britain and Russia. For example, the British received 38,811 planes from us, including 27,152 combat; and Russia was given 14,717 planes of which 13,929 were combat. This of course was part of the American air power had we wanted to use it under our own flag. Only 35 per cent of our total war production was devoted to our air power.

We came out of the war with the fastest, highest-powered and most devastating flying machines in the world. They represented manifold improvements over the very good planes with which we entered the conflict. Yet some of our most outstanding equipment was not necessary to victory. Our planes already in the field helped

U. S. Navy photo

U. S. NAVY AIR ATTACK ON JAP BASE

Our planes attack harbor and shore installations at Kure, Honshu. The sky is filled with flak and smoke from burning ships and buildings.

to bring about the enemy's collapse before the new machines were moved into the combat zones. We also had even more powerful planes either entering production or in the prototype stage. Our aircraft industry had achieved miracles in design and production that were the envy of friend and foe alike the world over. From July, 1940, to August 31, 1945, the American aircraft manufacturers turned out one batch after another of improved warplanes for a grand total of 295,959 planes, and each succeeding batch proved more distasteful to the enemy. It added to the confidence of our air forces, and was one of the factors creating efficiency. Our aircrew personnel became even more skillful and daring and successful with each month of war, while that of our enemies on both sides of the world deteriorated until few of them could be enticed into combat.

There were many other factors which brought us out of the war with the greatest air power. We had enough manpower in technicians and skilled labor. The youth of America provided more than enough airmen in a profession requiring the utmost in health, intelligence, courage and mechanical aptitude. That fact also offered convincing evidence that we could send our air forces into any corner of the earth without much opposition.

On the other hand, if we could take pride in what we had built up and what we had accomplished, it was tempered by the knowledge of our losses. Our human casualties were high, but not so numerous as had been anticipated, and a very large percentage had occurred here at home during the early stages of training, a tragic loss that could have been kept at a minimum had our youth been as familiar with aircraft as they were with motor cars. Our Army and Navy air forces lost 27,179 planes on combat missions alone, which proves that even successful aerial warfare is no picnic. Out of the total of 156,182 planes received by the two air forces, 73,056 were destroyed, wrecked or damaged beyond repair. While our casualties in men and planes were only two of the many debit items in the costly business of waging war, they serve to show that much can be saved by preventing war.

Better diplomacy and better understanding between nations ultimately may maintain world peace; but the last war is too recent for Americans to depend altogether on the future good will of other Governments. Even now, as this is written in March, 1946, all the others are making as much scientific progress as their individual resources permit; and none has divulged the slightest idea of relaxing efforts to build up air power.

Meanwhile, our air forces have been shrinking with the inevitable demobilization of the armed services. Our production of equipment was shrinking long before the end of the war. Our aircraft plants, for example, had their peak production year in 1944, when they turned out more than 96,000 warplanes, a production, incidentally, which was three times that of Great Britain and more than double

Germany's. Here contracts for 75,000 planes were cancelled in 1944 and 1945 because our losses in Europe were less than expected—the German air forces had been defeated and their production machine was crippled—and in the Pacific we had shifted largely to long-range bombers to strike Japan, and there attrition was lighter than in Europe. After the war, 90 per cent of the 1946 production program was cancelled. At the present time, fewer than 5,000 planes are on order for both the Army and the Navy. However, when they are delivered, they will be the latest and best planes in the world.

As these hundreds of pages will show, the United States is not lagging behind the rest of the world in design and invention. Production models of our warplanes have crossed the United States in a little over four hours. New fighters are coming off the assembly lines. Much larger bombers and transports have been developed, and some of them already are in the air. There are almost as many top secret planes and guided missiles now under development as there were during the war. Proof that our air force leaders are not resting on their laurels won in the thick of battle will be apparent in the coming months when new planes, new missiles and new electronic equipment will undergo fantastic tests, with still more fantastic things to come. Gen. Henry H. Arnold, shortly before he retired as commander of

U. S. Navy photo

OUR INVASION OF OKINAWA

the Army Air Forces early in 1946, stated that "we can be certain that the techniques and materiel of armed conflict with which this war was begun were in most cases outmoded when it closed. The necessity for continuous and organized scientific research will not be questioned by anyone who in the slightest degree is familiar with the course of war. By a tremendous acceleration of effort in our laboratories, our universities and our armed forces, we have arrived at the van of scientific research. Yet a potential aggressor can catch up with us in two years, and if we lag, can outstrip us in four. Security against such means of aggression as atomic weapons hurled thousands of miles straight into our cities and our industrial centers, at speeds so fast that we cannot even see or hear them coming with our human eyes and ears, rests upon our ability to take immediate offensive action with overwhelming force. The next war will start only when an aggressor believes that the United States cannot ward off the first, sudden and paralyzing blows. Therefore, to keep the peace, our purpose must be to make our air power so strong that we never will need to use it."

Our postwar air power, it is agreed, must embrace five main components in order to be readily available and effective. Combat force is first, of course. The Army Air Forces under their new commander, Gen. Carl Spaatz, have reorganized into a postwar strength of 400,000. Gen. Ira C. Eaker, deputy commander, has explained some of the vital principles of this reorganization which are extremely encouraging. It was decided after the surrender of Japan that a relatively small air force could not be a good one unless everybody in it wanted to be there; so the AAF demobilized all those who wanted to leave the service, at the same time calling for volunteers. The result was more than enough volunteers. Personnel requirements were met long before the due date of June 30, 1946. Several times the required number of officers made application to remain in the service. At the same time, our air force leaders believe that for several years to come, probably 10, the long-range bomber will be the main aircraft for our air defense. The largest bomber we possessed was necessary to carry the atomic bombs and drop them on Japan. Long-range bombers provide launching platforms for smaller machines, including radio-controlled planes and guided missiles. Long-range bombers with globe girdling characteristics may hurdle shorelines and penetrate the heart of an enemy's war effort, his munitions industries and the sites from which he launches his guided missiles against us. The Navy meanwhile continues to rely on its large and small carriers in the same way that the Army relies on its bombers, and with justification, considering the remarkable work of our fast carrier task forces in the last war. They made the island hopping program on the long road to Tokyo a fact instead of a strategist's dream. The Navy also is reorganizing its aviation to the maximum extent contemplated in the overall postwar program. It is providing for intense technical development and the training of sufficient aviation reserves to maintain its full share of our air power. The Army Air Forces also will have their reserves in the Air Reserve and the Air National Guard set up in all States.

The second component of our peaceful airpower is freedom of the air consistent with national sovereignty, freedom to fly out across the continents and seas on experimental and training flights and scientific missions, and freedom of the air for an international air patrol under international law.

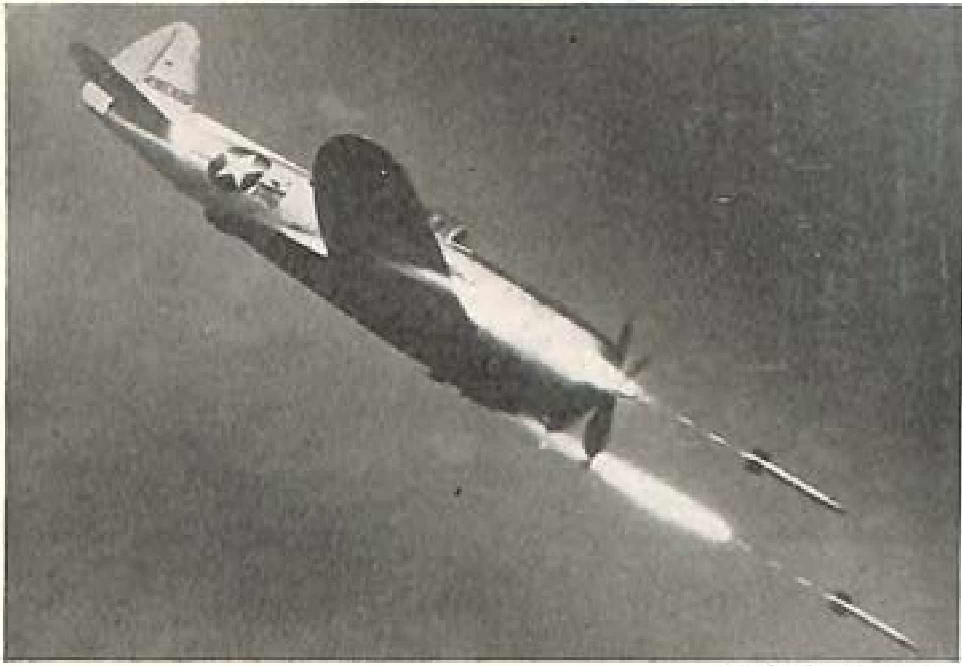
The third factor of air power is the continued expansion of our domestic and international air transport systems which grew to such huge proportions under the necessity created by our participation in global war. The new equipment being prepared for our air transport network is almost as revolutionary as our new air force equipment. In all the essentials of design and performance, of course, it comes from the same laboratories and factories, whether it is aircraft, navigational aids, automatic pilots or loran and radar.

The fourth requirement for a healthy air power is a strong, progressive aircraft manufacturing industry kept busy producing enough machines for all purposes and developing the machines of

U. S. Army photo

B-29 JET-ASSISTED TAKE-OFF

The use of jet propulsion gives the big bomber a boost that enables it to get off much shorter runways.



U. S. Army photo

ROCKETS FROM A THUNDERBOLT

**A Republic P-47 Thunderbolt launching rockets against heavy surface installations.**

tomorrow. The reconversion of the manufacturing plants from all-out war effort to peacetime production for civilian aviation as well as the moderate requirements of the Services is one of the greatest accomplishments in the history of American industry. The last several chapters describe the activities of the individual manufacturers in complete detail.

The fifth component of our air power is the further expansion of aviation for the use of the American people, in more transport facilities, in private flying and other non-scheduled operations and in the widespread education of American youth in all flying activities. The chapters devoted to those various branches of our civil aviation explain the phenomenal progress being made at the present time.

Obviously the development of air power in future will be far more expensive than ever before because of the higher cost of heavier machines and the huge quantities of auxiliary equipment necessary. As the speed of aircraft grows into the supersonic range, terrific temperatures will be set up, not only in the power plants and in the bodies of the aircraft, but even the air inside the cabins. A very great amount of research and development must be carried on in metallurgy and in control of high temperatures before men and machines can survive the high speeds of the near future. That is only one of the increased cost factors. There are countless others. The Army and

Navy want three hundred million dollars for aviation research and development alone. The problem in the future, if the Government adopts a policy of economy in spending money, will be to keep the public convinced of the need for air power expenditures on a scale commensurate with the requirements of national security.

Most of the civilian branches of our air power, it is believed, can be made self-supporting eventually, except for airways, some other surface facilities, the aids to navigation and maintenance of the reserves, which will require some public funds.

Air transportation will pay its own way eventually, at least as much as the railroads and ocean transport, if there is the right kind of Federal and State legislation. It cannot be taxed into poverty nor regulated into the status of a poor relation to the older forms of surface transport. Private flying, too, can pay its own way under the right conditions.

One of the best ways to help defray the cost of our aviation is the development of our export markets for all kinds of aviation products. That is an axiom long realized by other nations and it is

U. S. Army photo

**FIRE BOMBS THAT BURNED JAPAN**

The smaller 110-gallon droppable tanks being filled with "fire jelly" preliminary to a B-29 raid on Tokyo.

in the postwar programs of all that have made such plans. The Aircraft Industries Association of America reports a ready market for our products stimulated by our display of aviation efficiency during the war, the global operations of our air transport services which familiarized the whole world with Americans, their machines and the things they flew into the various countries for war purposes or relief. The AIAA reported that 22 foreign countries already had placed aircraft orders here by the first of the year. Fifteen foreign flag airlines had ordered 91 new transport planes. Twelve countries were represented in the purchase of surplus aircraft, including 80 transports and 31 trainers. Our manufacturers of light and other personal planes were assured a growing list of customers abroad after they had satisfied the domestic demand. Nine countries had received Export-Import Bank loans partially for purchase of aviation products. The Export Service of the Aircraft Industries Association carried out the policies set up by an industry committee of foreign trade experts, cooperating with the Federal and foreign governments in plans for the development of that international trade, and it promised soon to become an important item in maintaining a healthy aircraft industry, the keystone of the whole structure of American aviation.

NEW POWER PLANTS FOR NEW SUPERFORTRESS

The Boeing XB-44, prototype of the B-50 Superfortress, with its interchangeable powerplant nacelles, is powered by Pratt & Whitney 3,000 h.p. Wasp Majors.

## CHAPTER II

### TECHNICAL PROGRESS IN AVIATION

Epochal Developments a Heritage from the War—Giant Aircraft—New Power Plants—Jet Propulsion—Improved Metals and Other Materials—Standardization of Parts and Accessories—Reduction in Costs—Contributions to Safety—New Things to Help the Private Owner—New Instruments—Expansion of Aviation Electronics—The Story of Radar—Development of Loran—Cooperation Between Government, Industry and Science—Awards for Special Contributions to Aviation Progress.

UNDER the stimulus of the war effort, remarkable progress was made in the technical development of aeronautical equipment, and nowhere on earth were there greater facilities for continuing that work in order to keep the United States abreast of other nations in the air. The laboratories and test plants still were intact. The same keen minds that had brought forth so much which proved superior to similar creations of our enemies still were available; and after the war, they were bent on developments that should, in part at least, prove useful in a world at peace. Many organizations were working in that direction.

The following explanation of technical research and developments in aircraft and auxiliary equipment—in language that the layman can understand—was prepared for this edition of the Aircraft Year Book by Ivar C. Peterson, director of Technical Service, Aircraft Industries Association of America.

The recent advances in heavy airplane design are represented by such airplanes as the Consolidated Model 37, the Republic Rainbow, the Douglas C-74 and the Boeing C-97. These designs are the culmination of years of design and development. The C-97, and its passenger-carrying sister, the Stratocruiser, are built around the B-29 wing design with the fuselage much enlarged over that of the bomber version to provide room for cargo and passengers. The double deck structure is an innovation in design which surely will attract considerable interest. The C-74 follows the usual Douglas design pattern but is considerably larger than any of its commercial predecessors. While it was originally designed as an Army cargo airplane, commercial versions will follow as the DC-7 series. Consolidated's bid in the heavy aircraft field goes all the way in size. Its Model 37 is a com-

THE DOUGLAS C-74 GLOBEMASTER

mercial version of the XB-36. This 204 passenger land plane will be 230 feet long and has a wing span of 182 feet. In service across the Atlantic it is designed to carry seven tons of mail and freight in addition to a full complement of passengers. Aside from its enormous size, a conspicuous feature of the Model 37 is the pusher propeller installation. There has been much discussion on the pros and cons of pusher propellers, especially regarding the absence of slipstream effects. Apparently Consolidated has found the arrangement to be satisfactory.

The Republic Rainbow transport will follow closely the lines of its military prototype, the XF-12 reconnaissance design. Such a transport will represent an adventure into the 400 miles an hour range, the first announced commercial airplane to boast such speed. Outstanding features making this speed possible are close attention to aerodynamic detail and the powerful compound engines—Wasp-Majors with double superchargers, utilizing jet thrust from the exhaust. For sheer size the Hughes huge flying boat surpasses anything ever before attempted. To have a boat of such size built entirely of laminated wood makes it a doubly stupendous undertaking. It is doubtful if this method of construction could be applied economically to such a project on a production basis, but credit should be given for having attained an aerodynamically smooth surface which has been difficult in metal structures. While the Lockheed Constellation was flying before 1945 it seems appropriate to mention it again because it was put into commercial operation late in the year. The flying economy of the Constellation is a source of considerable satisfaction to the airline operators. Much of the work connected with heavy aircraft has been in the nature of continued development rather than any radical steps which have characterized some other phases of airplane progress.

In the reciprocating engine field, developments were announced of units with greater than 3,000 horsepower and with horsepower weight ratios less than one. The Allison V-3420 was announced as the first liquid cooled aircraft engine of greater than 3,000 horsepower. This unit was installed initially in the "flying laboratory" XB-19 bomber, and found application in a number of improved fighter and interceptor designs. The Army Air Forces revealed a new development by Chrysler Corporation of a 16-cylinder liquid cooled aircraft engine in the 3,000 horsepower class which is characterized by a design wherein the power is taken from the center of the crankshaft, thus eliminating to a large degree any objectionable torsional vibration. These developments indicated that the liquid cooled engine would be a strong contender for the future commercial transport market. Also announced was the long awaited Pratt & Whitney Wasp Major, a 28-cylinder radial air-cooled powerplant producing 3,650 horsepower. The unique construction of this powerplant comprised four banks of seven cylinders, each staggered about a single crankshaft. This powerplant has been installed in a new version of the Vought Corsair and in new bomber prototypes. It is scheduled to power all the heavy airplanes discussed here, as well as others still on the secret list. That engine probably approaches the power limit for internal combustion engines of conventional type. It seems certain that much greater increases in horsepower will be obtained with other than reciprocating engines.

CLOSE-UP OF REPUBLIC ARMY F-12 RAINBOW

The Services announced a number of experimental engines, including, besides those mentioned above, the 5,500-pound, 36-cylinder Lycoming XR-7755 designed to develop 5,000 horsepower; the 12-cylinder Lycoming X143625 for 2,100 horsepower with a weight of 1,445 pounds, and the Wright 42-cylinder R2160 rated 2,500 horsepower.

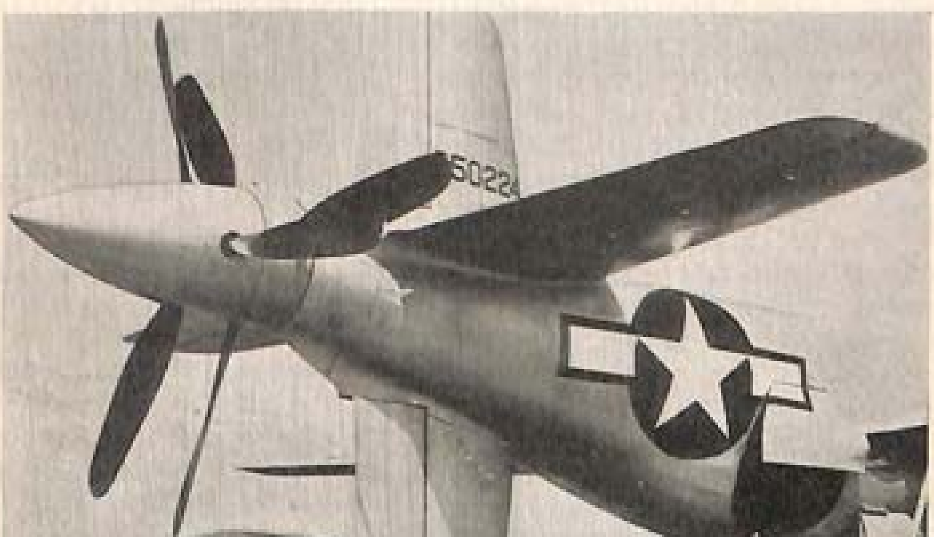
Concurrently with increased power ratings of reciprocating type engines came the announcement of improved turbo-superchargers. A new unit announced by Wright Aeronautical Corporation introduced a considerably smaller supercharger, about the size of a hat box, which develops power sufficient to raise water to the height of a six story building. Parallel with this development was the announcement by refineries that special light weight lubricants had been developed to insure safety of operation of the supercharger at all temperature extremes and at speeds heretofore unknown in the aviation field.

With the successful tests of the Douglas XB-42, came word that several new combinations of pusher and tractor drive installations were being developed by the industry, utilizing large extension shafting and new types of reduction gear drives. The obvious advantage of removing engines from aerodynamic surfaces through the use of these extension shaft drives may answer many problems facing the development of large transport type planes. More than three years of extensive testing by Allison on remote drives, both single and dual rotation, has proven the reliability and advantage of the "buried" powerplant with remotely driven propellers.

Among advances in the gas turbine type powerplant, General Electric announced two new turbo-jet models, one of which is used in the Navy's Ryan Fireball, a carrier based fighter, and another of increased power similar to that installed in the Lockheed P-80 Shooting Star. Units upwards of 5,000 pounds thrust were projected. Westinghouse announced a small axial flow unit of only 9½ inches diameter which developed around 250 pounds thrust at 375 miles an hour. The Army Air Forces indicated that all future fighter and interceptor designs probably would be based upon the use of turbo-jet or propeller-jet units or some combination thereof. The Navy had announced plans for two new carrier based aircraft powered solely by turbo-jet engines. Plans for incorporating propeller-jet combinations in the transport field were announced, and from all indications the possibilities of utilizing the gas turbine for an aircraft powerplant were unlimited. General Electric announced the development of a new gas turbine with propeller drive particularly designed for use in long-range high altitude operation. With improved combustion chamber design and development of new high temperature alloy materials promised within the next few years, the "jets" may give the conventional engines competition in all phases of military aircraft design, as well as some branches of the commercial field.

In the heavy plane field other important advances have been made; for example, power operated controls. The larger aircraft, of course, have control surfaces with vastly more area than small planes. The problem of moving such surfaces with sufficient rapidity to give adequate control requires at least a "power boost" system. In some of the larger craft the pilot's effort will be so small compared to the force required that the surfaces may be considered power operated. It is anticipated that full power-operated controls will be used in the near future. Notable advances have been made in autopilot design, especially useful in heavy aircraft. Certain autopilots are equipped with auxiliary controls which may be used to fly and even land the heaviest airplane with no more control force required than can be put in with one finger. At least one of these has an automatic trimming control which permits extension of flaps and landing gear without the necessity of operating controls or turning of tab wheels by the pilot. Such developments can do much to relieve the complexity of flying our larger multi-engine airplanes. Continued development of brakes and tires has been necessary to keep pace with the requirements of larger and larger loads. The main tires on the XB-36, for example, are 110 inches in diameter and weigh 1,500 pounds each.

An event of considerable importance in the design of heavy air-




TAIL OF THE ARMY DOUGLAS XB-42

Showing Curtiss Electric dual-rotation propellers. The airliner version of the XB-42 is the Douglas DC-8.

U. S. Navy photo

**RYAN FR-1 NAVY FIREBALL FIGHTER**

It is jet-pushed and aircooled engine-pulled, and it flies fast on either engine. Here the Fireball is flying with propellers feathered and still.

craft has been the development of 75S aluminum alloy. This alloy raises the available yield strength of aluminum alloy from 40 to 65 thousand psi in one angle step. The full importance of this factor can be realized only after actual design work has been done with the new material. However, in a large airplane now under construction the weight saving is measured in thousands of pounds. The 75S material is more difficult to form than 24S, and requires an age-hardening process; but it is worth all the troubles many times over.

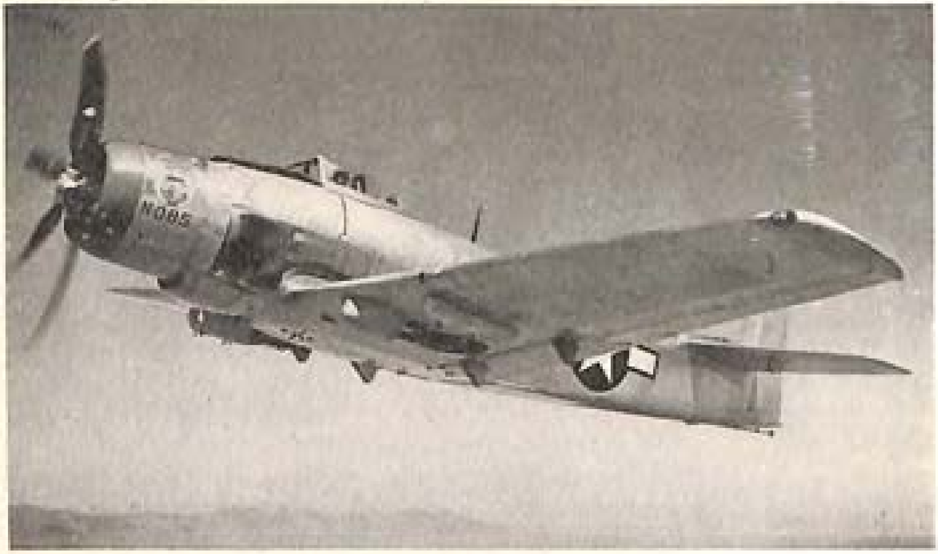
Fuel problems still exist, especially in the operation of heavy airplanes. In the laboratories of the National Advisory Committee for Aeronautics studies of fuel are being conducted with just about equal emphasis on reciprocating and turbine engine operations. High altitude operations during the war, especially bombing missions of the Superfortresses in the Pacific, have created a problem of gasoline vaporizing with substantial losses. As altitude increases, the fuel tends to boil and foam and a Superfortress mission, for example, can lose a good many tank car loads of gasoline by vaporizing in a matter of minutes. Several solutions to this problem have suggested themselves as a result of numerous tests, but the correct one has not yet been determined. Fuel synthesis with high octane and triptane gasolines blended is being tested with apparently good results for the triptane mixture.

Among the fuels for jet engines, kerosene is better than gasoline. Yet tests by the National Advisory Committee for Aeronautics have indicated that napthalene is in some ways superior to both other types. As NACA research progresses, a very high density fuel may be found so that the heat energy carried will be higher for the cubic space that is available for fuel. This space is somewhat more restricted on a jet plane than on a conventional design, the jet's higher speed operation calling for thinner wings, which eliminates the substantial wing tanks possible in conventional craft.

The best jet fuel found to date on a pounds per cubic volume basis is alpha methyl naphthalene, an aromatic. It is said to give 30 per cent greater range than types now in use, but still presents problems in the form of smoke and vaporization at altitude.

Many problems appeared only after the toughest kind of combat service, under the terrific strains to which flying equipment was subjected on extremely long flights with heavy loads, often in the worst kind of weather. The war brought these problems to light, and their solution will be of the greatest benefit to postwar aviation. For example, the AAF asked for a study of the problem of cooling the exhaust port on large radial engines used on bombers. This study was needed because of the number of failures occurring during bombing missions, overheating frequently melting down piston walls and damaging valves. Following careful tests of such overheating, the NACA recommended addition of about three ounces of metal per cylinder or about 4½ pounds for an entire engine. This permitted heavier cylinder head walls which, in turn, reduced the heat on top of valves by 200 degrees F. Valves were found to run much cooler with larger stems. Another such problem, to which a solution was found in the NACA laboratories, was icing of the induction system through entry of sleet, snow or moisture in the airscoop. As entry was directly through the scoop, NACA engineers designed an under-cowl installation which was protected from direct entry of freezing moisture. In-

THE REPUBLIC ARMY P-84 JET FIGHTER



THE DOUGLAS NAVY BT2D-1 DIVE BOMBER

side this scoop there were upper and lower channels separating moisture laden from lighter, desirable air. It almost eliminated that type of icing, according to NACA, and was estimated to be about 20 times more effective than the conventionally designed airscoop.

The Douglas BT2D-1 dive-bomber for the Navy came out with an application of fuselage dive brakes. With less than 80 per cent of the brake area previously required, the equivalent retarding effect is achieved, in addition to important aerodynamic advantages. The first large land plane to be equipped with reversible pitch propellers, the Consolidated Vultee B-32, has a combination of automatic multi-engine synchronization and reverse thrust propellers. The Curtiss electric propellers embodying these features are 16 feet, 8 inches in diameter. By means of the automatic synchronizer, constant speed operation of all the propellers is obtained by manipulation of a single control.

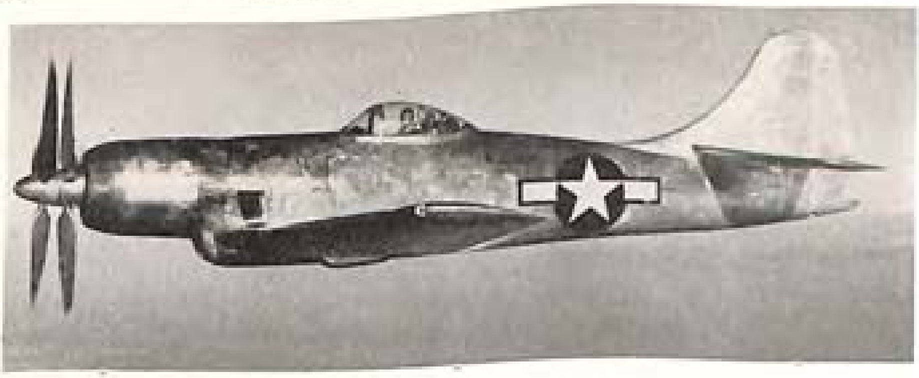
The heavy curtain of secrecy surrounding the metallurgic miracles which have made possible jet propulsion of combat aircraft was lifted ever so slightly when Fred K. Fischer, Westinghouse engineer, told the Electric Equipment Committee of New England the name of one of the wonder metals. It is, he said, "a new, nine-element alloy, called K-42-B. Its quality of toughness at red-hot temperatures of 1,200 degrees F., and its resistance to the centrifugal stresses which try to pull the speeding gas turbine motor apart with a force equal to 50,000 times its own weight, have played a large part in bringing gas turbine engines to the practical stage."

Development of the Northrop retractable aileron promises to be of importance in both the heavy and light plane field. The ailerons operate upward and out of the wing, well in front of the flap. This permits the use of full span wing flaps, which in turn, reduces landing speeds and the need for long and costly air strips for heavy aircraft. The Northrop Black Widow was the first airplane to incorporate retractable ailerons and full span flaps.

The prospect of jet-propelled and turbine driven transports is posing a problem for the landing gear designers, because the thin wings and small nacelles of these airliners of the future provide no space into which the main wheels can be retracted. As a result, some companies now are experimenting with unconventional types of gear, and one company has come up with a solution which is reported not only to meet the retraction problem, but also to effect considerable weight saving and to open up new possibilities for the use of multiple landing gear. Sweeping wings back at angles of 60 degrees or more may provide the solution to the compressibility problem at supersonic speeds. The 60 degree angle distributes the shock waves at a mach number of 2, and an even more pronounced sweepback may achieve the same results at higher speeds if these are found necessary to penetrate the compressibility burble.

Transmission of propeller power from liquid cooled engines submerged in an airplane's wing or fuselage, by means of an extension shaft, appears likely to become increasingly important in large airplane designs of the next few years. Most interesting recent example of the extension power shaft used in a new design is the Douglas XB-42 bomber and the DC-8, commercial version with identical power arrangement. Elimination of engine, nacelles and propellers from the wings makes possible maximum aerodynamic cleanliness, wing efficiency and safety of operation, saving about 25 per cent of the total drag of the airplane. The engines on the XB-42 are Allison V-1710 liquid cooled power plants having a take-off rating of 1,820 horsepower with water injection. They are located just aft of the pilot's cockpit in the fuselage and are connected to the dual rotation propeller reduction gear by steel drive shafts. Five-foot lengths of shafting are hinged at each joint by ball-bearing supports which provide for air load deflections of the fuselage. Each propeller is inde-

POWER PLANT OF DOUGLAS DC-8



BOEING XF8B-1 FIGHTER

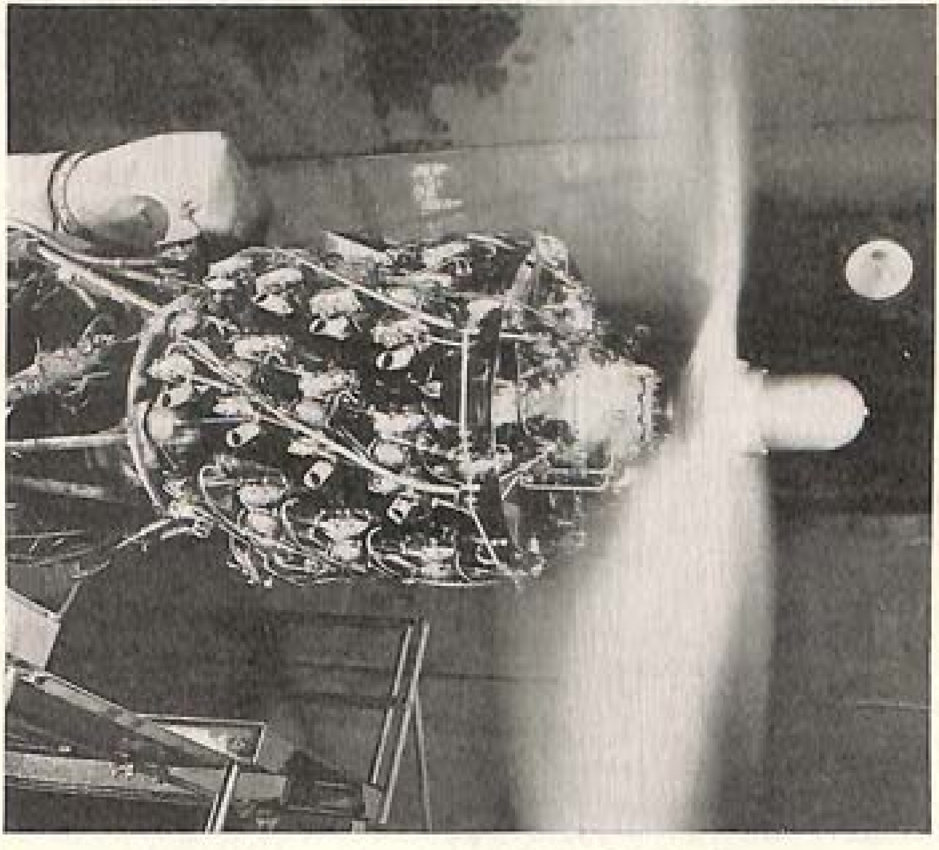
pendently driven and either propeller can be feathered when desired.

For the last five years, there has been very little development in the light plane field, insofar as design was concerned, because of the emphasis on combat machines and the limitless production programs taken on by all aircraft companies, large and small. However, the research results obtained on war problems undoubtedly will be applicable to light planes.

Philco has announced its intentions to continue the development of its VHF radio and navigation equipment for the private operator. Also the use of radio controlled light planes for familiarization solo flights is a design possibility for the immediate future. The day when the student pilot will be able to get into an aircraft, have the control tower take him off, after which he assumes control in the air, and then returns control to the tower for landing, is closer than most people realize.

There will be an increased use of flash and spot welding as a means of getting the price down on postwar private aircraft. These techniques have only limited military application because of their non-adaptability to field repair, but in civil aviation this will be overcome by making factory-built replacement assemblies available at even less cost than the normal field repair job. Republic Aviation Aircooled Motors is studying the possibility of equipping the Franklin engine for fuel injection to eliminate carburetor and carburetor icing problems. A pusher type propeller, and an unorthodox "bicycle-type" landing gear feature the VJ-21, a new two-place light plane now being developed by Jarvis Manufacturing Co., Glendale, Calif., for the personal aircraft market. Most unusual feature of the VJ-21 is its landing gear which consists of a single fixed main wheel located two inches in front of the most forward CG position and partly enclosed in the belly of the fuselage, a three-inch steel nose skid, a steerable and full swivel tail wheel, and two small manually retractable wing wheels which swing down to support the wing for taxiing. According to the designer, a builder and flyer of sailplanes, this single wheel arrangement has been used previously on gliders and makes it practically impossible to ground loop. In addition it eliminates the drag of the conventional fixed gear with long struts.

In the realm of high speed design the one outstanding factor has been the development in jet engines. It is a foregone conclusion that our higher speed aircraft will be jet powered. The advancement in jet engines has been very rapid. Jet engines are attractive to the airplane designer from nearly every standpoint. They adapt themselves better to streamlining; the fuel is relatively safe; the engine controls are potentially simple, although there are problems of burner blow-out and danger of burning tail pipes. The fuel is more dense than gasoline and hence occupies less space. The attachments to the engine are simple, allowing quick engine changes. Jet engines lend themselves to submerged installations, but the problem of insulating structural elements from the high temperatures has created problems. There have been some aerodynamic refinements in the realm of high speed, with emphasis on airfoil design and attempts to develop smooth skin wings.



PRATT & WHITNEY WASP MAJOR TEST

LOCKHEED SHOOTING STAR REFUELING

The record flight of the Lockheed P-80 Shooting Star from Long Beach, Calif., to La Guardia Field, New York, early in 1946 illustrated the trend in high speed, and it was done with jet engines combined with modern design and a smooth skin wing. The distance of 2,470 miles was flown non-stop in 4 hours, 13 minutes and 26 seconds—584.82 miles an hour, clipping nearly an hour and a quarter from the previous record. The top speed during the flight was estimated by the pilot, Col. William M. Councill, at 660 miles an hour. Altitude during the flight was generally between 35,000 to 41,000 feet. A glass-smooth "piano" finish added greatly to the plane's overall speed and performance. To attain that surface, rivets were cut and surface ground. A zinc chromate primer was applied. All butt joints were cement filled, and flexible joints were covered with organdy mesh tape. A surface was applied in preparation for the paint, which was baked on in special ovens large enough to hold the entire plane. Light sanding and buffing followed. A specially developed wax was sprayed on and polished. Aerodynamicists are now talking of wings with thickness ratios as low as 75 per cent. Structural engineers wince at such a figure but may have to accept it and start a new trend in structural design. German data seized at the close of the war is being carefully scanned for new ideas, and some useful aerodynamic information has been gleaned. When finally corroborated by American tests this data may lead to new avenues of advance toward higher speeds.

No attempts to use rocket power for piloted aircraft have been announced although there is no reason why such designs could not be made. Indeed at least one rocket powered "flying mock-up" is known to have flown successfully. Perhaps the greatest accomplishment in the high speed field is the erasing of the imaginary line which many prominent engineers had drawn at the speed of sound. This line was supposed to represent the maximum speed attainable in aircraft, with a "practical" limit some 20 per cent lower. This practical limit has been exceeded by several airplane designs and it is now realized that it is quite within the realm of immediate possibility to design airplanes with existing powerplants capable of flights well into the supersonic range. An important German development was the use of sweepback in the wings to prevent compressibility effects on the wing.

The new transports coming out soon may obtain increased speed by the same general method used by military aircraft during the last five years, that is, by the following related steps: a. Lower horsepower loading (lbs. per h.p.), b. Higher wing loading, c. Greater weight carried in the fuselage, per square foot of cross section of fuselage area, obtained partly by wing sections and wing-tail relationships which permit greater center of gravity range fore and aft. The net result is much greater thrust per square foot of flat plate drag area.

INSTALLING NORTHROP RETRACTABLE AILERON

CONSOLIDATED VULTEE B-32 BOMBER
One of its major characteristics was the 32-ft. high tail.

Deserving special mention, insofar as its effect on increased speeds for new transport aircraft is concerned, is the elimination by the Civil Aeronautics Board of the 80 mile per hour stall speed limitation that up to the present time has been included as a requirement in the Civil Air Regulations, Part 04. This requirement in effect controlled the wing loading of commercial aircraft, which in turn is directly related to speed. Its elimination was one of the most significant developments during 1945 in the commercial airplane field.

The cruising range of transports and the amount of payload carried has steadily increased with each new, larger airplane model. Certain limitations, a combination of safety and structural, have played a basic part in the increases which have been attained and which are possible in the immediate future.

The payload of an airplane can be limited physically by available cabin space, and in the interest of safety, limited structurally by a maximum permissible take-off weight and a maximum permissible landing weight, the latter of which is usually less than that permitted for take-off because of higher structural loads being imposed as a result of landing acceleration and impact.

To illustrate the trend of design advancements as measured by larger, higher speed aircraft, several transport versions used by the Army Air Forces Air Transport Command are listed below for comparison. From the following chart, it is apparent that the newer, larger airplanes can operate at considerably greater distances and with much larger payloads than the prewar equipment.

Their efficiencies can best be observed through their load carrying rates or carrying power. Increases in carrying power are a result of the designer's success in creating aircraft with cargo-carrying capacities larger in proportion to the weight of the aircraft alone. The allowance of provisional maximum loads for take-off beyond those approved for landing, further increase the carrying power of the aircraft, but extend the distance at which maximum carrying power is attained. Accordingly, the carrying power for distances less than that at which the maximum is reached, is reduced, and the usable load increment thus involved either must be expendable (fuel) or go unused.

| *Aircraft* | *Max. Take-off Wt. (lbs.)* | *Max. Landing Wt. (lbs.)* | *Average Speed (m.p.h.)* | *Max. Range (Miles) (Wing Fuel Only)* | *Max. Carrying Power (Ton Miles per Hour)* | *Distance (At Which Max. C. P. Is Obtained) (Miles)* |
|---|---|---|---|---|---|---|
| C-47 (DC-3) | 29,000 | 26,000 | 198 | 1400 | 420 | 325 |
| C-87 (B-24) | 60,000 | 52,000 | 215 | 2800 | 1125 | 1225 |
| C-54 (DC-4) | 65,000 | 62,000 | 233 | 3000 | 1470 | 550 |
| C-69 (Constellation) | 86,250 | 75,000 | 280 | 3600 | 2100 | 1580 |

NOTE: Figures based upon same conditions for each case, i.e., same altitude, wind, percentage power and reserve fuel. C-54 and C-69 weights have since increased.

While a definite distance can be established, as indicated above, at which the carrying power of an aircraft is maximum, it has been found

U. S. Army photo

ROBOMBS LAUNCHED FROM PLANES

Showing a Flying Fortress with a robomb slung under each wing, ready for launching from any designated point in the air.

THE NAVY MARTIN MAULER

The new BTM torpedo-bomber produced for the U. S. Navy by The Glenn L. Martin Company

that there is considerable latitude in either direction from that point still allowing from 85 to 90 per cent of the maximum carrying power but at distances varying from one to several hundred miles. Thus it is apparent that payload is not seriously effected by trip length.

A further comparison on distance limits can be made between the prewar and present transports. The former have operated at distances at which payload was limited by take-off gross weight, whereas the latter will operate at distances at which payload is limited by cabin volume. This is the most significant difference between the old and new type of transports, and establishes how the planes can be operated most economically as well as the type of powerplant required for the greatest earning value. In the older airplanes, operated at longer ranges than for the newer models, long-range cruising, at low horsepower and low altitudes was the optimum type of operation for maximum payload. In the newer airplanes, which will be operated at distances in which payload is controlled by cabin volume, a constant cruising power equal to the maximum permissible for the engine used, at the highest possible altitude for the engine and airplane, will be the most economical.

There have been three important changes (during 1945) in the transport category airplane design requirements, Part 04 of the Civil Air Regulations, that will permit an increase in transport cruising range and payload capacity. These can be enumerated as follows: 1—Elimination by the Civil Aeronautics Board of the arbitrary 80 m.p.h. limitation on stall speed of transport aircraft (85 m.p.h. limitation for purely cargo aircraft also was removed). 2—Elimination of the arbitrary 115 per cent limitation on the amount by which the take-off weight of a transport aircraft can exceed the landing weight. (This was allowed only when provision was made to dump sufficient fuel in a specified time to bring the weight down to the landing weight.) 3—Revision of the maneuvering load factors required for design purposes.

With reference to item (1) above, the stall speed requirement elimination means that payload no longer will be restricted by landing weight due to high landing speeds. The recent activity of such manufacturers as Douglas and Lockheed in boosting the gross weight (and payload) of the DC-4 and Constellation is due directly to the stall speed elimination. Under the old rule, aircraft such as the Boeing C-97 and Consolidated Model 37 would have been worthless for commercial purposes. Empty, they landed at speeds approximately equal

BELL RADIO-CONTROLLED P-59

Planes in the radio remote control of aircraft project, developed by the Air Technical Service Command and Bell Aircraft Corporation, are pictured here. Both are jet-propelled P-59 Airacomets with the controlling flight station, also known as the "mother" ship, shown at the top, and the controlled or "robot" aircraft the lower plane.

THE GRUMMAN NAVY F7F TIGERCAT

to 80 m.p.h. Under the new rules they have great promise. Wing loadings for new transports will continue to increase. For a given cruising speed, the airplane with a low wing loading requires more engine power and therefore more fuel than one with a higher wing loading. This subtracts from the net useful load. It has been stated that wing loading and aircraft operating efficiency are synonymous. Wing loadings and efficiency no longer are hampered by the stall speed limitation.

With reference to item (2) above, the take-off weight of new transports will only be limited by structural strength considerations and not by an arbitrary 115 per cent in excess of landing-weight factor. This is tremendously important from a payload standpoint, which load can be increased to any amount, provided (a) structural strength is not exceeded (b), fuselage capacity or volume is sufficient and (c), provision for fuel dumping down to the landing weight, in case of emergency, is incorporated. (This assumes, of course, that the minimum performance and flight characteristic requirements are met.) This increase in load can be fuel to increase the range greatly, if so desired.

With reference to item (3) above, the increase in payload possible is not quite so direct as in items (1) and (2). The maneuvering design load factor, which was formerly calculated from an arbitrary formula involving weight and engine power, now has been changed to a flat 2.5 limit value. This is lower than the previous factors for airplanes below 50,000 pounds gross weight. In addition, however, a 40 feet per second gust factor has been imposed as a new requirement which covers the condition of an airplane encountering a gust while flying close to the stall speed. The net change is that high wing loaded airplanes of the future below 25,000 pounds gross weight will not be required to meet as high load factors as in the past. The difference in weight resulting can be put to fuel to increase range, or cargo to increase payload.

The costs of aircraft engineering and production form a subject in general so complex, and the influencing factors so nebulous, as to preclude the possibility of stating any hard and fast rules for determining comparable engineering and production costs of all aircraft. Attempts have been made by some companies to develop empirical cost formulae based on certain parameters, some even involving aerodynamic and performance factors. None, however, have seemed to replace the general rule (for production costs) of so many labor or man hours per pound of aircraft structural weight.

Structural weight, rather than empty weight, has become more or less standard usage in determining production costs of aircraft due to the established practice of manufacturers quoting prices to the Army


U. S. Army photo

THE TELEVISION-CONTROLLED BOMB

The Roc, developed by Douglas Aircraft and the Air Technical Service Command, AAF, was equipped with a television camera through which the bombardier could watch the target, and guide the bomb to it by moving the circumventing wing by radio control.

and Navy for airframe only, that is, with engines, equipment and instruments not included, since these items are Government furnished on military aircraft. There is no reason, however, why empty weight could not also be used as the basic parameter since the weight and cost of the engines, propellers, etc., remain an approximately constant percentage of the empty weight and completed aircraft cost respectively. Labor costs for installation of these items are relatively small.

Production cost of a model is normally determined by using the 100th airplane as an index figure. In other cases it is based on the middle airplane of a production contract; for example, the 150th airplane of a 300-plane contract. It has been found from experience that as the number of aircraft produced (of a particular model) is doubled, the cost per unit is reduced to 80 per cent. This is generally accepted, and is called the "eighty per cent curve."

Production costs of a typical military pursuit ship run about five labor hours per pound of structural weight, based on the 100th airplane. For commercial transports, the figure is about three and a half labor hours per pound. In dollars this would be $15/lb. for pursuit and $10/lb. for transport. Again it is emphasized that these values are dependent upon the number of aircraft produced. The differential in production cost for a pursuit and a transport airplane is due largely to two items: a—the difference in accessibility or room-to-work during fabrication; and b—the necessity for installing so many more gadgets, fittings, lines and armament on pursuit aircraft to accommodate military equipment, guns, and special controls.

Manufacturing costs are largely dependent upon the particular materials employed and the fabrication problems encountered. The advent of thin or low-drag airfoils for high-speed aircraft has increased construction time required due to less accessibility provided for the shop personnel to work. These low-drag wings also have added weight because the decrease in moment of cross-section inertia has required more material to carry the bending loads on the wing.

The change-over from 24ST aluminum alloy to the higher strength 75ST also has increased production costs. New tooling is required, forming and working processes must be revised and shop personnel retrained. For example, the dimpling and bending characteristics of 75ST and 24ST are vastly different and require different techniques. It is a painful and costly process to get into production with a new material.

The matter of integral wing tanks also has increased production costs because of their own unique problems. Care with which the installation must be made and joints sealed have increased the man hours. This also complicates the installation of control cables, hydraulic and electrical lines because they must be routed around the integral tanks in some fashion. Advanced radio equipment installations also have increased production time required because of the structure added as fittings and support, and the exactness with which the components and lines must be installed to eliminate or reduce the noise level. Companies are experiencing tremendous difficulties and time delays in tracking down troubles that sometimes are found to be caused by what previously had been considered insignificant factors; for example, wire lengths cut to precision measurements.

On the other side of the ledger, there are certain construction practices that tend to reduce the overall production time required to build an airplane. The trend toward use of constant cross sections, such as in the fuselage of the Consolidated Model 37 and the Boeing C-97, makes fewer part types due to interchangeability. Similar efforts are being made to reduce the number of left and right hand parts, which practice the Germans adopted early in the war to increase production. Also the increasing size of the various sections and compartments of the airplane makes for greater accessibility, thus facilitating construction.

With the emphasis that has been placed on roominess or accessibility, the question might arise as to why the production costs of large airplanes of a given type cost more per pound of weight than the smaller ones. The answer is simply in the quantity produced. The passenger capacity of a large transport, for example, means that there will be fewer purchased to handle a given volume of business. Furthermore the 80 per cent curve for production costs does not hold true when the quantity is increased, say, from three to six or from five to 10 airplanes. The larger the quantity the more accurate this "80 per cent rule" becomes. A comparison in production costs between the Douglas DC-3 and the Boeing 377 illustrates that point.

| *Type* | *Wt. Empty* | *Cost* | *Cost/lb.* |
|---|---|---|---|
| DC-3 | 16,600 lbs. | $ 125,000 | $ 7.5 |
| Boeing 377 | 65,000 lbs. | 1,250,000 | 19.2 |

A final factor that cannot be evaluated, but which has a great effect on production as well as engineering costs is the morale of the company personnel involved. Costs are proportional in some degree to the elapsed time spent in getting a new model into production. The importance of the personnel morale factor cannot be over-emphasized in this regard.

Engineering and development costs of new models are difficult of comparison because this work does not stop when the model is ready for production. Further, the cost is affected by the innovation of new or untried design features which might, in the end, cost millions of dollars but produce an unsatisfactory airplane. Such costs then become research costs although engineering in nature. One manufacturer spent $122,000,000 as of 1944 in developing two current bombers, one a heavy four-engine type and the other a superbomber. An-

McDONNELL NAVY 2-JET PHANTOM FIGHTER

other company, which specialized in fighter types, spent no less than $155,000,000 on development costs up through 1944. One famous fighter plane which was in action in Europe and the Pacific necessitated an expenditure of only 35,000 engineering man hours up to the prototype stage, but fifty-three times as many engineering man hours in later improvements and modifications.

In view of the high costs of engineering research and development, it is apparent that the Government must continue to appropriate ample funds for that work, if the United States is to keep abreast of other nations in the air. The Senate Military Affairs Committee which considered a national research program was given additional details about aircraft development costs from R. E. Gillmor, vice president of the Sperry Corporation, on behalf of the Aircraft Industries Association. He said in part: "There is a wide-spread impression that the chief effort and greatest cost in developing aircraft occur during the initial stages of product research leading to and including the design and construction of the first model usually called the prototype. Let us see if this is true. One of our companies spent a total of $1,777,311 and 526,000 engineering man hours to bring a fighter plane through the wind tunnel and prototype stages. But it expended more than three times this amount in money and man hours for production engineering to develop this model and incorporate improvements to meet maximum performance requirements.

"The preponderance of engineering time and money necessary to maintain the development of an airplane or engine after prototype is further illustrated by these examples: One Navy fighter plane cost 399,000 engineering man hours before prototype, and 2,698,000 engineering man hours afterwards. This particular airplane underwent 19,000 individual minor design improvements during its production and service life. One Navy scout plane cost 370,000 engineering man hours before prototype, and 800,000 engineering man hours after prototype. It took 315,000 man hours and 8,500 separate engineering drawings to place the first of a famous model of medium bomber into the air. Better than half-a-million man hours and 11,000 drawings were employed to keep this bomber superior to comparable enemy aircraft.

"Take another example. The NACA laminar-flow wing was announced at a time when one of the manufacturers was coming out with a new fighter plane. It was decided to incorporate the laminar-flow wing in this plane, and approximately 40,000 man hours of engineering efforts were expended by the aerodynamic and engineering departments to adapt this new airfoil to the design. The task of incorporating the airfoil constituted over 15 per cent of all of the engineering time expended on the new plane."

The following table showing the direct engineering hours of another member company on two planes, one of which first flew in 1939, the other in 1940, demonstrates conclusively that engineering development is a long continuing process:

*Total Direct Engineering Man Hours*

| *Year* | *Bomber* | *Fighter* |
|---|---|---|
| 1939 | 78,842 | ...... |
| 1940 | 329,415 | 131,562 |
| 1941 | 419,060 | 151,054 |
| 1942 | 695,488 | 465,436 |
| 1943 | 761,213 | 815,657 |
| 1944 | 200,321 | 775,574 |

In the changeover from production of military to civil aircraft, the all important questions of costs and methods stand foremost in the consideration of new design; this is further amplified by the highly competitive aircraft market and the airline operators insistence on the ease of aircraft operation and maintenance. The knowledge gained during the war emergency in the maintenance of military combat and transport aircraft will greatly influence the trends in the industry. The logistics of supply, a paramount factor in military aircraft operation, has a parallel in civil aircraft, particularly so with regard to airline maintenance. Likewise in the past the personal plane operator has experienced maintenance difficulties in procuring adequate spare parts locally; and the high costs of such parts, due to their design peculiarities, have applied to the many and varied models of each individual aircraft. The lack of interchangeability of similar parts is a cause for the high cost and inadequate stocking of maintenance spares.

One answer to the problem of cost reduction and ease of operation and maintenance of aircraft is standardization. By improving the design with an objective toward increasing the utility of components and individual parts, a net result in cost reduction and improvement in procurement follows. Increased utility of the part or component resulting in an increased demand creates a greater source of supply, thereby establishing a competitive spirit among the suppliers. This competition tends to improve the quality and reduce the cost of the part.

In the present trend in transport design, a direct application in improvement toward this end can be noted in the use of constant fuselage and wing sections. This application reduces the number of unlike members within the particular aircraft, resulting in simplification of tooling and manufacture. Considerable attention is being given to the elimination of the number of left hand and right hand parts, thereby increasing the interchangeability of parts and components. New development in welding and forging as applied to landing gear struts has reduced machining costs and weight, and has increased overall utility of the part. Consideration is being given to the standardization of wheels and tires on individual aircraft. Several new designs employ wheel and tires of the same size on the main landing and nose gear. The net result of the new design trends is reduction in the types and numbers of parts and components required for stocking as spares.

During the last year the National Aircraft Standards Committee has sponsored a number of projects which had as their objective the improvement of design and utility and the reduction in the cost of manufacture and maintenance of materials and parts. Notable among these is the light plane standardization program which has been established for the development of standards and interchangeable parts. The NASC is cognizant of the desires and needs of the personal plane operator.

The aim of the NASC in this respect is to further the standardization in construction and to increase the distribution and stocking of standard parts so that they are accessible to the light plane user. Since it is not economically possible for each airport to maintain stock of parts, it is proposed that the manufacturers maintain complete stocks on a regional basis.

The NASC has undertaken the standardization of ground servicing connections both on a national and international basis. This project is being carried on with the assistance of the government, industry, the airlines, parts manufacturers and other national and international agencies and professional standards societies.

A noteworthy achievement of the NASC is the recent release of the fourth edition of the catalog of Aluminum Alloy Extrusion Dies which was prepared and assembled by the project sponsor, The Glenn L. Martin Company. This edition of the catalog includes dimensional and die number information regarding a total of 10,621 dies. It represents a comprehensive and vigorous study of more than three years on the aluminum alloy extrusion study program. As a war emergency expedient, the various editions of the catalog served a tremendously valuable purpose in listing available extrusion dies and providing means for exercising control over the large number of dies developed during the war. It further served to assist in alleviating the critical shortages of extrusions which were threatening a breakdown in the aircraft production program. As to the future value of this catalog, there can be no question of the usefulness of the tabulated information which it contains. The progression of extrusion design in shape and detail characteristics will be of considerable assistance to the designer of new extrusions, as well as serving as a guide to all interested in the selection and use of extrusions.

The research developments that have occurred during the war years (reported elsewhere in this summary) will, in some cases, have application in the personal aircraft field. The result should be an increase in utility and performance and a decrease in cost of operation and maintenance. Aside from purely research developments, however, there were a number of important happenings that will effect personal aircraft.

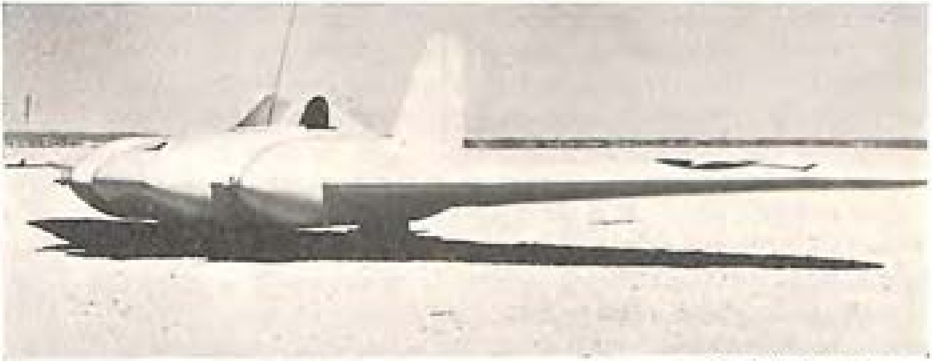
Up to the present time the design requirements specified in the Civil Air Regulations have encompassed both transport aircraft and personal aircraft in the same document. The manufacturers' Airworthiness Requirements Committee of the Aircraft Industries Association considered it urgent and essential that the design requirements for these two aircraft types be completely segregated and placed in individual documents. Unless this was done, the cost of personal aircraft would continually increase over a period of years as the design requirements for transport aircraft became more complex and rational. The ARC recommendation to the CAB and CAA was substantiated by these 13 reasons:

1—One book, or separate Parts, for each of the two categories would provide a more convenient reference source and less material to check to determine compliance with all provisions.

2—The basic philosophies governing the regulations for transport and personal aircraft are different; the regulations are intended to provide a greater degree of safety to public passengers than for the private operator who assumes some degree of personal responsibility.

3—Transport requirements will continue to become more rational and complex and the personal aircraft manufacturers feel that with the present arrangement in CAR 04, the complexity will be carried automatically over to the personal aircraft requirements. Example: Unsymmetrical flight loads and control surface loads (if rationalized for transport what happens to personal aircraft?)

4—Regulations in general are arrived at by a compromise of the various factors which are involved; these sometimes being contra-



U. S. Army photo

NORTHROP GLIDER BOMB

One of the radio-controlled guided missiles developed for the Army Air Forces.

dictory or conflicting in nature. Consideration of both transport and personal aircraft simultaneously for the sake of arriving at a general or common requirement usually increases the number of factors involved, makes a decision more difficult, and often results in one or the other category being penalized unjustly.

5—When changes to a common requirement are being considered, they must be reviewed in light of the effect upon both transport and personal airplanes. Although desirable for one category, the change may not be satisfactory for the other, thus causing complete rejection of the proposed revision.

6—Designations consisting of lettered paragraphs are now used to differentiate between categories and strength classes. However, when two paragraphs tend to read somewhat alike, a strong tendency exists, for purposes of simplification, to eliminate all differences and combine into a single requirement. This may not be in the best interests of both categories, transport and personal aircraft.

7—ARC activities also have illustrated the need for separation. Transport and personal aircraft subcommittees studying independently the same problem often arrive at very different conclusions, based on their group desires. In these cases, the separate transport and personal aircraft decisions are made without too much argument. However, these individual conclusions are rarely found acceptable to the other group, and when complete agreement is desired, it is found that some alternate solution usually must be adopted. Universal requirements are not always best suited for every type of aircraft. It is similar to the old saying, "Jack of all trades and master of none."

8—Structural requirements for transport and personal aircraft may not, at present, be too much different. However, there is recent evidence to indicate that the performance requirements for the two categories (as desired by the industry) are not similar in form or content.

9—The present trend seems to be to put material affecting design in the operating rule regulations. This is still another argument for assembling and segregating airworthiness design requirements pertaining to each airplane category. (At least cross referencing is desirable.)
10—Although CAR 04 now contains so-called common or general requirements, it is noted that CAB and Safety Regulation Releases are often issued as proposed modifications with a stipulation regarding applicability to only one category. This confuses the picture.
11—Manual material, interpreting regulations and presenting acceptable methods, soon will have to distinguish between very large airplanes (say 300,000 pounds gross weight) and personal aircraft (say 1,200 pounds gross weight). Items in certain computations that can be neglected in small airplanes may be very important for larger structures and the same methods or procedures may not apply.
12—When it is necessary to phrase requirements in such a manner that they are applicable to all types of aircraft, that is, non air carrier and air carrier, the wording is apt to become so general or vague that it is necessary to make constant interpretations and policy rulings in the administration of that requirement.
13—If it were not for the existence of the aircraft manufacturers, the airworthiness requirements would not exist. The manufacturers are the only group that works directly with the airworthiness requirements and for whom these requirements were specifically written. Under such circumstances it is extremely difficult for the manufacturers to understand or to recognize any argument that is presented in opposition to the unanimous recommendation of the industry for a complete separation of the transport and personal aircraft requirements.

The ARC recommendation was approved by the CAB with the result that the transport category requirements are contained in CAR 04, and the personal aircraft design requirements in CAR 03. These new and revised documents were issued in November, 1945.

Following another joint ARC-CAA recommendation, the Board established an aircraft category system which will increase greatly the utility of personal type aircraft. The basis of the previous maneuvering load factor requirements involved trying to guess the nature of operations for which a particular airplane of a given horsepower and gross weight would be used—obviously an impossible task. In view of the difficulty of anticipating the pilot's handling of the airplane, it was recommended that it appeared logical to set up a balance between operations and design requirements, i.e., to establish operational categories with a constant load factor for each class. Knowing the limitations of his airplane, it would be the operator's responsibility to insure that the operation limitations were not exceeded.

Under the new category system just established, an airplane can be certificated for one, two, or three classes of operation, i.e., normal, utility and acrobatic. Appropriately higher design strength factors are specified for these classes and operating limitations (that is, maneuvers permissible in each class) have been set up to guide the aircraft owner. Increase in aircraft utility is achieved by the category system. For example, assuming that a particular airplane has been certificated under all three categories, with an acrobatic permissible gross weight of 2,000 pounds, this same airplane could be used for training purposes (snap rolls not permitted) at a gross weight of 2,712 pounds, and for long-distance conservative flying operation at a gross weight of 3,157 pounds. If the airplane were characteristically incapable of spinning, the latter gross weight could be boosted to 3,430 pounds. Such a system provides the maximum utility for operation based on the structural strength inherent in the airplane. The category system also has the advantage of a—Conforming more closely with foreign practice, thus facilitating reciprocal agreements for export purposes. b—Permitting the owner to change engine power without requiring a reanalysis of the aircraft structure to be approved by the CAA. c—Permitting the manufacturer to design and build aircraft intended for special or unique operations and still obtain an NC certificate.

A further regulation change effected, at the recommendation of the ARC, was the increase in permissible stalling speed of from 65 m.p.h. (suggested by CAA) to 70 m.p.h. This represents a slight increase over the previously allowed 65 m.p.h. landing speed—this being discarded as a performance parameter due to extreme difficulty of consistent or accurate measurement. As a result, the wing loadings of new aircraft models can be increased slightly with a resultant increase in speed and range.

Probably the two most important factors that had in the past, and that will continue to have for some time in the future, an adverse effect on the utility of personal aircraft are (a) weather conditions and (b) airports. Until navigational aids and instruments have been perfected for the personal aircraft to permit reliable and safe operation in nearly all weather conditions, and at reasonable cost, the utility of private planes will be limited severely. Reports on developments along this line have been encouraging.

The new civil air regulations also are different in that emphasis has been placed on angle-of-climb rather than rate-of-climb, as was the case previously. A floor value of 300 fpm. has been retained, however, to overcome possible gusts and turbulent air conditions. The accident records indicated that too many personal aircraft pilots were trying to take off from very short fields, often resulting in collision with obstructions at the far end that could not be cleared. In such cases, the main criteria is a steep angle of climb and not a high rate of climb. Adoption by the Board of the ARC recommendation should do much to eliminate this type of accident that has occurred frequently in the past. The best angle of climb must not have greater than a 1 to 12 ratio and this angle, together with the corresponding indicated airspeed, will be checked by the CAA and made available to the private operator for his information.

Safety to the personal operator will be increased in the future as a result of new regulations which will insure that he is informed of the distances required, to take off and land with normal piloting technique and clearing the standard 50 foot obstacle. Manufacturers are planning to expand upon this in their airplane operation manuals by listing these two distances for various altitudes.

Safety will be further enhanced through adoption by the Board of ARC recommendations on more rigid stall and spin characteristic requirements. The manufacturers are designing new models that will not spin and that will have safer stall characteristics. Two-control aircraft or modified versions thereof are indicative of the general trend in design for personal aircraft.

Improvement in cockpit arrangement and location of controls in new models in conformance with conclusions reached by the National Research Council's crash injury project will result in less serious injuries to the aircraft occupants in the event of mishap. Some personal aircraft manufacturers are employing safety engineers whose duties it will be to investigate accidents involving the manufacturers' respective products for the purpose of recommending ways and means of eliminating accidents and reducing injuries when accidents do occur.

Design of simplified controls and ease of operation are receiving considerable attention by the manufacturers to reduce the possibility of "pilot error" when a critical situation arises during flight.

There have been no outstanding developments in the last year, either in costs of aircraft engine operation or in cost of fuels, that would provide a marked decrease in cost of personal plane operation. The gas turbine developments look promising, however, and should have direct application to the personal plane field—resulting in considerably reduced operating cost of future models.

If anything, the cost of maintenance for personal aircraft has increased during the war years, and it is still rising. Parts not only have been unavailable but such items as engine overhaul, repair work and incidental maintenance and storage costs have risen just like all other commodities. Increased cost of mechanic labor probably is the greatest contributing factor to this rise.

For purposes of mass production, many of the aircraft companies are constructing all metal airplanes. While metal is less subject to deterioration than fabric and wood, the problem of repair is considerably more costly for the former in the event of corrosion or damage from accidents. Equipment and facilities required for welding or riveting metal sheet and extrusions are far more extensive than the pot of glue and pair of scissors required for patching fabric covering. Wood repairs also are fairly simple and inexpensive. The most encouraging trend in lower cost of personal aircraft maintenance is the project established by the AIA National Aircraft Standards Committee to standardize on light plane parts and components. Such standardization will facilitate greatly parts stocking by dealers throughout the country and, by volume production and use, will decrease the cost of such parts to the personal aircraft operator. The NASC Light Plane Standards Subcommittee is making a complete analysis of the entire airplane to determine which items can be standardized on by the entire industry without adversely affecting design improvements or operating efficiency. Other organizations such as the Society of Automotive Engineers will play an important role in this work in cooperation with the NASC.

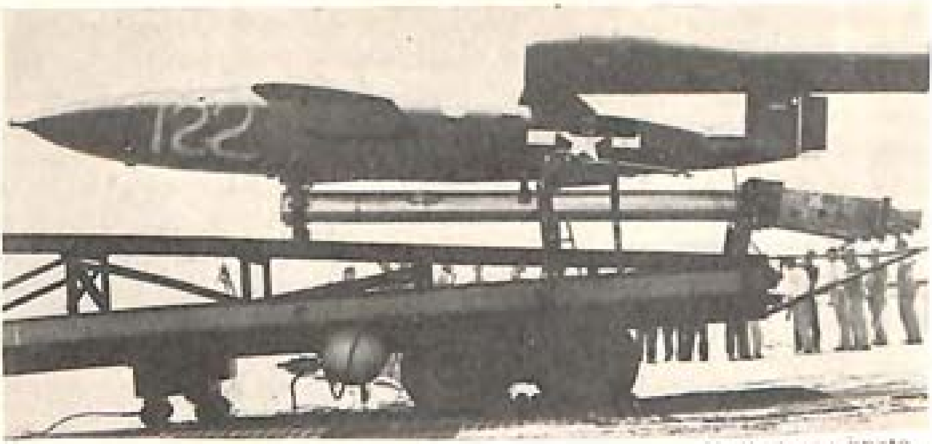
In the field of rotary wing aircraft, the helicopter has been subjected to intensive development work by Sikorsky, Bell, Kellett and G & A. Outstanding have been their practical demonstrations of usefulness—all tending to prove their efficiency and versatility in all kinds of weather and under the most adverse conditions. Their long record for rescues in the various combat zones during the war, as well as inland and offshore here in the United States, definitely established the place of these hovering aircraft in patrol, rescue and relief work. Crop dusting and spraying were among other activities in which they demonstrated especial efficiency. Sikorsky helicopters had combined records of more than 35,000 hours flying time. In January, 1946, a Sikorsky made a new altitude record of 21,000 feet and a speed of more than 115 miles an hour.

"Hoppicopter" was one of the new rotary wing devices, and the CAA granted it an experimental license NX31222. It is a one man flying machine wholly reminiscent of contrivances fashioned by enthusiasts centuries before the Wright brothers invented the first man-carrying flying machine, and suggesting, too, Buck Rogers and his flying belt; only this new idea involves a motor. The "hoppicopter" is strapped to the back of the pilot with harness resembling parachute harness. A metal tubing framework supports the two-cycle, two-cylinder, aircooled 20 h.p. engine that rests on the wearer's shoulders. The engine turns two counter-rotating two-bladed rotors, which have a total diameter of approximately 13 feet. The device is operated by a single control stick which is suspended, inverted, in front of the wearer-pilot. The throttle is operated by turning the end of the control stick. The device weighs about 100 pounds.

Of primary interest in the instrument field was the announcement by the Services of various types of radar and electronic equipment used by the air forces during the war. Such things as radar-equipped gun sighting and firing mechanisms, radar-controlled pilotless planes and many other similar developments were announced and gave some indication of the type of purely automatic devices which soon will guide our flying. The Army announced this year that the development of guided missiles and similar airborne weapons would be undertaken primarily by the aircraft manufacturers in conjunction with the Army and Navy air forces and the ordnance departments of both Services. At the same time the Services announced various types of weapons which had been developed and used to a limited extent during the war. These announcements gave promise of a number of commercial applications for mail and freight delivery for these pilotless weapons. With the advent of the jet engine, there was considerable hope for the use of compressed air for boundary layer control and wing de-icing in new aircraft designs. Progress on this equipment, however, has not gone beyond the stage of preliminary development at this time.

Developments in the field of electronics will have tremendous influence on commercial and private flying. Writing on aircraft electric systems in Western Flying magazine, Francis S. Nelson and G. C. Close made these comments: "Electronic applications in aircraft have developed in true perspective since the outbreak of World War II. Though the technical principles of many applications are still a military secret, enough has been revealed to indicate the important status that will be occupied by the vacuum tube in postwar commercial and private flying. To date, the greatest stress on electronic applications has been to increase safety during flight. A long step has been made in this direction. The increased safety so far achieved derives both from electronic navigational aids such as directional beam transmission and radar, and from safety devices such as electronic flame detectors and ice indicators. Electronic flight instruments have proved reliable and promise much in reducing flight hazards and eliminating errors in flight control. Another innovation indirectly contributing to safer flight is the development of electronically operated automatic flight controls. The gyro-pilot, turbo-supercharger control, propeller feathering mechanisms, control surface compensators and similar devices, not only assume a portion of pilot responsibility, thus allowing more time for concentration on other flight duties, but are instrumental in eliminating the ever-present danger of human error. Development of the rotary power amplifier with its ability to boost the output of an electronic amplifier to motor control proportions has stimulated the application of electronics to major control functions. Electronically controlled landing gear, cowl flap actuation and cabin pressure control installations have been tried and proved successful. The servo motor with its compact size and light weight, in conjunction with an electronic amplifier, offers almost unlimited possibilities in the field of electronic control."

Also of significance is the development of jet assisted take-off




U. S. Army photo

**THE AMERICAN BUZZ BOMB**

The JB-2 robomb and its cradle on a mobile launching ramp 49 feet long and pitched to six degrees.

units in which a number of rocket tubes are installed on conventional aircraft, both land and seaplane, to permit take-offs at greater capacity than heretofore have been possible. Improvements in this field point toward considerably higher pay loads for cargo aircraft.

An electronic control stick for heavy four-engine bombers, which moves like the stick control of a pursuit plane but by means of electronic amplification and the servo motors of control surfaces, has been announced by the Air Technical Service Command. It is described as a pistol-gripped lever, 10 inches long, mounted with an arm rest beside the pilot, and especially designed to diminish pilot fatigue on long missions. It makes possible the same results with a one-pound pull on the stick, which the pilot and co-pilot formerly had to obtain with one hundred pound force on both hand and foot controls.

An "engine performance indicator" has been developed by Consolidated Vultee research engineers which gives warning of impending engine trouble in multi-engine aircraft. This new type indicator, a rectangular metal box holding the instruments, is installed adjacent to the carburetor, and measures the distance right or left to which the engine is displaced when the propeller is rotating. If the engine is functioning normally, the instrument actuates a gauge in the pilot's compartment. This gauge shows, with great accuracy, how much horsepower the engine is putting out. If the engine begins to operate improperly, the gauge needle oscillates accordingly, and a warning light flashes on the pilot's instrument board, giving him time to cut the engine and feather the propeller.

A new type water injection pump to provide the extra push needed for fighters and bombers in take-off or combat emergencies has been announced. The pump is designed to operate completely submerged in a tank containing a mixture of water and alcohol, pumping the fluid in a vaporized condition to mix with gasoline in the combustion chamber to increase appreciably engine horsepower. The new design not only saves space but eliminates the necessity of extra fuel lines needed for the conventional type pump. A 27-volt explosion proof motor is geared to the pump mechanism. The complete unit weighs six pounds, four ounces, and has a capacity of 250 gallons an hour at a pressure range of 10-40 pounds per square inch. The unit may become standard equipment on virtually all aircraft using reciprocating engines in the future.

An electronic instrument that makes possible the increase of bomb carrying capacity by thousands of pounds and promises commercial possibilities has been developed. It weighs less than 16 pounds and is called the liquid level indicator. It is said to be accurate within five per cent under extreme conditions of temperature, altitude and plane attitude. This compares with at least 15 per cent error in most existing means of aircraft fuel measurement. With no moving parts, bellows, gears, cams or levers to get out of calibration, the liquid level indicator weighs slightly more than the present fuel measuring systems in general use and operates from an infinitesimal electric current passed through the gasoline tanks.

The next step in the Sperry A-12 gyropilot, after tying it into either a VHF or microwave radar set-up for automatic instrument approaches and blind landings, will be a tie-in with the aircraft's braking system to hold a straight track on the ground. Some airline engineers believe that this can be done even more effectively by tying-in with reverse thrust propellers.

A new type stall warning device which can be used either as an indicator alone, or in combination with a stall delaying mechanism is covered in two patents recently issued to the late Edmund T. Allen and Robert J. Minshall and assigned to the Boeing Aircraft Co. The device differs from other stall warning indicators in that it is actuated by "burbling" or a disturbance in the smooth airflow over the wing rather than by the attitude of the wing, differences in pressure, or airspeed; and its inventors claim that this not only permits it to indicate incipient stalls during steep banks and other abnormal conditions as well as during normal flight, but that in addition it can be located anywhere on the wings or tail surfaces to detect the stall at its starting point for each particular airplane. If there are several stall starting points for different flight conditions such as power on and power off, several indicators can be used, one at each of the critical points. The indicating mechanism itself consists of a flap which is held in close contact with the wing by the normal flow of air over the wing, but which pops up when the smooth normal airflow is interrupted and stalling airflow is initiated. The change in position in the tab closes an electrical circuit which in turn operates a light or some other

THE BELL HELICOPTER

It is being operated with hands off by Test Pilot Floyd W. Carlson.

indicating means in the cockpit and warns the pilot that a stall is imminent, permitting him to take corrective measures. In addition to activating the cockpit indicator, the same circuit can be used to open a slot or operate some other stall delaying means automatically to delay or counteract stall that is being approached too rapidly to be overcome by the pilot's normal controls. In general the new device would be located near the trailing edge, as stall conditions generally start at this point and work forward to the leading edge, at which point lift ceases, and the stall takes place. It can be used also to detect stalling conditions on the stabilizer and other surfaces as well as the wing.

Making an entirely new approach to the problems of aircraft brake design, Bendix engineers have developed a type of brake called a "segmented rotor brake" as distinguished from the shoe-and-drum type and from the usual multiple disc brake. The new brake offers improved performance with these additional advantages: compact construction permitting within-the-wheel application or with minimum extension beyond the wheel; lighter weight; adaptable to a broad range of capacities to meet the needs of all types and sizes of airplanes; the need of less hydraulic displacement and less contact pressure between the friction surfaces; simple adjustments made from the outside without removing the wheel, or the option of fully automatic adjustment to compensate for lining wear. It is pointed out that the construction of the Bendix segmented rotor brake is such as to provide the compactness and adaptability of the disc type with the added advantages of large heat absorption capacity, and heat dissipation from internal ventilation. The self-aligning, nonwarping characteristics of the segmented rotors, combined with the segmented friction lining surface, give maximum friction effects with minimum contact pressure. This in turn also reduces the hydraulic displacement and hydraulic pressure needed for brake application. A remarkable result reported is that water within the brake apparently has no adverse effect upon its operation; even the presence of oil or hydraulic fluid does not seriously impair its effectiveness or smoothness of operation. In a recent test on a Navy fighter, a total of 200 landings were made within 150 flying hours; during this time the brakes were adjusted only twice. In another instance, dual shoe-type brakes were removed from a bomber and a Bendix segmented rotor brake substituted. The new brake, which was of the two-rotor type, was placed entirely within the inboard end of the wheel, eliminating all outboard construction and at the same time saving 500 pounds in weight.

Reversed propeller pitch operation for retarding the airplane is a development arising from war experience. While reversing operation of propellers is not new, either as an idea or as an accomplished fact, it is relatively recently that operators have felt it to be desirable. As far back as 1935, Hamilton Standard satisfactorily developed and flew a reversing propeller. It was not carried into production, however, because a demand for this type of function did not crystallize. With the increases in airplane size that have occurred since, a definite problem has arisen in connection with brake capacity for ground braking. Airplane size has, at least temporarily, outrun airport size; and relatively large braking capacity is desirable. This increased braking capacity can be provided most efficiently by reversing operation of propellers. It also is desirable as a safety feature in the event that wheel brakes become ineffective. Another development, which received considerable attention in prewar years and apparently has been crystallized through wartime operational experience, is automatic propeller synchronization. Heretofore, operators, both military and civilian, have felt that automatic synchronization did not justify the weight and complication involved. Experience, particularly with four-engine aircraft, has demonstrated clearly the practical difficulty of achieving satisfactory propeller synchronization in order to alleviate nervous fatigue of both the crew and passengers resulting from the noise of unsynchronized propellers.

THE KELLETT XR-8 HELICOPTER

Still another new development of importance is a new type of hollow steel blade, designed to meet the increasing problem of propeller weight. Minimum weight always has been of major importance in connection with all elements of the airplane. Considerable attention has been devoted to the problem of reducing weights of the basic propeller, as well as other elements of installation, such as the synchronizer. The requirement for larger size propellers brought about by the development of larger airplanes, as well as the increases in engine power and operating altitudes, has served to emphasize this importance. Also new to the propeller field are recent developments in connection with control of propeller vibration, which indicate that further reductions in weight of solid aluminum alloy blades may be possible in the near future. Concentrated research and development on this subject has resulted in the practical application of vibration absorption devices to propellers. In considering these devices, engineers took into consideration the fact that the propeller blade, as a mass of shaped material, must withstand both the steady loads imposed by centrifugal force and vibratory loads resulting from vibration excitations. Any reduction in the vibration loads would make it possible to meet even higher steady loads. Should the steady loads retain their previous level, the decrease in vibration loads would make it possible to reduce the mass of the blade. Although engine manufacturers are devoting more and more attention to the suppression of vibration within the engine, and many of the latest designs are excellent in this respect, absorbers for the propeller are desirable to control residual engine vibration excitations as well as to control propeller vibrations arising from other sources, such as aerodynamic interferences. It is believed that the ensuing years will see a wider and wider application of vibration absorbers to propellers, and it is hoped that through this means it will be possible to achieve further weight reductions.

Low cost flight instruments within wallet range of all private flying enthusiasts are steadily becoming a reality. Most emphatic statement about lowering the price of instrument panel equipment, accountable for many dollars in the overall cost of a small plane, has come from General Motors, which promises a complete postwar instrument panel on a mass production basis for only $75. Panel equipment now ranges from $300 to $400 for a small private plane. One such cheap device, although new, is the "odometer" developed by General Motors to sell for $10 and to replace the conventional log book by automatically recording time flown in a given ship. The instrument already is being put to military use. Another stride toward economy in instruments is being made by Lear Avia of California Inc., where a gyro pilot is being tooled to sell for about $100. Weighing less than 25 pounds, the new pilot aid is said to be capable of performing all the duties of heavier, more expensive gyro pilots, and is powered by only 24 volts direct current. Space conservation also is highlighted in the development with only six inches being devoted to the control box base, fitting it for use in small planes as well as possible utilization in larger craft.

Radio devices which may do just about everything except mop a pilot's brow are promised the private owner as well as airlines. The CAA is experimenting with radar in an attempt to develop: 1—a screening instrument to permit an airport control operator to ascertain positions of all aircraft within a radius of 25 miles; 2—a collision warning indicator, mounted on the instrument panel, to show proximity of other aircraft. Another idea is to set up a coast-to-coast chain of transmitting stations of "microwaves," super high-frequencies used in radar. This would make possible automatic reports to pilots of their positions, and warning of approach to objects; and furnish airports with glass maps on which lights would indicate the position of every plane in their areas. Yes, this is a new day of miracles in aviation.

Radar was a major development of the war and one of the scientific miracles that brought victory to the allied nations. It had limitless peacetime applications; but it remained generally a military

THE SIKORSKY 4-PLACE S-51 HELICOPTER

secret until the defeat of Germany and Japan. Early in 1946, the Army and Navy Office of Scientific Research and Development released these facts about radar during the war: "No longer is man's vision limited by fog and darkness, by distance or clouds, for the radar beam can give a visual indication of objects within its range as it sweeps the sea and sky. Radar is an electronic invention. Its principles were known, but never used to any extent until the war. Then, the combined minds of the finest engineering talent available in government and industry produced a weapon that has received credit as one of the most decisive instruments to bring about victory for the United Nations.

"A radar system consists, in its basic form, of a transmitter, receiver and a common antenna. Pulsed radio energy, generated by the transmitter, is radiated by the antenna. In the space between pulses, the receiver is operating to detect any radio frequency energy returned as an echo by reflection from some object in the path of the radar beam. These radio echoes then are converted into a visual signal on the radar scope, giving a graphic presentation of range and bearing. This process is repeated continuously, so an image remains on the screen at all times that any object is within range of the radar beam.

"At first, the shortage of time and necessity for secrecy interfered with the free flow and exchange of information about radar. It is true that there was full and mutual exchange of research accomplishments between the British and the U. S. Governments, but it was mostly on the extreme top level of scientific research. The majority of the men working with radar were limited to specialized applications and often did not have any knowledge of radar developments outside their own fields. Interest in radio detection as a military device can be dated from communications experiments carried on by two civilian scientists working for the U. S. Navy, Dr. A. Hoyt Taylor and Leo C. Young. In the Autumn of 1922, they observed a distortion or 'phase shift' in received signals due to reflection from a small wooden steamer on the Potomac. The principle of pulse ranging was first used in 1925 by Dr. Gregory Breit and Dr. Merle A. Tuve of the Carnegie Institution for measuring the distance to the ionosphere, which is the radio reflecting layer near the top of the earth's atmosphere. In the Summer of 1930, Dr. Taylor and Mr. Young made the important observation that reflections of radio waves from an airplane could be detected. As a result, in November, 1930, the director of the Naval Research Laboratory submitted to the Navy Department a detailed report on radio-echo signals from moving

SIKORSKY ARMY R-5 HELICOPTER
Showing load test on January 10, 1946, when the R-5 lifted 18 persons.

objects. Subsequently Mr. Young proposed that an attempt be made to get the transmitter and receiver into the same ship. After much experimentation, a radar set, built at the Naval Research Laboratory and operating on a wave length of a meter and a half, was installed on the U.S.S. New York in December, 1938.

"The Army's first pulse radar was designed as a complete anti-aircraft detector system at the Signal Corps Laboratories early in 1936. A radically improved form of transmitter tube was developed later. A complete set demonstrated to the Secretary of War in November, 1939, showed a range of more than 100 miles against bombers.

"Working independently, the British had made a somewhat parallel investigation. At the end of 1934, the Air Ministry had been so impressed with the inadequacy of visual and acoustic means of detecting the approach of hostile aircraft that it set up committees for the scientific survey of air defense. In 1935, in the radio department of the British National Physical Laboratory there was conceived the idea that, because airplanes reflect enough energy to disturb radio reception, they might be detected and located by an improved apparatus of the kind built to receive radio echoes from the ionosphere. The demonstrations by the radio research staff held such obvious promise that in December, 1935, a decision was made by the Air Ministry to establish a chain of five stations on the east coast of England. This was the first operational radar system installed anywhere in the world.

"At the outbreak of war all vulnerable areas on the south and east coasts of Britain were covered. For effective defense, as the Battle of Britain proved, it was not enough merely to detect approaching aircraft and to know their distance. Efficient fighter interception demanded three-dimensional location of the enemy—distance plus direction and altitude—and an estimate of the numbers. Height-finding was developed about the same time as the bearing determination became possible, by the application of known optical laws. By comparing the strength of the received echo at two sets of aerials at different heights above the ground, it became possible to determine the height of aircraft.

"The first necessity after determining the position of an aircraft was to ascertain if it were hostile or friendly. It was obvious that airplanes would give the same kind of electrical response whatever their flag. Indeed, this was the problem—how to make friendly aircraft continuously exhibit a difference from others in their responses. A remarkable series of British devices culminated in one giving coded alterations of the returned echoes. These devices were known under the generic term IFF (identification, friend or foe).

"The large aerial system used for the British coastal chain could not be adapted for naval or aviation purposes. As early as 1935, it was clear that a device for fighter interception would have to be evolved, with aerials small enough to be housed in the thickness of the wing. Also it was apparent that for most naval purposes small aerial systems, capable of producing narrow beams, would be essential. Much intensive research was made into the use of shorter wavelengths. At 1.5 meters, conventional radio transmitting tubes were adequate to give the required pulse power, but no generator of waves much shorter was known which gave more than about one per cent of the power required. The problem of developing a generator of microwaves was given to a research group at the University of Birmingham, sponsored by the Admiralty. With the cooperation of British industry, that group developed a practical form of cavity magnetron. Electromagnetic waves no more than several centimeters in length were generated successfully, at a power of many kilowatts.

"During early 1943, the bulk of the German bombers came in very low, attempting to get under coverage of the long-wave radar on which the Allies were relying. Five new American-built microwave sets proved valuable in supplying coverage against such low planes. This was the first proof that microwave equipment had a place in air warning, supplementing the original British and Signal Corps long-wave radar, improved versions of which, however, played a part in safeguarding Okinawa.

"A set named ASV (air to surface vessel) which showed the presence of shipping was installed in RAF coastal command aircraft in 1939. This was actually the first instance of airborne radar being used in the war. By early 1941, the first microwave radar sets for interception were installed in night fighters. During January, only four German bombers fell to the British. The figure went up to 24 in March, 52 in April and 102 in May, 1941. Losses became so great that the Luftwaffe could no longer afford them. The night blitz was conquered. This was brought about in the main by combined methods of radar ground control and AI (air interception radar) in night fighters.

"A whole new technique of aircraft control was built up rapidly, named GCI—for ground controlled interception. A controller on the ground, watching the air situation on a special radar set, chose a specific German airplane as a target, gave detailed course instructions (termed 'vectors') to the fighter under his control, and skillfully maneuvered the fighter to a position one to three miles behind the target. When this had been done, the fighter was instructed to 'flash his weapon' and the AI radar in the plane took over.

"Searchlights no longer were essential for discovering the enemy, but in the Battle of Britain, and especially in the clear skies of the Middle East, they proved very helpful to the pursuing night fighter. Radar searchlight control (SLC or 'Elsie') put an end to inefficient searching of the skies. When the order 'Expose' was given and a great beam leaped across the night, it was on the target.

"One of radar's most uncanny developments—a gun which aimed itself and followed a moving target automatically and unerringly—in 1944 was the climax of the British Army's research into radar applications. In the United States by mid-1943, a radar was developed in conjunction with the new electronic anti-aircraft fire computer. These two devices, with the new power-driven and automatically controlled guns of the anti-aircraft artillery, gave the United States the most accurate and powerful local area defense against air attack that the world had ever seen. Artillery radar at the end of the war was so accurate that its error was less than the ballistic error of the guns. It meant that if the target was not hit 'blind' with the first shot, it was the gun itself, or its charge, which was not quite accurate—not the aim.

"The Navy at sea was working out doctrines for integrating these various types of radar for the defense of their task forces. The result of their work was the creation of CIC—combat information center. The purpose of CIC was to coordinate information—predominantly from radar, but also from lookouts, from other ships, and from technical devices other than radar—evaluate this information and determine what the enemy was doing. CIC grew and developed hand-in-hand with shipboard radar. In fact, it was originally called Radar Plot, its function being just that—to plot the movement of planes and ships tracked by radar, and to direct friendly fighter planes to an interception where enemy raids developed.

"Giving a clear picture of a whole convoy and its outlying escorts, radar was a tremendous help in station-keeping at night or in bad weather. As operating skill grew, and the sets were improved, not only could a clear picture of a convoy be obtained, but conning-towers and periscopes could be 'picked up' at great distances. Indeed, anything that was likely to 'get in the way'—a big piece of wreckage, a rock, another ship—showed up in good time.

"In 1943, several bombing aids were developed by the British from their ASV equipment, to meet the need for accurate bombing through clouds. The 'H2S' set was a startling device which enabled a navigator to see, on a cathode-ray tube screen, a picture in glowing green spots and shadows comparable to a map of the area over which he was flying. The signals shown on all other radar sets were just a distortion of a quivering line. 'H2S' showed at last a direct picture on the PPI, or 'plan position indicator.'

"In the United States by the summer of 1943, the first production of the Army LAB (low altitude bombsight) was coming off the line. LAB was designed as an attachment to radar on the one hand and to the Norden bombsight on the other. When used from low altitude against ship targets, it got one direct hit in three tries, even during the training of the first crews who got a chance to use it. The problem of high altitude bombing was something else again. The availability of the microwave frequencies suggested that a set like the British BTO, but with greater accuracy, could be built. The U. S. Radiation Laboratory, with a good deal of help from the Army and Navy, undertook to build sets in June, 1943. 'Mickey,' as the Eighth Air Force termed BTO, was in. A technique for coordinating the work of BTO operator and bombardier was worked out. The radar operator went on as if he were going to do the whole job, and the optical bombardier kept his sight lined up according to the radar sighting. It meant that, if the radar was right, the telescope of the Norden bombsight always was kept pointed at the aiming point which was down there below the clouds. The slightest break in the undercast which permitted the bombardier to see enabled him to take over the run and complete it optically. The system joined the best features of radar and visual bombing, and made the bombardier and radar operator a team, instead of competitors.

"Early in the war, the British developed a new type of navigation system which used radar pulses, but which did not use the pulse echoes. Each airplane was equipped with a special receiver which enabled the navigator to interpret signals sent out by a ground station. This was Gee-Radio, one of the most important of the new electronic devices. It made possible extremely accurate position fixes at ranges over 350 miles. Later in the war, a system developed by the Americans, named Loran, was put in use. Loran demonstrated vastly extended range.

"A number of systems were devised to make possible bombing through clouds by using pulse navigation. OBOE, developed in March, 1943, required ground operators to guide the aircraft and signal bombing. It was replaced by Gee-H, in which the navigator on board the airplane controlled the equipment and worked out the moment for bomb release. This in turn was supplanted by an American system called Shoran which had greater accuracy and easier operation.

"Radar altimeters existed before the war, but they reached their present high plane of performance in military service. Late radar altimeters indicated automatically the height above ground within 50 feet at altitudes as great as 30,000 feet.

"Another major radar development was 'Rebecca Eureka,' the radar device used by the airborne forces. 'Eureka' was the name given to small portable radar beacons or 'racons' which were dropped by parachute with the first wave. 'Rebecca' was a radar receiving set installed in gliders and troop-carriers which made it possible for subsequent waves to home directly to the drop zone."

Shortly before the end of the war the Civil Aeronautics Administration asked the Army and Navy to lend them whatever radar equipment they thought would be applicable to commercial aviation for the purpose of further development. The Services shipped to the CAA experimental station in Indianapolis, Ind., a sample of virtually every

G & A ARMY XR-9B HELICOPTER

piece of radar equipment they had, some 10 carloads of it, and the CAA began to work radar projects into its program. In this, as in most other activities at the experimental station, there was the handicap of budgetary requirements. Every major project had to be justified before the Bureau of the Budget, and planning must always be on the basis of the coming fiscal year. The delays occasioned by this inescapable routine affected progress in radar development. Early in 1946, there were not enough engineers at Indianapolis to continue radar projects already planned, and several pieces of important radar equipment were stored in the station's compound where they could be protected by the small staff of guards in accordance with the instructions of the Army and Navy that they be under guard at all times.

Three major radar projects were under way. One was a distance indicator which the CAA regarded as a most important development for commercial aviation. It would make it possible to revise considerably the system of fan markers in use along the airways, perhaps even to the extent of eliminating them entirely. The indicator worked on the familiar radar principle of an impulse sent out from one point which triggered a transmitter at another point. The transmission from the second point was received at the first, and the time required to complete the cycle was measured in terms of mileage separating the two points. Thus a plane would be equipped with a small radar transmitter, and it would actuate another transmitter at a ground station. The indication in the plane would be a simple dial marked off in miles, and the pilot would know his exact distance from the point contacted. A refinement of this method would make possible measurement of distance separation in yards, which would make the indicator valuable in instrument landing.

An equally important radar application, and perhaps the first one to be adopted commercially, was the scanning screen principle so widely used by the Services. This would be installed in the airport traffic control tower, and would be of great value to approach procedures, giving the controller actual vision of the planes which he had controlled previously only by voice. An experimental scanning screen was under order by the CAA. It was to be installed at Indianapolis for service tests as soon as it was delivered. The importance of this device was indicated by two demonstrations staged by the CAA. At Washington, five airplanes, manned by crews of varying skills, and each of a different type, were brought in to land under the existing low-frequency methods of traffic tower control. These planes were landed at five minute intervals. The demonstration later was repeated at Indianapolis, using the very high frequency communications system there and planes equipped with VHF receivers. On this occasion, planes were brought in at intervals of three minutes. Use of radar would simplify approach procedures, CAA officials believed, and in all probability would speed up the important job of getting planes on the ground safely in bad weather.

The third major radar development was a collision prevention device. This, officials believed, would require considerable development. The idea was to show on a radar screen in the airplane, the proximity of other airplanes in flight, or an obstruction ahead, such as a tower or mountain. The problem here was that the pilot would have to keep his eye on such a screen at all times during his flight. One solution would be to have an additional member of the crew constantly reading the screen and communicating with the pilot. This was the kind of adjustment of military procedure which the CAA experimental station had to work out in order to make military apparatus work in commercial aircraft. CAA engineers were at work constantly on those radar projects; but they had to confine their activities to projects which had been set up and for which specific funds had been appropriated. Meanwhile, other radar possibilities were shelved temporarily or ignored.

Loran, a new name coined from LOng RAnge Navigation, was one of the fantastic miracles performed by science during the war. It was a radio system developed in 1941-42 by a group of physicists at the National Defense Research Council's Radiation Laboratory at Massachusetts Institute of Technology, working under the direction of Dr. Lee A. DuBridge. Adopted at once by the Joint Chiefs of Staff, Loran grew under a blanket of military secrecy, until at the end of the war the Loran network covered over half of the earth's surface, mostly oceans, and was being expanded rapidly, particularly in the Pacific. Loran was wholly independent of celestial navigation. It first let ships and planes get through the prevailing bad weather on the North Atlantic route to the United Kingdom and to Russia. It created safe navigation for our AAF transports operating the Himalayan "Hump" route between India and China. It was set up in the Marianas where its accuracy permitted our bombers to cut down their reserve fuel and thereby carry more bombs in the knock-out campaign against Japan. It guided our military and naval transports across the oceans on the water and in the air, and was one of the chief agents responsible for the safety and on schedule performance of those long distance operations. Early in 1946, Loran was being developed for commercial use, and the Sperry Gyroscope Company installed Loran equipment on the Swedish liner Gripsholm. Our transatlantic aircraft were using it, one of the great heritages of the war.

The Loran system was ably described by Nathaniel F. Silsbee writing in Skyways magazine: "Loran stations transmit medium-frequency radio pulses from related pairs of ground stations known as 'master' and 'slave,' located mostly along coastlines and often in sets of three, one master working with each of two slaves. These stations are usually situated from 200 to 400 miles apart, with a maximum of eight ground-station pairs in one complete 'chain.' When these pulses are received they appear as sharp-pointed 'pips' on the cathode-ray screen of an airborne or shipborne Loran receiving set. The airborne receiver-indicator is known as AN/ANP-4 (AN indicates a major item of equipment assigned in the joint Army-Navy system of nomenclature; A applies to airborne equipment, P for radar and N for navigational); shipborne receivers are designated LRN, DAS, or DBE. The screen on which the pips show up resembles a radar 'A' scope, which has horizontal indication rather than the circular map-like indication of the PPI scope, a type from which most of the published scope photos have been taken (PPI stands for Plan Position Indicator). By measuring the time difference in microseconds between the reception of the pip from the master station and that from the slave station, the navigator can plot his line of position in relation to this pair of stations on a special Loran hyperbolic chart. However, in order to locate the exact position on this line, known navigationally as obtaining a 'fix,' another reading is taken from a second pair of stations whose hyperbolas cross those of the first pair—where the two lines cross is where you are. Thus the complete Loran system consists of three elements: (1) A series of radio transmitting stations based on prominent points of land along a coast, something like lighthouses, now covering most of the northern hemisphere. (2) The receiving and time-measuring radio equipment carried in aircraft or ship. (3) The Loran hyperbolic charts, now supplied to the tune of nearly a quarter million per month by the U. S. Navy Hydrographic Office, the AAF Aeronautical Chart Service, the British Air Ministry and Admiralty.

"With everything in order—ground and airborne equipment and charts—Loran is accurate within half a mile in favorable locations under good conditions. Under poor conditions in unfavorable locations errors may extend to 5 or 10 miles. This is fully as accurate as the difficult and complicated celestial navigation system. However, Loran is almost completely independent of the weather, working in rough sea or air, and under all conditions except nearby heavy lightning or severe precipitation static. Over water, standard Loran can obtain accurate fixes with direct radio waves at ranges up to 750 miles in the daytime, and up to at least 1,500 miles at night. By day standard Loran utilizes ground waves, that portion of the transmitted radio energy which parallels the surface of the earth. Another portion of the radio energy travels upward and outward, encounters electrified layers of the atmosphere known as the ionosphere, and is reflected back to the receiver near the earth. Pulses received in this way are called skywaves which increase night range to 1,500 statute miles. Before the close of the European war an improved type of Loran called SS (Skywave Synchronized) Loran had been demonstrated as the most accurate long-range navigational system in the world, with average errors no greater than a mile anywhere in the main coverage pattern. So accurate was SS Loran that from September 1944 night-flying Mosquitoes of the RAF Bomber Command used it almost every night on nuisance raids against Berlin and other objectives. Some 22,000 sorties were flown in all, and the average bombing accuracy was fully equal to that obtained by the use of radar Bombing Through Overcast equipment (BTO), popularly known to military airmen as Mickey, and technically as $H_2X$.

"The greatest usefulness of Loran is to aircraft on long flights over water because it is the only navigational aid which, under weather conditions which prevent celestial observations, assures sufficiently accurate navigation to bring the aircraft within range of local radio navigational aids at the destination. Homing by following a Loran line of position is a new method of readily and accurately reaching a desired destination. Every point in the area of a pair of Loran stations, including every spot along the coast, and every airfield, has a Loran hyperbolic line of position running through it. The particular line corresponding to any desired destination is determined from the Loran chart. The navigator simply has to get his aircraft to some point on that line of position, and then instructs the pilot to follow a course corresponding to the setting of that line. This is done by lining up the two pips (master and slave) on the scope. If the plane veers to the right, one pip will move one way, and if it veers to the left, the pip will move the other way. The method is accurate to within a few hundred yards.

"Another use for Loran which not only has great convenience but has added materially to navigational efficiency is in connection with search and patrol of designated areas. If Loran service is available throughout the area, there will be Loran lines of position crossing it. Search or patrol can then be conducted by entering a Loran line which most nearly forms one boundary of the area, at a point near the corner of the area. Then the line is followed to an adjacent corner by the simple method of Loran steering, keeping the pips constantly lined up. At this point the course is changed 90 degrees and followed to another Loran line parallel to the first and separated from it by a distance equal to the area-sweep spacing desired. The new line is then traversed by Loran steering, and so on until the whole area has been covered by the 'Loran lawn-mower.'

"It will thus be seen that the Loran system of navigation can do more than supply knowledge of position at a fixed point. It has two features which make it possible to use procedures which are not possible by previous navigational methods, and which are highly advantageous. It is something new under the sun to have an accurate knowledge of position available continuously—from minute-to-minute if desired. Previous methods have determined position accurately every few hours at best, using dead reckoning in between. The other feature is that position knowledge is available not in isolated points only but from lines of position which have definite unchanging location on the surface of the earth (and ocean), while the Loran receiving equipment, once set for a particular line and left untouched, shows instantly and constantly by visual inspection whether the ship is on the line, or to the right or left of it."

The Technical Service of the Aircraft Industries Association of America and the engineering committees under whose direction it operated, completed the most active period in its history, and as the industry adjusted itself from wartime to peacetime requirements, it was proposed that the Association continue to provide the services desired by its members to aid in their problems in the field of design requirements, specifications and standards. Although some shift in emphasis was anticipated between certain phases of the work, the only new activity would be that of the Research Planning Committee recently established by the Aircraft Technical Committee to coordinate the manufacturers' interests in the field of research and testing. It also was proposed to coordinate the technical interests of the four basic branches of the industry, aircraft, engine, propeller and accessories. Another desirable move was to have more direct industry participation in the standards program on utility parts, operated by the Army-Navy Aeronautical Board. Another was to urge the Government to develop international airworthiness standards by unifying existing national requirements, rather than through formal international technical agreements. The AIA also urged the Army and Navy to sponsor certain uncompleted research projects pending the creation of a national research foundation. At the same time it asked for greater industry participation in the work and policies of the National Advisory Committee for Aeronautics.

The Aeronautical Board of the Army and Navy complimented the National Aircraft Standards Committee of the Aircraft Industries

THE DOUGLAS C-74 MILITARY TRANSPORT

Showing the built-in cargo elevator. The plane carries 125 soldiers with full gear, or equivalent cargo load, including two jeeps.

THE BOEING C-97 TRANSPORT

This transport counterpart of the B-29 Superfortress had a length of 110 ft., 4 in. and wing spread of 141 ft., 3 in., its two decks capable of carrying more than 100 fully equipped troops.

Association, stating "the advances made in the airframe standardization program are due primarily to the unceasing efforts of the National Aircraft Standards Committee." After the war the NASC started a program to increase the quality and utility and reduce the cost of personal aircraft through standardization and simplification of component parts and processes, and early in 1946 this work embraced wheels, brakes, tires, axles, batteries, propeller attachments, instruments, radios and lights.

The Airworthiness Requirements Committee of the Aircraft Industries Association worked with the Civil Aeronautics Board on revised airplane design requirements which would influence all aviation activities. The ARC also had brought about investigations by industry experts into powerplant fire protection, oxygen requirements for passengers and high altitude pressure cabin design, all calculated to add to the safety and comfort of air travel.

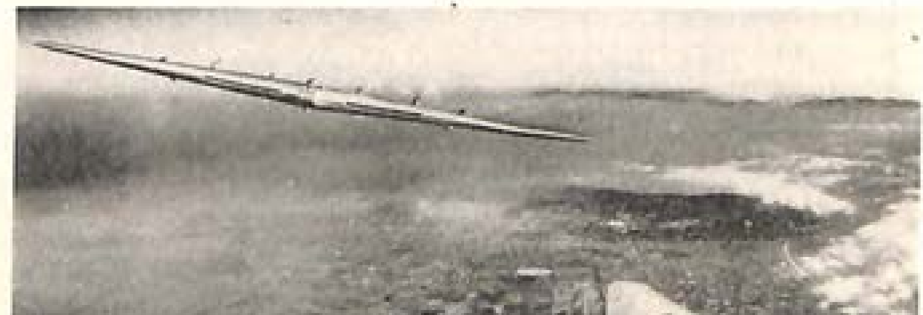
The AIA Engine Technical Committee developed and recommended a single set of Army-Navy procurement specifications for jet powerplants, and assisted the Services in revising standards on accessory drives and envelopes. Early in 1946, it was working with the Government agencies in research and development on aircraft engine fuels, engine maintenance tools and powerplant materials. The Propeller Technical Committee of the AIA worked with the Government on new airworthiness requirements.

The Manufacturers Aircraft Association, which had administered the cross-license agreement in the aircraft patents pool since 1917, reported that the equivalent of many years of research and technical development were represented by patents during the last year of war, when 182 patents were made available to the MAA for cross-licensing and licenses were issued to the entire manufacturing group under 191 patents. A total of 1,828 patented inventions had been brought under the cross-licensing agreement since 1917. The cross-licensing agreement served to prevent all litigation and other controversies throughout the aircraft manufacturing industry, thereby leaving the Government and industry free to use all inventions for the improvement of equipment both during the war and in the postwar years so important to the development of American air power.

The Society of Automotive Engineers had a Technical Board which was preparing an aeronautical drafting room manual, standards for helicopters, data on aircraft bearings and lubricants, the preservation and packaging of engines and parts, standardization of aircraft engine accessory mountings and drives, screw threads and fastenings, involute splines, small engine propeller shafts, standards on propeller clearance envelopes, governor mounting gaskets, control of two-speed gears, buttress threads, aircraft pumps, flexible hose assemblies and landing gear equipment, and adaptation to commercial needs of the technical data on cold starting of engines developed by the Services during the war. For the second time in its history the SAE Manly Memorial Medal and the SAE Wright Brothers Memorial Medal were awarded to the same recipient. He was Kenneth Campbell, of the Wright Aeronautical Corporation. The awards were for his technical paper "Engine Cooling Fan Theory and Practice," adjudged the best SAE paper of 1944. The Daniel Guggenheim Medal, awarded jointly by SAE, American Society of Mechanical Engineers and the Institute of the Aeronautical Sciences was presented to Lawrence D. Bell, president of Bell Aircraft Corporation for his achievements in designing and manufacturing military aircraft.

The Institute of the Aeronautical Sciences presented the Sylvanus Albert Reed Award to Prof. Charles S. Draper, Massachusetts Institute of Technology, "for application of the gyroscope to computing sights for gunnery and to other computing devices." The Lawrence Sperry Award went to Richard Hutton, chief development engineer of Grumman Aircraft Engineering Corporation, "for his outstanding contributions to the development of carrier-based aircraft." The Octave Chanute Award was presented to Robert T. Lamson and Elliot A. Merrill, test pilots in the engineering department of the Boeing Aircraft Company, "for obtaining at great personal hazard data contributing to the design of high-altitude military aircraft." The John Jeffries Award went to Commodore John C. Adams, Chief Flight Surgeon, Bureau of Medicine and Surgery, Navy Department, "for outstanding contributions to the advancement of aeronautics through medical research." The Robert M. Losey Award was presented to Major Harry Wexler, Chief of the Special Scientific Services Division of the U. S. Weather Bureau, "in recognition of outstanding contributions to the science of meteorology as applied to aeronautics." The Thurman H. Bane Award went to Capt. Myron Tribus, Headquarters Air Technical Service Command, Wright Field, "for reducing the icing hazards of high-speed flying through research and flight testing."

Gen. Carl Spaatz, who commanded the U. S. Strategic Air Forces in Europe during the campaign that led to the surrender of Germany, was awarded the Robert J. Collier Trophy by the National Aeronautic Association "for demonstrating the air power concept through employment of American aviation in the war against Germany."



ARTIST'S CONCEPTION OF NORTHROP XB-35 BOMBER

## CHAPTER III

### THE ARMY AIR FORCES IN WAR AND PEACE

The AAF Devastates Germany and Japan—Total Combat Sorties—More Than Two Million Tons of Bombs Hurled on the Enemy—The Size of the AAF Overseas—Enemy Losses Compared to Ours—AAF Casualties—Attrition of Aircraft—Gen. H. H. Arnold's Report and His Appeal for Preparedness—Report of Strategic Bombing Survey—AAF Tactics Justified—1946 Program for Guided Missiles.

THE U. S. Army Air Forces became the largest and most effective striking force the world has known. It knocked Germany into a mass of ruins, paralyzed and virtually helpless before the final onslaught of the invading armies, this of course with the help of allied air power. At the same time, the AAF made a shambles of Japan and whipped the Nipponese so decisively that invasion no longer was necessary. All this the AAF accomplished before it threw the atomic bombs into Hiroshima and Nagasaki. Japan was much easier for the air forces to destroy than was Germany. Comparative figures on air force operations show that the AAF had to put nearly three times the devastating pressure on Germany, besides the vast efforts of the British RAF and other allied air forces. While the complete statistics will be found in the section on Flying Facts and Figures, some of them can be used here to explain what the Army Air Forces accomplished during the war and what they can do to preserve the peace.

From Pearl Harbor to V-J Day, the AAF made a total of 2,362,800 combat sorties. A sortie is one flight by one plane. Against the Germans the AAF made 1,693,565 sorties, against Japan 669,235. Even in 1945, the AAF made 438,192 sorties against the Germans during the four months up to May 8 when Germany surrendered; and during nearly eight months up to August 14, the AAF made 247,573 sorties against Japan.

The AAF dropped a total of 2,057,244 tons of bombs during the war. Of that tonnage, 1,554,463 tons were hurled against the European enemies, and 502,781 tons against the Japs. The AAF alone dumped 641,201 tons of bombs inside Germany, 291,462 tons during the closing months of the war. The rest of the explosives, unfortunately, had to be thrown against the enemy in those countries we were liberating. France was the greatest sufferer. The AAF had to drop

339,651 tons of bombs against vital German installations in France.

The heavy bombers of the AAF dropped 1,096,794 tons of bombs against Germany from June, 1942, until the surrender. They put 315,307 tons into railway marshalling yards—138,522 tons in 1945—with results which are explained in the reports by Gen. H. H. Arnold, commanding the AAF, and the Strategic Bombing Survey later in this chapter. Oil installations were important to the Germans. The AAF knocked them out with 126,191 tons of bombs. Flying fields were wrecked by 117,727 tons of explosives. Aircraft factories received 58,763 tons of bombs. Railroads, roads and bridges were obliterated by 70,569 tons of bombs. Military installations got about the same tonnage, as did other German factories and plants. Our AAF heavy bombers dropped 57,106 tons of bombs in cooperating with the surface forces in their advance. Cities, towns, shipyards, submarine pens and various communications facilities received tens of thousands of tons of bombs from the AAF.

The AAF did most of the bombing against the Japs in their homeland, although the U. S. Navy contributed some mighty blows, and the British had a few contingents helping. The 21st Bomber Command of the 20th Air Force, AAF, from November, 1944, until the Japs surrendered, threw 104,930 tons of bombs into important cities in Japan, 66 of which were checked as to results. Some were wholly destroyed, including munitions plants. The average destruction was 43 per cent. The 21st Bomber Command made 16,112 sorties against the Japanese cities and lost 179 planes, but it destroyed that part of the enemy war effort. Tokyo was an example. The capital had an area of 111 square miles. The 21st Bomber Command made 2,531 sorties against Tokyo and dropped 14,054 tons of bombs. It lost 74 B-29 bombers, but destroyed 56.3 square miles or more than 50 per cent of the built-up area.

The 21st Bomber Command made 2,838 sorties against Japan's aircraft factories and dropped 14,152 tons of bombs. It lost 103 planes in these attacks but caused an average of 60 per cent destruction to 25 plants, with others hit but unidentified.

The world's first atomic bomb attack was made on Hiroshima, Japan, by the Army Air Forces on August 7, 1945. The crew of the Boeing B-29 which carried out the dangerous assignment included Col. P. W. Tibbets, Jr., pilot; Capt. R. A. Lewis, co-pilot; Major Thomas W. Ferebee, bombardier; Capt. T. J. Van Kirk, navigator; Lt. M. U. Jeppson, electronics officer; Lt. Jacob Beser, radar operator; Capt. W. S. Parsons, Navy technical adviser and observer; Sgt. R. R. Shumard, assistant gunner and assistant flight engineer; Sgt. W. E. Duzenbury, flight engineer; Sgt. G. R. Ceron, gunner; Sgt. J. A. Stiborik, radar operator; and Pfc. R. N. Nelson, radio operator.

Hiroshima was a city about the size of Seattle, Wash. The bomb caused 306,545 casualties, according to the results of a careful survey by the U. S. Army and other American experts after our occupation. The survey fixed the dead at 78,150, 9,428 seriously injured, 27,997 with minor injuries and the rest missing or suffering from loss of homes and food after the bombing. Fire and the panic created by crowds jamming the littered streets and small bridges probably caused most of the casualties. The one atomic bomb apparently had an effect similar to the normal load of explosives dropped by 200 B-29 bombers.

While the complete tables of bombs dropped, sorties, enemy plane losses, and our own losses, with casualties and other data are carried in the section Flying Facts and Figures, some of the figures are of interest here, because they show the gigantic task performed by the Army Air Forces.

During the war the AAF destroyed 40,259 enemy aircraft. It lost 22,948 planes on combat missions.


U. S. Army photo

ATOMIC BOMB RESULTS AT HIROSHIMA

AAF Air Intelligence photo surveying results of the first atomic bomb on Japan.

The AAF destroyed 29,916 enemy planes in the European war, and lost 18,418. In the European theater, the enemy lost 20,419 to our 11,687. In the Mediterranean theater, the enemy lost 9,497 to our 6,731.

The AAF destroyed 10,343 Japanese planes and lost 4,530 on combat missions against the Japs. The Far East Air Forces accounted for 6,298 Jap planes and lost 2,494. The China and India-Burma AAF got 1,913 Jap planes and lost 1,076. Our AAF assigned to the theater known as the Pacific Ocean Areas destroyed 794 Jap planes and lost 378. The AAF in the Alaskan theater of operations got 113 Jap planes and lost 88. The 20th Air Force, embracing the 20th and 21st Bomber Commands, destroyed 1,225 Jap planes and lost 494. Our victories and losses by type of plane and action will be found in the complete tables.

What did it take to do all this? How much of an Army air force did we require in order to help win two wars on opposite sides of the globe? It took too much. The record, as shown by the official statistics, proves that the effort was stupendous. At the peak of its war strength, in March, 1944, the Army Air Forces numbered 2,411,-294 personnel, including 306,889 officers. If the casualties that did not return to service were added to that number, the total personnel required in the AAF would be much higher. In April, 1945, the peak month, the AAF had a total of 1,224,006 personnel, including 163,-886 officers, in overseas service. In May, 1945, the AAF had its largest number of officers in the entire organization—388,295. One of the major accomplishments of the war was the training of all this personnel.

The AAF flight training courses graduated 1,561,288 between Pearl Harbor and the end of the war, some personnel graduating in several courses. The pilot courses graduated 768,991, including 233,-198 primary, 202,986 basic and 193,440 advanced. Transition courses graduated 108,337, and there were other miscellaneous graduates, including 1,282 women pilots. A total of 1,436,744 graduated in the AAF technical courses, including 125,984 officers who studied everything from administrative duties to cryptography, helicopter training and radar. There were 1,310,760 graduates among the enlisted personnel, including 695,866 trained in aircraft maintenance, 158,766 in armament and 222,223 in communications, besides many other air force activities. The training was the beginning of the great effort.

The AAF had at home and abroad a total of 159,677 pilots during the peak month of April, 1945, also 28,660 bombardiers, and during the peak month of February, 1945, 37,030 navigators. With many other specialists, they made up the total officer roles. In August, 1945, at the time of the surrender of Japan, there were in the AAF a total of 368,344 officers, including 142,246 pilots, 26,894 bombardiers and 31,972 navigators. The enlisted personnel totalled 1,884,-

838, including 317,949 airplane maintenance, 155,134 aerial gunners and 45,166 other aircrew personnel.

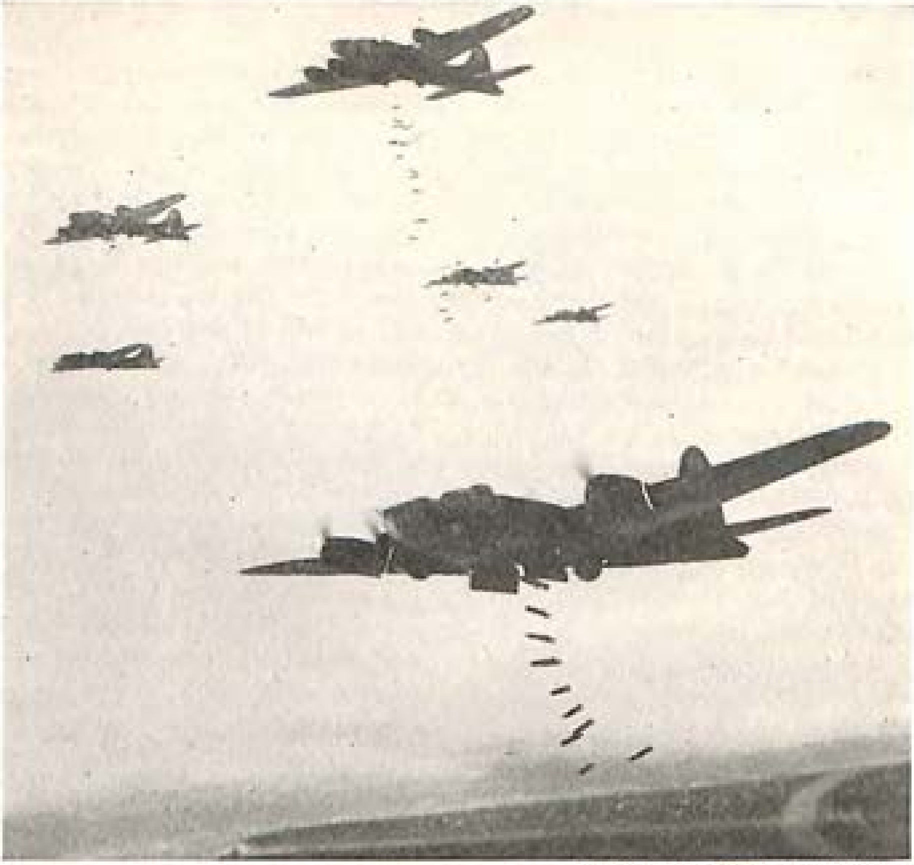
The AAF put in a total of 107,886,000 hours of flying time from January, 1943, to V-J Day. Of that total, 26,519,000 hours were flown in the overseas theaters, including 13,821,000 hours by combat planes, 5,652,000 hours by non-combat and 7,046,000 by the Air Transport Command. In the United States, AAF planes flew a total of 81,367,000 hours, including 23,132 hours by combat planes, 7,584,000 hours by transports, 49,060,000 hours by trainers, and 1,591,000 hours by communications planes. AAF combat planes overseas flew 1,037,000 hours in March, 1945, the peak month of the war.

The AAF suffered 121,867 battle casualties. Among the 40,061 who died, 17,021 were officers and 23,040 were enlisted men. Let this be an answer to the radicals who tried to stir up trouble in the Services after the war by asserting that the officers led a life of ease and relative safety. The total of 18,238 wounded and evacuated included 6,442 officers. The total of 63,568 missing, interned or captured included 26,952 officers. Heaviest AAF casualties were during the months before and after the invasion of Normandy in 1944, with 5,242 in March, 7,777 in April, 6,517 in May, 7,165 in June, 7,105 in July and 6,389 in August, after which they went down to four and five thousand monthly. Only in March, 1945, did they go up again, to 5,523.

The AAF acquired 158,880 aircraft between July, 1940, and August, 1945. Of that total 47,050 were fighters, of which 31,273 went overseas. The AAF had 16,799 fighters on hand at home and abroad at the end of the war. It received 3,740 very heavy bombers of the B-29 type, and 1,751 of them went overseas against Japan. On V-J Day, the AAF had 2,865 on hand at home and abroad. It received a total of 27,867 heavy bombers—Flying Fortresses and Liberators—and 18,774 were sent overseas. On V-J Day, the AAF had 11,065 on hand at home and abroad. It received 19,614 medium and light bombers, of which 8,982 went overseas. On V-J Day, the AAF had 8,463 on hand at home and abroad.

A total of 65,164 aircraft were lost by the AAF during the war—43,581 overseas and 21,583 at home. Of the 772 very heavy B-29 bombers lost, 512 were lost overseas and 260 in the United States. The loss of 14,280 heavy bombers was largely overseas, 12,291 against 1,989 in the United States. Of 8,479 medium and light bombers lost by the AAF, 5,225 were lost overseas and 3,254 in the United States. Of the 26,743 fighters lost, 19,964 were lost overseas and 6,779 at home. Other aircraft losses totalled 14,890, of which 5,589 were lost overseas and 9,301 at home. The last figure, of course, included planes lost during training operations.

While the statistical tables offer a most comprehensive record of the Army Air Forces throughout the war, enough has been chronicled



U. S. Army Air Forces photo

STRIKING AT GERMAN SUPPLIES

Our Eighth Air Force Fortresses dropping bombs on a target in Germany.

here to show that the war in the air was no holiday. History records no greater achievement by any military organization.

Gen. Arnold, pioneer Army pilot who commanded the AAF during the period of its great development and who led it to victory in his second war, retired early in 1946, after one of the most brilliant careers in the history of the armed forces. He was succeeded by Gen. Carl Spaatz who also had grown up with the AAF and who had commanded the strategic bombing forces against Germany until that war ended, when he took on the same job against Japan.

Shortly before he retired, Gen. Arnold presented a most comprehensive report on the AAF operations in the war and his recommendations as to what should be done in the future if the United States is to have a chance of survival in any future war. It follows:

"Although only six months have passed since V-E Day (the surrender of Germany, May 8, 1945) it already is possible to add a new perspective to our study of the European war. We can judge our achievements in the air and our shortcomings from the enemy's point of view. If anyone knows what allied air power has done to Germany, it is the Germans. During the war, our intelligence service possessed a great deal of information of this kind, but military security required that we keep our knowledge secret. We could make statements that we knew were true, but we could not reveal the source of the proof when the enemy denied or discounted our claims. Now we can make full use of this material, and of much more besides. This report will present the story of 1945 air operations in Europe—the final phase—both from our standpoint and, as revealed through documents and interrogation, the enemy's standpoint.

"The year 1945 opened at the climax of Rundstedt's Ardennes offensive. Eighth Air Force heavy bombers were flying the tenth straight day of a twelve-day offensive in atrocious flying weather to attack enemy strongpoints and supply lines. The Ardennes offensive had been outlined fully by Adolf Hitler at a melodramatic meeting of German Army Corps and Division Commanders in an underground room near Ziegenberg on December 12, 1944. If it failed, Hitler said, the war was lost; but, it would not fail. Everything had been scraped together for this effort. Manteuffel would take Antwerp; Dietrich would take Liége. Montgomery's 21st Army Group would be pocketed and destroyed, and the shocking loss would take Canada out of the war and utterly discourage America. The planes of a reborn Luftwaffe would clear the skies.

"Such was the plan, but our air attacks had made Rundstedt's supply problem a nightmare. Our strategic oil campaign had put motor fuel in critical shortage, and our bombing of railroads hindered deliveries of reserves intended for the push. 'We still had lots of materiel and sent it to the front in hundreds of trains,' Col. Gen. Alfred Jodl has said, 'but the trains got there only after weeks or not at all.'

"Preparations for the accompanying air offensive were creditable and on a large scale, but they were carried out amid conflict among high-ranking Luftwaffe officers. However, morale among German airmen at the time was good. They hoped that this would be Der Grosse Schlag—the big aerial blow that they had hoped for since the blitz of London that would inflict a crushing aerial defeat on the Allies, and enable the Luftwaffe to regain control of the sky. During November and December the Luftwaffe had been ready, waiting for the right weather on the right day. According to the plan, some 2,500 fighters would take the air, saturating the American fighter escort, and shooting down perhaps 500 of our bombers. But bad weather postponed the Nazi aerial offensive day after day. Weather that was fit for the AAF to make deep penetrations over enemy territory was not fit for large scale German defense of their homeland; because of the gasoline and oil shortage due to our bombing, German airmen had had to skimp navigational training. The Luftwaffe's 'Big Blow' did not come off.

"On New Year's Day, however, the German Air Force made a desperate effort. Risking their last reserves of fuel, Luftwaffe commanders flew 800 sorties, most of them at low level, against allied airfields. They struck hard, destroying, according to final figures, 127 allied aircraft on the ground, and damaging 133. But in return the Nazis lost to flak and fighters about 200 aircraft, which was more than they could stand. In addition to the failure of the Luftwaffe to furnish air cover, Nazi ground forces were having far more serious troubles—traceable to our air attacks. German armored units had been promised fuel for 500 kilometers for the offensive; they received less than half the allotment, which, in the mired winter roads and mountainous terrain, was sufficient for only 100 kilometer. The bombing of railheads near the front forced long hauls from points back along the Rhine, burning precious fuel and exposing trucks to fighter attack. Fuel dumps intended as reserves or earmarked for special attack were consumed in the initial push.

"Gen. Fritz Bayerlein, commander of the crack Panzer Lehr Division, said that during the retreat, 'Fuel was so desperately scarce that in realigning my division a regiment marched on foot through the snow from the extreme north to the extreme south end; there was no gasoline to be spared. Fuel had to be transported partly by daylight, and enemy fighters singled the tank trucks out. There were repeated air attacks on my forward tank repair shops, and bombing had made the main roads impassable through the retreat route at the Houffalize bottleneck, requiring the use of rough by-pass roads. Because of these factors I left 53 tanks by the roadside between January 11 and 15. Road discipline relaxed during bad weather. When the sun broke through on January 21 after several bad days, enemy planes caused fearful damage. As I approached the Gemuend bridge (southeast of Aachen) I saw planes circling in huge formations. I had to thread a way through wrecked and burning vehicles, dead horses, scattered equipment. It was a one-way bridge, and planes caught traffic on both sides. Several hundred vehicles were destroyed and the column thrown into panic. On January 27, 1945, I was finally behind the Siegfried Line. The Ardennes offensive had cost me 80 per cent of my combat troops, between 60 and 70 tanks, 200 motor vehicles, and 30 half-tracks.'

"As that battle marked the end of the Luftwaffe, this appears to be an appropriate place to review the factors that led to the collapse of a potentially mighty air power. Prior to the uncovering of many facts after V-E Day, it was popularly supposed that the Nazis were a ruthlessly efficient organization, with a system cleansed by purges, rallied by a deified leader, spoon-fed with propaganda, spied on by secret police, and forced by grim necessity to present a solid front to the enemy. Actually, policy, decisions and strategy of the highest importance were often dictated by personal ambition, Nazi party feuds and pressure politics. Germany began the war with a great numerical superiority in aircraft, and succeeded against little opposition. Consequently, the Germans delayed in making needed changes, and then made far too many. A substantial share of these changes was due to parts shortages caused by bombardment. For instance, after our attacks on plants producing ball bearings, the Daimler Benz 603 engine was modified for sleeve bearings, and was unreliable from then on—engine failures caused many accidents.

"Dr. Albert Speer, Reichminister for Armaments and War Production, said, 'We had blueprints every few months and then had to change or tear down the buildings. If a program lasted longer than three months it was a miracle. It was the fault of the Luftwaffe General Staff.' When Speer had taken over the industry in March, 1944, there had been 50 different types of fighters being produced. And even in the drastic emergency, faced with rebuilding and dispersing the shattered industry, he could not reduce the number of types below 38. Gen. Werner Kreipe, in command of all flying training, stated that Hitler, Goering and the General Staff never understood the significance of air power because of the ease of early German conquests. They did not, at any rate, analyze the combinations of power, and it was not until March 1, 1944, after our effective attacks on the fighter aircraft industry, that fighters were given priority over tanks, U-boats, flak guns, and V-weapons. Kreipe said that the Wehrmacht and Luftwaffe General Staffs became loaded down with party fanatics, whose belief that quick victory could be had on the ground thwarted a pre-war Luftwaffe plan for a strategic air force.

"In April, 1944, the High Command faced our bombing threat realistically and decided to go all-out for defensive fighter production. Gen. Adolf Galland, commanding the fighter arm, pushed a plan calling for an eventual production of 5,000 fighters a month to combat allied bombers and regain control of the air. He was opposed by Goering, who clung to the belief that Germany could have a great bomber force as well, despite inadequate manpower and training facilities, and a shortage of aviation fuel. The amended plan called for a reduced fighter figure and for bombers, a scheme which Galland termed 'entirely unrealistic.'

"However, if the plan was unrealistic, upon seeing it, Hitler projected it to fantasy. The ME-262 jet plane, Germany's great hope, and, we must state frankly, the greatest threat to our continued bomber operations, was then in production. Under no circumstances, Hitler declared, would the ME-262 be used as anything but a bomber. Messerschmitt had promised him that it would carry a 1,000 kilogram bomb. Actually, it never carried more than a 500-kilogram bomb, but the Nazis were obsessed with the idea of retaliation bombing at any cost. Hitler named the ME-262 the Blitzbomber, and vetoed the scheme of Goering and Galland to compromise by equipping it with a bomb rack and using it as a fighter-bomber. Hitler persisted in this amazing decision from April until October, a period which saw the invasion and the sweep across France. As a bomber, the ME-262 did nothing. The ME-262s which our airmen fought during that period were a few Galland had secured, despite Hitler's edict, for an 'experimental unit.' In October, when Hitler relented, only a handful were released to the fighter arm, and it was 1945 before the bomber idea was finally discarded. Speer estimated that he could have made from 30 to 50 per cent more fighter planes, but for our bombing.

"The Reich had a labor shortage despite millions of imported slave workers. The repair and reconstruction of bomb damage, defensive measures, and labor wastage in dispersing industry, digging underground factories, building railroads and power lines and living quarters at dispersal sites—every effort to combat or escape air attack drew upon manpower. Speer said between 250,000 and 300,000 men were employed in the removal of bomb damage in the chemical industry (including oil), and in all industry about one million men. This figure was for clearing away bomb damage, and did not include those engaged in reconstruction or in manufacturing materials for replacement. Bomb damage multiplied. The first attack on an oil plant was relatively easy to repair. Subsequent bombings compounded the damage; pipe joints sprang leaks far from any bomb strike, valves failed to work, linings fell out of furnaces, distillation units had to be overhauled. There was not enough manpower to go around. Even so, Speer was never able to stop the use of men and materials for expansion of basic production, which cost manpower and enormous amounts of critical materials for planned future schedules at the cost of armament production in existing plants. Despite military necessity, Germany was never able to allot more than approximately 60 per cent of its raw materials to armament production. The demand for consumer goods remained inordinately high because of air attacks.

"By February, 1945, Germany's transportation system was overstrained as the result of air attack. Every move of the dispersal program for industry put an added load on transportation. Machinery had to be shipped, building materials transported, plus everything required by the workers. When factories had been established, one part made here, another there, a third somewhere else, there was a constant shuttling of components before the final assembly was ready to ship. Gen. Jodl said, 'It was most annoying to have to route artillery from Essen to central Germany to equip and test fire, and then to ship it to an Army camp up front.'

"Putting factories underground in the effort to escape bombing created new problems. In June, 1944, the Junkers aircraft engine factory at Magdeburg had been moved because of air attack. The main body of the plant was put underground at the notorious Mittlewerk at Niedersachswerfen, near Nordhausen. The supercharger and small components section was put in a former chocolate factory at Hasserode. The injection pump section went to Lengefeld, while the propeller section went to Ebersbach. And these were temporary moves until a new underground installation near Woffleben was completed. At Mittlewerk, because of bad ventilation, workers had headaches. It was necessary to work three eight-hour shifts instead of two twelves, as formerly. Metal dust lay an inch thick on the floor of the polishing shop, and workers wore masks. Temperature had to be too cold for comfort, or the limestone roof would fall. Two roof falls killed several workers and injured others. Following these accidents the compressor rotor polishing shop was moved outside to a former flour mill. The local water was unfit to drink and a supply had to be hauled in. Sanitation problems were left unsolved; employees had to walk out the long tunnels to latrines at the foot of the hill outside. Food difficulties arose in the area from the influx of workers. Speer himself summed up the production end of dispersal underground, 'One cannot win aerial warfare through cement and tunnels.'

"The bombing of oil production had all but eliminated civilian trucking. The German armies had discontinued the use of trucks in large measure except on the battlefronts, and the air threat was such that they no longer kept big supply dumps near the front but required the railroads to bring supplies from the rear as needed. The industrial burden on the railroad system was graphically described by Franz Hayler, Secretary of State, Economic and Political Counselor to Field Marshal Kesselring, who said that in February, 1945, Germany's entire war production for a month and a half was loaded on railroad cars in transit—components going here, assemblies going there, raw materials somewhere else. The Germans had a large repair organization. They could run a line through a bombed marshaling yard, and get trains running, but that left the marshaling yard useless to do its job. Another switch yard, farther away, had to take its place.

"The bombing of railroads was cumulative in effect. By the summer of 1944 the Germans were unable to deliver stocks of coal to war factories in preparation for winter. Most coal came from the Ruhr, and normally much of it was shipped to Northern and Central Germany via the Dortmund-Ems and Mittelland canals during the summer (the canals were iced over in the winter). The RAF repeatedly had bombed strategic points on these canals, the Gland by-pass of the Dortmund-Ems, and the Gravenhorst embankment of the Mittelland, with the result that these important water routes were open to traffic scarcely a fortnight during six months. The railroads could not take the added burden. It was either more coal or less armaments. The Germans made a gamble. They did not ship coal in the summer to store for next winter's factories. Perhaps they saw the end, or perhaps they could do nothing about it. They did not store coal. Daily shipments of Ruhr coal by the end of 1944 had dropped from 14,000 tons to 6,000. In November, Speer had ordered stocks of coal on hand to be used up for armament manufacture, regardless of where the next lump was coming from. By February, 1945, the coal shortage was paralyzing the German armament industry. The Russian drive had cut off coal from Silesia, which had furnished more than half the coal to run the railroads. Germany depended on the harassed railway system to get coal from the Ruhr and Saar. In mid-winter the Reichsbahn was faced with getting and distributing coal for industry, totally reorganizing the complex system of shipment priorities, and redistributing locomotives and rolling stock. This in itself was a tremendous task.

"Such was the situation on February 22, 1945, when the allied Air Forces flew Operation Clarion. The target: German transportation. On the morning of February 22, 1945, more than 10,000 Allied planes were airborne from their bases in England, France, Holland, Belgium and Italy. The 200 individual targets covered an area of nearly a quarter of a million square miles. The object was to paralyze the Reichsbahn. Instead of bombing from 25,000 feet, the heavies were to glide over the targets as low as 5,000 feet. Instead of operating in huge formations, they were to break up over Germany into groups and squadrons, and fan out for the many targets, with and without fighter escort.

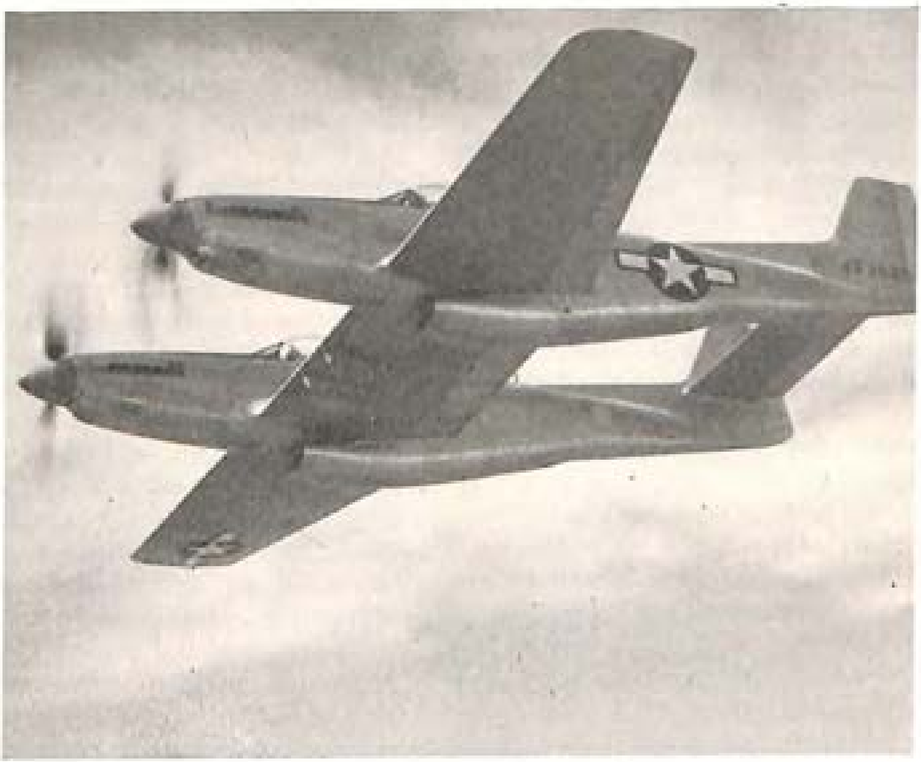
"The Luftwaffe was still potent, and our operations men paced the floor the night of the 21st. They studied the skies next morning, when the mission was airborne. Major Gen. Orvil Anderson, Eighth Air Force Chief of Operations, said, 'We could lose three hundred planes today, but we won't.' He gambled on the German inability to improvise quickly to meet a new situation. He said, 'By the time that Gauleiter gets through thumbing the pages of his manual, the boys will be coming home.' And, true enough, Operation Clarion was a 'milk run.' All over Germany bombs exploded on signal control points, marshaling yards, main lines, level crossings, embankments, bridges, viaducts, roundhouses, over-passes, small junctions. Fighters and fighter-bombers attacked rolling stock. Herr Dorpmuller's rail repair organization was swamped. Immediately, according to Gen. Buhl, war production was cut in half. Gen. Peters said traffic was reduced 90 per cent. Operation Clarion marked the end of large scale mobility for the German armies.

"Hitler's last chance to hold his Western front was the Ruhr, one of the world's great arsenals. The heart of the Ruhr consists of an industrial belt east of the Rhine running east and west, some 40 miles long and from 10 to 15 wide, lying mainly between the Ruhr river and the Rhine-Herne canal. The area is built up, and had a normal population of three and a quarter million. In the Ruhr were coal mines, steel plants, armament works, chemical plants, and many other industrial installations. Paced by the Ninth Air Force, allied air power began sealing off the Ruhr, as it had the Normandy battlefront in 1944. The Germans used all their ingenuity to keep traffic moving with armaments and supplies. The railroad repair system was highly organized, with concentrations of foreign labor and prisoners of war in reserve at likely points of attack to run lines through bombed marshaling yards, and throw up replacement bridges.

"In the Ruhr campaign, as in Operation Clarion, air power set out to swamp the repair facilities. In addition to the Dortmund-Ems and Mittelland canals, there were five main rail lines and a number of subsidiaries fanning out from the Ruhr. The plan called for isolating the Ruhr district and smashing the extensive transportation system within it. Air attacks began in late February on the bridges in a line from Bremen south to Marburg, thence southwest to Coblenz on the Rhine. This was called a line of interdiction; nothing was to cross that line if air power could prevent it. There were 16 bridges on this line of interdiction. In 40 attacks by 1,800 heavy and medium bombers, 14 were destroyed, or made impassable. Of the two still standing on March 24, bombs had cut approaching rail lines. The line of interdiction was maintained. Transport inside the line was hammered continually.

"Meanwhile allied ground forces made a splendid drive forward early in March. The Rhineland was lost to the Germans, along with the flower of three armies. An allied column thrust down the natural corridor from Euskirchen, broke the German 74th Corps, reached the Rhine at Remagen, and crossed to make a bridgehead. The Fifth Panzer Army was pocketed and cut to ribbons, and the German Seventh Army had collapsed in the southern Eifel. For the Germans, the war from here on was chaos.

"On March 1, 1945, an order had come that under no circumstances could any Nazi staff officer cross back over the Rhine. Two days later the order came to retreat across the Rhine. When the American ground forces gained the Remagen bridgehead, Gen. Model ordered Bayerlein to plan an attack to wipe it out. Next day Model rejected the plan. Two days later Field Marshal Kesselring arrived as Commander of the West, saw the plan, and was furious that it had not been carried out. In a rage, Model dressed Bayerlein down, and turned 1,500 reinforcement troops intended for Bayerlein to a commander of a Volksgrenadier Division named Tollsdorf, an incompetent whose 'Division' consisted of 200 men with practically no arms. Eight swimmers tried to go down river to bomb the bridge, and were never heard of again. Hitler ordered the bridgehead wiped out with V-2s. Nothing came of the order. Five officers were shot because of the Remagen affair, and a bridge complex swept over the officer corps, causing the blowing of many bridges without regard to



THE P-82 TWIN MUSTANG FIGHTER

Two powerful 2,200 h.p. engines pull North American Aviation's P-82 Twin Mustang into the air at a rate of more than 5,000 feet a minute. The plane will operate efficiently up to 45,000 feet.

military necessity. Because of the bombardment of railroads, tanks had to be driven from railheads far to the rear; of 42 new King Tigers sent to reinforce Bayerlein, 34 were worn out on the way and never reached him. The Eleventh Panzer left its entire supply column in a wood near Altenkirchen for want of gasoline.

"On the morning of March 24, the 21st Army Group, British and American, began crossing the Rhine north of the Ruhr river. At 10 o'clock, troops of the First Allied Airborne Army, carried in by heavily escorted aircraft and gliders of the U. S. 9th Troop Carrier Command and the RAF 38th and 46th Groups, began landing on the opposite side of the Rhine.

"In seventy-two hours preceding the airborne landing, AAF heavies and mediums flew 2,090 sorties in 56 attacks against small towns and villages in the area, which had been turned into strong points. More than 8,500 tons of bombs were dropped on communication centers. On March 21-22, some 1,200 Eighth Air Force heavies pounded 10 airfields in the area. Escorting fighters knocked 53 enemy fighters out of the sky and destroyed 116 on the ground.

Fighter-bombers and fighters of Second British Tactical Air Force and U. S. Nineteenth Tactical Air Command joined in the assault. On the day of the landing, allied aircraft flew more than 7,000 sorties over the battlefield and the area bounded by the line of interdiction stretching from Bremen to Coblenz. Ninth Air Force mediums and the Second British Tactical Air Force hit 23 flak positions. Fighter-bombers joined the task of silencing enemy flak before the airborne trains arrived. Throughout the day the air forces gave direct cooperation to the landing, hitting communication centers and defense points, gun and mortar sites, forward positions and strong points. Fighter-bombers flew armed reconnaissance against the enemy lines of communication. From Italy, the 15th Air Force sent 150 heavies escorted by five groups of fighters on a 1,500-mile round trip to Berlin. A tank factory was bombed, and this attack drew off enemy fighters in Central Germany which otherwise would have gone to the Rhine.

"Despite ground haze and smoke, all but two per cent of the paratroopers and three per cent of the gliders made successful landings, setting down 14,365 men, 109 tons of ammunition and explosives, 695 vehicles, 113 artillery weapons, 765 pieces of equipment and supplies. Eighth Air Force Liberators dropped 582 tons of supplies and equipment that day. The airborne landing was successful. Ground troops began closing a great pincer around the Ruhr and the German armies in it.

"The enemy counted on supplying himself within one of the world's greatest arsenals. Hopes were high at first among the 17 German divisions. There was food for a month and a half. Motor fuel would be available because of the many benzol producers in the Ruhr. Ammunition production could be continued and deliveries made on the spot.

"During the Ruhr campaign, the Luftwaffe was heard from once more. Goering had begun plans for this last try in March. In a special order of the day Luftwaffe pilots were asked to volunteer for a secret, dangerous duty. Some 300 were selected and sent to Stendal for a 10-day course in ramming training, most of which consisted of getting them into the right frame of mind by lectures, films and Nazi indoctrination. They were taught ramming technique—the technique of flying out of the sun on a line astern of the bombers, opening fire at extreme range, and holding it until the final sharp ramming dive aimed just forward of the bomber's tail. Unlike the Japs, the pilots were allowed to bail out if possible. Eighty pilots were equipped with FW-190s and sent to Prague to operate against the Fifteenth Army Air Force heavies. The remainder were given ME-109s and organized into a unit of four groups known as Sonderkommando Elbe and given such fancy names as Falken and Raubvogel, or birds of prey. On April 7, these groups were ready. At 9:30 a.m. they were alerted; our Eighth Air Force was forming. Thirteen hundred heavies and 850 fighters were in the air at 11:16 a.m. Sonderkommando Elbe rose to do and/or die. In their ears were dinned patriotic music and exhortations, and the pilots' radio transmitters had been removed from their planes so that they could not talk back.

"When it was over, 65 German planes had gone down before our fighters; the bombers' guns brought the total to 104, and there is no estimate of how many enemy planes were destroyed by our 22 bombers and three fighters which were lost. The final 'Big Blow' had failed. And we went on. In the two-weeks period of April 5-19, the Eighth and Ninth Air Forces almost annihilated the Luftwaffe, between them destroying 3,484 planes in the air and on the ground.

"As for the Ruhr pocket, it vanished in the 18 days from April 1-18. German commanders blamed the breakdown of distribution on our air attack. It was impossible to supply the ammunition factories or ship the finished product. An ammunition dump was useful only if a unit happened to be alongside it. The artillery regiment of the 59th Volksgrenadier Division had plenty of food, but there was no way of sending it to the infantry regiments of the same division, some of which had been without food four days upon surrender. Rear echelons were stripped of weapons. Even so, infantrymen of the 176th Volksgrenadier Division were captured unarmed. Tanks, being mobile, could get fuel and ammunition from the dumps, but they ran out of spare parts. Fighting units on the front had no fuel to send trucks back to the dumps. Dump staffs found their trucks overburdened with the necessity of constantly shifting location, and could spare few vehicles to deliver to the front. And as with tanks, there were no spare parts. Dump crews burned their gasoline, unable to evacuate it, while front line crews destroyed tanks and artillery because there was no fuel to move them. The air interdiction of the Ruhr was complete.

"On April 16, Gen. Carl A. Spaatz, Commanding the U. S. Strategic Air Forces in Europe, announced the end of the strategic air war as such. Our big job was done; there remained only the mopping up. The AAF's organization for these successive steps in aerial conquest of Germany had undergone many changes since the early days of August, 1942. For the final phase we were formed into a series of air armies working in close and constant cooperation, with flexibility of operations as the keynote. The U. S. Strategic Air Forces in Europe, under Gen. Spaatz, comprised not only the Eighth Air Force of Lt. Gen. James H. Doolittle, with three air divisions, but also the Mediterranean-based Fifteenth Air Force under Lt. Gen. Nathan F. Twining and the Twelfth Air Force, under the command of Major Gen. John K. Cannon. In addition to these powerful air forces was the tactical Ninth Air Force, under Lt. Gen. Hoyt S. Vandenberg, comprised of medium and attack bombers, fighters, and fighter-bombers. Directly under SHAEF was the First

Allied Airborne Army, commanded by Lt. Gen. Lewis H. Brereton.

"Although our air organization was adjusted to meet the needs of a changing strategic and tactical situation, we held steadfastly, despite early discouragement and temporary setbacks, to our over-all objective of fatally weakening from the air the enemy's will and ability to continue the war. We achieved that objective.

"This does not mean that we won the air war alone. We must never forget that the air war over Europe was a case of the closest joint effort with the RAF, from beginning to end. At times the AAF and the RAF employed different tactics and their secondary objectives differed, but at all times it was done with complete understanding of each other's capabilities and limitations. A case in point is the coordinated efforts of RAF night bombing and AAF daylight bombing of Nazi industry; each complemented the other. Another notable example of cooperation is the use of Soviet bases by the AAF for shuttle bombing. Under this arrangement, at a critical stage of the air war, Mediterranean-based and England-based heavies were able to extend their range greatly and to strike at vital industrial targets the Nazis believed they had placed beyond the reach of air attack.

"With the Normandy invasion, another partner, the ground forces, joined the all-out battle against Germany proper. Nazi war industry had been shattered by air attack, the Luftwaffe had been crippled, but there still remained huge and powerful Nazi ground armies to be crushed before final victory. The magnificent job done by allied ground forces is a matter of record. But again it was a case of cooperation, this time between allied ground and air forces. Strategic bombing continued as before, whereas tactical air operations shifted from the role of softening up for invasion to cooperation with the invasion forces in battle.

"The flexible organization of the AAF was suited to this dual role. Our based-in-Britain heavies could at a moment's notice turn from a strategic mission to such tactical roles as bridge destruction. When bases were gained in France, our medium and attack bombers, fighters and fighter-bombers became more deadly; and as airfields were secured closer and closer to Germany, and even within Germany itself, they could more and more effectively combine strategic strikes with their tactical operations. It was at this point, with distance no longer a factor in differentiating strategic from tactical operations, that the air war reached its ultimate objective.

"This objective reached, we could look back almost with amazement to those dozen Fortresses pioneering daylight strategic bombing on August 17, 1942, through the long uphill fight of 1943; the bombing of rubber production; the shock of losing 60 bombers in the attack on the Schweinfurt ball-bearing works; the fight against weather as the Luftwaffe grew in potency in 1943; the development of long-range fighters that could give us escort all the way; the fine days in February, 1944, which permitted our all-out offensive against the German air force; the assault on V-weapon sites months before the first buzz bomb hit London; the pounding of airfields and transportation along the 'invasion coast'; the opening of the, strategic oil campaign on April 5, 1944, from Italy and on April 11 from England; D-Day on June 6, the sealing off of the battlefield on the Seine-Loire triangle; carpet bombing for the breakthrough at St. Lo on July 25, the sweep across France, the Ardennes, the Rhineland; Operation Clarion; the Ruhr; and finally, Germany prostrate under nearly a million and a half tons of bombs. Our total aircraft losses on combat missions were 18,418; the enemy lost 32,921. Some 284,000 airborne troops had been transported by 9th Troop Carrier Command, 210,000 casualties from all services evacuated. Millions of propaganda leaflets had fluttered from the skies.

"We saw that mistakes had been made. Strategic bombing was a new military weapon, and we had had to learn many things as we went along, but we took pride in the job as a whole. Nazi ground commanders, Luftwaffe generals, manufacturers, politicians and transportation men saw our air domination as the root of their disaster, particularly the incessant bleeding of industry by strategic bombing, especially the oil campaign and the cumulative dislocation of transportation. And it was the air threat, according to Speer, the certainty that the bombers would keep coming, day after day, week after week, that brought the final collapse.

"An exhaustive and impartial study of the results of the allied bomber offensive on Germany was made during 1945 by the U. S. Strategic Bombing Survey, an organization working directly under the Secretary of War under a directive from the President, and under the chairmanship of Mr. Franklin D'Olier. Its interim reports were extremely valuable for use against Japan, and its final reports will be fully utilized in future AAF planning.

"The actual end of the war in Europe brought little elation to the fighting men. All romance and adventure had gone from war, even in the air. It was big business, a great and grinding effort day in and day out for millions. On V-E Day waste paper fluttered from Fifth Avenue windows and crowds milled in Piccadilly Circus; but for the fighting men, the airmen, mechanics, operations men, intelligence men and headquarters men, there was just the slow lifting of a pressure. The war did not end in Europe; it ran out. The Germans had been defeated for a long time. And, too, the war was still on. Europe was only a part of the great war, and the men in Europe turned to the Far East with little to say. They did not want to go, just as they had not wanted to come to Europe, but there was a job to be done and they would do it.

"Redeployment began. Some AAF units went direct to the Pacific, some were redeployed to the United States—the Zone of the Interior

—for training in B-29's. High point men were discharged. And then in the midst of the vast program, the Japanese surrendered. Schedules had been worked out, units were moving, some flying, some on ships, some at replacement depots. An entirely new program had to be devised for demobilization, and all schedules had to be revised.

"Remaining in Europe to guard the peace are light bombers, fighters, troop carriers, reconnaissance, night fighters, liaison squadrons and very heavy bombers. The Army Air Forces does not plan to retain in Europe such bombers as the Fortress and the Liberator which helped so very much to defeat Germany. Very important work remains to be done. Aside from redeployment, flying men home and ferrying them to Air Transport Command bases and the policing of Germany, there are still big jobs unfinished. One is the making of a large-scale photographic map of the conquered country, something sorely needed and partially obtained only with great difficulty during the war—a bird's-eye view of Germany, just in case. Another is the job of disarming the Luftwaffe—not only pulling its fangs but plucking its brains.

"Air disarmament includes seeking out and impounding Luftwaffe documents, locating its technicians, scientists and experimental specialists for interrogation, and securing the records of their work and experiments. There is matériel of vital interest for testing and development at Wright Field. Strange devices are being ferreted out, crated, and shipped for study—from blind landing equipment to infra-red meteorological instruments and range finders, from radar apparatus to crew chief stands, from jet engines to bomb sights, flak guns to airborne cannon, compasses and cameras to medical documents and automatic pilots. Whatever the Germans had of worth, we shall have. Whatever they hoped to develop, we shall know about. We want to make sure it is not being worked on under the guise of a peacetime product. Winning this war was a hard job. Air power intends to do its share toward keeping the peace.

"On August 14, 1945, Japan, still the military ruler of half a billion people and a land area of nearly 3,000,000 square miles, admitted complete defeat. This admission had been forced on her as the result of a vast and well-coordinated effort on the part of all arms of the United States services, the forces of our fighting Allies, and the enormous industrial resources of our country. It is the province of this report to sum up the part played by air power in the coordinated effort.

"Fully recognizing the indispensable contributions of other arms, I feel that air power's part may fairly be called decisive. The collapse of Japan has vindicated the whole strategic concept of the offensive phase of the Pacific war. Viewed broadly and simply, that strategy has been to advance air power, both land and carrier-based, to the point where the full fury of crushing air attack could be loosed on

Japan itself, with the possibility that such attack would bring about the defeat of Japan without invasion, and with the certainty that it would play a vital role in preparation for and cooperation with, an invasion. No invasion was necessary.

"The war fought against Japan fell into three general phases. First was a 'defensive' phase, from the attack on Pearl Harbor and other allied bases to the Battle of Midway. This was followed by the 'holding' phase, preventing the Japanese from extending their stolen empire until our men and materiel could be deployed over the wide expanse of the Pacific for offensive operations. As Germany came first on most priority lists, an immediate offensive was not possible. The third, or 'offensive' phase came during 1944 and 1945. Here we shall discuss our principal accomplishments in the Pacific from the close of 1944 to the Japanese surrender, with full recognition of what had gone on before to make those accomplishments possible.

"The harnessing of atomic energy and its application at the climax of the Pacific war have tended to overshadow a most important point. Even before one of our (Boeing) B-29's dropped its atomic bomb on Hiroshima, Japan's military situation was hopeless. Without attempting to minimize the appalling and far-reaching results of the atomic bomb, we have good reason to believe that its actual use provided a way out for the Japanese Government. The fact is that the Japanese could not have held out long, because they had lost control of their air. They could not offer effective opposition to our bombardment, and so could not prevent the destruction of their cities and industries. A modern industrial nation such as Japan would never have admitted defeat unless her industrial potential had been hopelessly weakened, the morale of her people seriously affected, and her isolation from the essentials necessary to wage war rendered virtually complete by blockade and the destruction of her Navy and merchant fleet. The fanatical Japanese would never have offered to accept the crushing terms of the Potsdam ultimatum merely because of the odds against them. The Japanese Army was still capable of inflicting heavy casualties on an invading force. The Kamikaze Suicide Corps had shown its capabilities in the Philippines and Okinawa campaigns and was preparing for an even greater effort against our invasion. Yet the Japanese acknowledged defeat because air attacks, both actual and potential, had made possible the destruction of their capability and will for further resistance. It should be emphasized that the many phases and separate operations of those sustained air attacks were closely and carefully related to each other and had as a primary objective the defeat of Japan without invasion.

"Let it be clearly understood that the blockade of Japan was by no means exclusively an air blockade. Since early in the war the Japanese merchant fleet had been a primary target of our sea, air and submarine forces. To the submarines goes the chief credit for reducing the Japanese merchant fleet to the point where, on V-J Day, that fleet consisted of about 300 ships—a little more than a million gross tons or 20 per cent of the shipping afloat when the war began. Nevertheless, aircraft sank over a million tons of shipping in 1944, and in spite of the dwindling number of targets, continued attrition at the 1944 rate until the end of the war. By the end of the war, the sea-air blockade was, to all intents and purposes, complete.

"Meanwhile, our B-29's were making Japan bleed internally. A necessarily candid report was given on September 4, 1945, by the then Premier Prince Naruhiko Higashi-Kuni to the Japanese Diet. 'The general conditions of the country,' he said, 'began to show marked signs of impoverishment and exhaustion . . . so much so that in the days just preceding the termination of the war it seemed almost impossible to carry on modern warfare further for any long period of time. The manufacture of modern war materials, principally aircraft, by mass production methods such as we had adopted before would shortly have to face insurmountable difficulties as a result of the destruction of transportation and communications fa-

THE BOEING B-29 SUPERFORTRESS

The long-range heavy bomber which made history by its raids on Japan. It was powered by four 2,200 h.p. Wright Cyclone engines.

cilities caused by air raids . . . Our losses in naval and aerial strength were so enormous as to obstruct seriously the prosecution of the war . . . Moreover, various industries suffered directly from air raids which caused huge damages to plants and lowered the efficiency of the workmen . . . Frequent air raids together with depreciation of rolling stock and equipment brought about a steady lowering of its capacity and a tendency to lose unified control. Despite the exertion of all possible efforts the carrying capacity of railways . . . would have to be reduced . . . to less than one half as compared with last year.' Experts now on the scene confirm this summary. What were in some circles regarded as over-optimistic claims of the damage we were doing have turned out to be conservative.

"By the end of 1944, our Twentieth Air Force had only begun its assaults on the sources of Japanese industrial, economic, and political strength. In 1944 not more than 100 bombers attacked Japan in a single operation. In early August, 1945, 801 Superfortresses attacked in a single night's operation. This increase in the numbers of bombers is not the whole story. Bomb load per aircraft increased from 2.6 tons in November, 1944, to 7.4 tons in July, 1945. During the entire period of operations the XXI Bomber Command flew nearly 90,000,000 miles to and from the Japanese mainland, with an accident loss rate of slightly more than one aircraft for every 1,000,000 miles flown. The percentage of airborne aircraft lost on bombing missions dropped from a high of 5.7 per cent in January to 0.4 per cent in July. The B-29 airmen became steadily more independent of weather or natural vision, more a day-or-night air force, until in July, the record month of B-29 effort, more than 75 per cent of all bomb releases were by radar.

"In March, Major Gen. Curtis LeMay, then commanding the XXI Bomber Command, made one of the important decisions of the war —to attack Tokyo with incendiaries at low level at night with his full force. In no previous operation, night or day, had our B-29s bombed from altitudes of less than 24,000 feet; but on the night of March 9, Tokyo was attacked by 279 B-29s at a mean bombing altitude of 7,050 feet. The Japanese defenses were confused, and only 14 B-29s were lost to all causes. Some 15.8 square miles of the heart of Tokyo were burned out in what was, prior to the use of the atomic bomb, the most destructive air attack in history. The Tokyo attack was followed by devastating night incendiary attacks on Nagoya, Kobe and Osaka in quick succession, and thereafter the air campaign to destroy urban industrial areas vital to Japan's ability to carry on the war continued by night and by day until the day of capitulation.

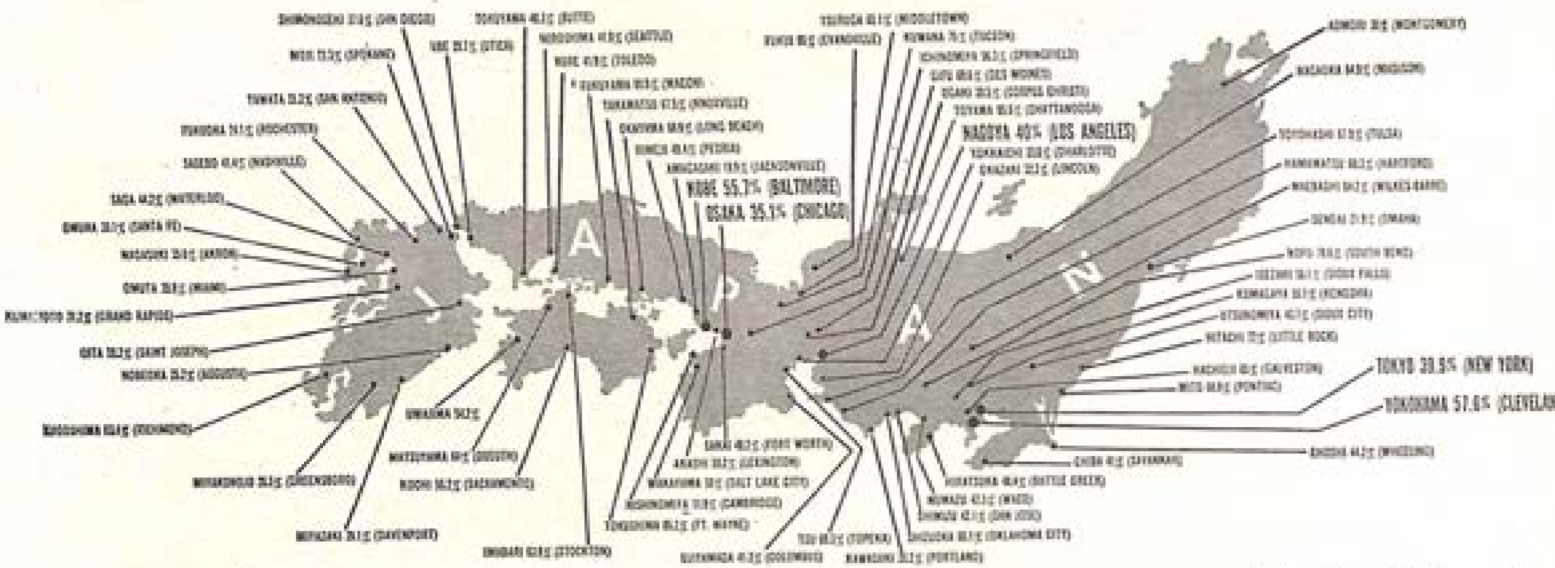
"In all incendiary attacks over 100,000 tons of bombs were dropped in the course of more than 15,000 sorties, against 66 Japanese cities ranging in population from Tokyo, with its teeming millions to the fish-processing city of Tsuruga, with a population of 31,000.

Nearly 169 square miles were destroyed or damaged in the 60 cities for which photographic reconnaissance is available, with more than 100 square miles burned out in the five major cities attacked. The destruction, including that caused by the two atomic bombs, amounts to over 42 per cent of the urban industrial areas involved. The 68 Japanese cities attacked with incendiaries and atomic bombs had in 1940 a total population of over 21,000,000—almost exactly equal to our 12 largest American cities. We can imagine the effect on our capacity to continue the war if the tables had been turned, and Japanese airmen had destroyed nearly half of any group of our industrial cities having a population of 21,000,000.

"Premier Prince Naruhiko Hagashi-Kuni admitted that by June, 1945, when all of the major cities of Japan had been attacked with incendiaries, Japan's ability to carry on modern warfare was 'disastrously undermined,' and that the destruction of the medium and small cities in rapid succession thereafter had 'calamitous consequences.' In addition to the destruction of industrial installations, the casualties caused had significant effects in the dislocation of industrial manpower and on enemy morale. The Japanese have stated that air attacks killed 260,000, injured 412,000, left 9,200,000 homeless, and demolished or burned down 2,210,000 houses. Never in the history of aerial warfare has such destruction been achieved at such moderate cost. The combat efficiency of the B-29s was such that we were able to reduce Japan more economically than Germany. We needed fewer bases than had been required by us in Europe. In all the attacks on urban industrial areas, the loss ratio, due to all causes, was only 1.22 per cent of attacking aircraft. In the group of cities under 100,000, three and one-half square miles of urban industrial area were destroyed for each B-29 lost to any cause. The smaller cities were, generally speaking, attacked during the months of July and August, and the low loss ratio reflects the steadily increasing operational efficiency of the B-29s, the decline in scale of attacks and aggressiveness of the Japanese Air Force, and the total ineffectiveness of the anti-aircraft defenses of the smaller cities.

"In the last months of the Pacific war we had, as previously stated, the benefit of interim reports of the U. S. Strategic Bombing Survey, which had been evaluating damage in Europe. Survey teams including specially qualified men visited the bombed targets, studied the damage on the ground, interviewed German personnel, and examined German records. Their findings supported the value of attacks on the enemy's key industries.

"In the Japanese aircraft industry total serious damage amounted to 30.6 per cent of the estimated 89,500,000 square feet of plant area devoted to that industry. It has been estimated that the combination of attacks on the aircraft industry and on urban industrial areas denied to the Japanese some 7,200 combat airplanes which, in the absence of




U. S. Army Air Forces Map

THE STRATEGIC BOMBING OF JAPAN

This map was used by Gen. H. H. Arnold, commanding the U. S. Army Air Forces, in his final report to show how our AAF bombers covered Japanese centers and what per cent of each city was destroyed. The size and importance of the cities is shown by comparable American cities.

bombing, would have been produced by August, 1945. The attacks on urban industrial areas were responsible for substantial losses, especially because of the destruction of propeller plants. The two most important plants, which together were responsible for 70 per cent of the output of propellers for combat aircraft, were rendered useless. It is thought that the damage to the propeller plants alone without further attack on the aircraft industry would have reduced Japanese airplane production by November, 1945, to a rate equivalent to 41 per cent of January, 1945, production.

"Prior to the cessation of hostilities, Japanese home islands rates of production of petroleum products had been reduced to 65 per cent of requirements at the July, 1945, monthly rate of consumption. The synthetic oil industry was a material sufferer—it has been estimated that air attacks in 1945 against synthetic oil plants cost Japan thousands of barrels of petroleum products. By the end of hostilities, air attack had at least temporarily put out of operation 100 per cent of Japan's high grade lubricating oil capacity. Tetraethyl lead production was down to 28 per cent of capacity. While the Japanese had a considerable surplus of refining capacity at the end of the war, B-29 attacks during 1945 against 11 of the largest and most modern refineries in the Home Islands had, nevertheless, rendered these refineries useless. Likewise, although Japan's inability to ship oil from the southern areas had led her to develop a large excess oil storage capacity, that capacity had been reduced by nearly 6,000,000 barrels by air attack.

"There were other important phases of the integrated over-all plan of air warfare. For instance, the story of B-29 mining operations and the part these operations played in the blockade of the Home Islands has for security reasons never been fully told. This was the first use of aerial mines as a truly strategic weapon. Concerning the B-29 mining operations, Adm. Nimitz cabled Gen. LeMay, 'The planning, operational and technical operation of aircraft mining on a scale never before attained has accomplished phenomenal results . . .'

"By combining the four basic types of influence mines, each with a wide range of adjustments, 200 different mines could be produced, each tailored for a special job. The mining program was divided into five major phases. The first phase, started on March 27, 1945, involved mining the vital but narrow Shimonoseki Straits between Honshu and Kyushu, and certain naval bases out of which Japanese naval units were likely to steam to the defense of Okinawa. In the second phase, B-29's ranged from Shimonoseki Straits to Tokyo Bay, the plan being to interdict the shipping lanes between the great industrial cities, which depended on water transportation for 75 per cent of their requirements. In the third phase, attention was turned to the secondary ports along the western and northern coasts of Honshu, on which Japan was becoming more and more dependent for any commerce from Manchuria and Korea across the Sea of Japan. The fourth phase involved intensified mining of the ports of northern and western Honshu and Kyushu, Kobé and Osaka. In phase five, every port of consequence used by the Japanese on the southern and eastern coasts of Korea was mined, and re-mining of other ports was continued. Mining the port of Rashin, Korea, only 125 miles from Vladivostok, involved a round trip of 4,160 miles, using Iwo Jima for staging purposes. Throughout the mining campaign, nearly half the mines dropped were reserved for Japan's shipping bottleneck, Shimonoseki Straits. All mines were dropped by radar at night. Accumulating evidence points to the fact that this mining campaign achieved greater success than was anticipated. More than half a million tons of shipping were sunk, damaged or immobilized. The blockade as a whole was so complete that only the thinnest trickle of raw materials flowed from the Asiatic continent, shipments of food were a fraction of that required to keep the Home Islands above a starvation diet, and the Japanese were unable to supply their vast forces in 'Greater East Asia' with adequate equipment.

"These were the principal operations against the Japanese Home Islands. What did they cost in terms of men and airplanes? In eight months of operations of the XXI Bomber Command, 212 highly trained crew members were killed, 397 were seriously wounded and 2,279 were reported missing. The figures are substantial, but they amount only to 1 per cent of the crew members airborne on bombing missions. To the end of July, 359 B-29s were lost by the XXI Bomber Command to all causes, 218 of them being lost to enemy action or to an unknown cause in combat. The Japanese reached the peak of their air effort in April, particularly over the Kyushu airfields, and against the Allied Air Forces as a whole. Thereafter, the effort of the Japanese Air Force against the B-29s dwindled steadily in numbers and aggressiveness, to the point that in July, when B-29s dropped more than 42,000 tons of bombs on Japan, only 99 Japanese fighter attacks were reported. B-29s held their own against Japanese fighters. The XXI Bomber Command during its eight months of operations claimed 756 enemy aircraft destroyed, or 3.4 enemy aircraft destroyed for each B-29 lost to enemy aircraft, anti-aircraft, or to an unknown cause. Some 216 enemy aircraft attacks were reported made for each B-29 lost to enemy aircraft.

"In taking up the air operations in other Pacific theaters, it should be remembered that, though distinct, these operations were parts of a whole—steps in a planned progress. The destruction of Japanese air power in one theater not only advanced or made possible the land and sea operations with which it was coordinated, but also contributed materially to the more and more fatal over-all weakness of the Japanese Air Force. In the Philippines, the rapid construction of air strips on Mindoro, Leyte, and Samar at the end of 1944, provided

Major Gen. Ennis C. Whitehead's Fifth Air Force with its first adequate bases, particularly for operations against the network of air bases around Manila. In the meantime, the Thirteenth Air Force (Major Gen. St. Clair Streett) moved from the Admiralty Islands to Morotai and became active against the southern Philippines and the adjacent areas. These two air forces then turned their attention to the destruction of the Japanese Air Force, which had continued its efforts to keep up its strength, despite ruinous losses. In a single month, the Japanese Air Force in the Philippines dropped from 654 combat aircraft to 69. The Japanese from then on were through in the Philippines; apart from a suicide effort against convoys on the way to Lingayen gulf, the landings and the campaign on Luzon and the other islands were unopposed by enemy aircraft.

"The enemy air force having been eliminated, the Fifth Air Force went to work softening up Luzon for invasion. Corregidor, which fell to the Japanese on May 6, 1942, after five months of battle and 28 days of siege, is an example of the effectiveness of this phase of operations. This island was blasted again and again by our heavy bombers, and was so battered that when our forces landed, they met no organized opposition. The few Japanese encountered were too dazed by the ordeal to offer effective resistance.

"When air bases on Luzon became available, the Fifth Air Force again moved forward. Once again the Thirteenth Air Force moved into bases vacated by the Fifth, and entered a phase of concentrated ground cooperation with guerrilla forces. Under Brig. Gen. Paul D. Wurtsmith, the new commander, special fighter control sectors were organized, equipped with radio jeeps, and assigned to guerrilla headquarters for direct air-ground coordination. These jeeps were able to give on-the-spot ground control to our fighter sweeps, aiding their effectiveness and the effectiveness of the guerrilla forces as a whole. Meanwhile, the Fifth Air Force entered the ground cooperation stage of its activity. The growth of its effort is illustrated by the fact that 105 ground cooperation sorties were flown during January, and 4,963 sorties were flown during March, 1945.

"Napalm bombing was used effectively during these ground-air operations. Napalm is a soft gasoline-impregnated jelly which our tests at the AAF Proving Ground in Florida and in experimental drops both in Europe and in the Pacific had proved almost non-extinguishable. Loaded in 110-gallon tanks with a detonator the small fuse of which exploded on impact, napalm could be laid down, by fighter planes carrying two or three tanks apiece, in a literal blanket of fire over the caves and ditches in which a stubborn enemy might try to hold out.

"The Ipo Dam east of Manila was essential to an adequate water supply for the Philippine capital. The well-armed Japanese were holed up in an organized series of cave positions, where artillery shells and aerial bombs were comparatively ineffective, and it began to appear that the campaign might last indefinitely. Into the Ipo area crawling with Japanese the Fifth Fighter Command dropped over 1,000 tanks of napalm in a series of raids on May 16-18. The stubborn, fanatical Japanese were transformed into a rabble. The 43rd Division went in standing up.

"Possession of air bases in the Philippines gave us the opportunity to cut off by air blockade the water shipment of the rich and badly needed resources of the south regions of Japan's stolen empire; Gen. George C. Kenney's Far Eastern Air Forces, in coordination with brilliant efforts by the Naval Air Arm, lost no time in making good the opportunity.

"In the Okinawa campaign, it was necessary not only to knock out the enemy air strength on that island, but also to hold down the flow of reinforcements and scale of attacks from other areas. Jap air strength on the Home Islands, on Formosa and lesser islands, and along the China coast was all in position to be brought to bear against the invasion fleet, and many other lucrative targets. On the other hand, our advances permitted us to plan the greatest, best-coordinated air effort the Pacific war had seen up to that time. Before D-Day carrier task forces struck Kyushu, Formosa, and Okinawa itself. The XX Bomber Command, based in China, commenced its attacks on Formosa. The XXI Bomber Command, based in the Marianas, flew photo reconnaissance missions over Okinawa, mined naval bases in the Home Islands, and helped to contain the Japanese Air Forces based in the Home Islands by the steadily mounting scale of its attacks, both day and night, against the Home Islands. During April alone, after the invasion had begun, the XXI Bomber Command flew 1,212 sorties against airfields on Kyushu, damaging repair and maintenance installations. During April, P-51 (North American Mustang) fighters from Iwo Jima also started their attacks on Kyushu airfields. Heavy and medium bombers of the Fifth Air Force in the Philippines pounded airfields on Formosa day and night, maintaining their attacks on that island until the end of the war. The Fourteenth Air Force bombed Japanese airfields along the China coast.

"Two days after the landings on Okinawa, Marine fighters were using repaired Japanese air strips. During May the first P-47N (Republic Thunderbolt) fighter group in the Pacific theater commenced operations from Ie Shima. From every standpoint, however, Okinawa was the grimmest battle of the Pacific war. The supreme effort of the Kamikaze Corps hardly requires detailing in this report. In a little over two months the Japanese lost more than 4,000 aircraft. Their staying power was gone; as had been the case before in the Pacific, the Japanese Air Force was not present for the climax of the ground campaign. Nor did the Japanese Air Force ever come back in strength; our subsequent operations from Okinawa, as well as our air attacks as a whole against the Home Islands, met dwindling opposition.

"Bulldozers and shovels were busy on Okinawa air strips on the day our forces landed. The Japanese had left us seven battered air strips on Ie Shima and Okinawa; without making use of more than three of these, we planned a minimum of 23. By the end of July an average of 35,000 tons of materiel was being daily unloaded on Okinawa. At the end of hostilities the Army Air Forces alone had four heavy bomb groups, five medium and light bomb groups, and nine fighter groups operating from Okinawa and Ie Shima. By early November, when an invasion of southern Kyushu was scheduled, we planned to have 47 groups of Army, Navy and Marine planes (including 12 groups of B-29s) based on Okinawa and Ie Shima. Ultimately, Lt. Gen. James Doolittle's Eighth Air Force would have consisted of 20 groups of B-29s.

"From a small beginning on May 17, when P-47N fighters based on Ie Shima first attacked Kyushu targets, the scale of coordinated air attack by the Fifth and Seventh Air Forces (the latter commanded by Brig. Gen. Thomas D. White) rose steadily until, during the last weeks of the war, it surpassed in scale and concentration anything previously achieved in the Pacific war. This was achieved notwithstanding the almost continuous handicap of adverse weather, particularly the low clouds and fog of summer over Japan. More than 800 sorties were flown in a single day, and nearly 400 aircraft attacked a single target on Kyushu. Bombers and fighters, after an early concentration on enemy airfields on Kyushu, turned their attention principally to communications and industry. Shipping targets near Kyushu, in the Inland sea, Tsushima straits and the Yellow Sea ranged from battleships to small fishing craft. Land communications targets included rail yards, tunnels, bridges, tracks, locomotives, and rolling stock. Factories, warehouses, radar facilities and fuel dumps were attacked with bombs, rockets, napalm bombs, and machine gun fire. Meanwhile, P-51 fighters based on Iwo, although concentrating generally on airfields in the Tokyo, Nagoya, and Kobe-Osaka areas, were in fact hitting virtually as wide a variety of targets as the Fifth and Seventh Air Forces. In approximately four months of operations, Iwo-based P-51 fighters flew 6,800 sorties against targets in the Home Islands and as escort for B-29s.

"The Japanese Air Force, carefully husbanding its remaining strength for the day of invasion, never opposed this growing tactical effort with as many as 100 aircraft at one time. When opposition was offered, it was generally an effort to attack small AAF formations of less than 25 aircraft; such AAF formations became increasingly difficult to find. In effect, the Japanese Air Force defaulted the final tactical air battles over Japan.

"In introducing this account of the air war in the Pacific, it was pointed out that the epoch-opening fall of the atomic bombs on Hiroshima and Nagasaki did not cause the defeat of Japan, however large a part they may have played in assisting the Japanese decision to surrender. Japan was defeated already by the cumulative destruction of her capacity to make war. The implications of the bomb will be dealt with later, when we consider the lessons of this war and what may be expected of air power in the future. One point, however, should be noted here.

"In defaulting the final tactical air battles over Japan, the Japanese Air Force proclaimed its own total defeat. The hoarded planes would certainly have done tremendous damage to our invasion fleet if they had been thrown in in mass suicide attacks, but this hoarding meant that we could deliver unopposed the atomic, or any other bomb, to any point we chose in the Japanese islands. The atomic bombs were staggering in their destructive scope; but their unheard-of powers simply underlined the basic truth that our command of the air had already marked out every Japanese war installation or production facility for certain and complete destruction. Japan was lost from the moment it became plain that the long outmatched Japanese Air Force was both powerless to prevent us from setting up bases for the huge B-29 missions against the key industrial cities, and incapable of making these missions so costly that we would have to slack off.

"The first achievement in 1945 of the Fourteenth Air Force under Major Gen. Claire L. Chennault in China was smashing its opponent in the air. In January the Japanese Air Force was still countering our attacks. During this month 211 enemy aircraft were destroyed and on several days there were determined air battles. The Fourteenth Air Force ran up over-all aerial combat scores of three-to-one, and the collapse of the Japanese Air Force was rapid. After January only 98 Japanese aircraft were claimed destroyed in the air, and none were claimed after June in that theater. In 1944 about 600 Japanese aircraft were based in China. In July, 1945, the force included only 200 dispersed and inactive aircraft. The attainment of air supremacy in China was an uphill fight. In spite of the reopening of the Burma Road and the completion of the pipeline to Kunming, the supply position of the Fourteenth Air Force was never better than critical. Resources had to be husbanded for the most essential commitments. Loss of the forward air bases threw our aircraft back on high altitude fields, to which aircraft damaged in combat were forced to fly back, frequently over mountains. Only stamina and the ability to do much with little kept these airplanes flying. Notwithstanding such handicaps, the Fourteenth Air Force flew more than 13,000 sorties in 1945.

"Fortunately, by Spring the South China and Indo-China coasts were within more economical range of Philippine bases, and after the capture of Okinawa, the Shanghai area was heavily attacked by the Fifth and Seventh Air Forces. These developments made it possible for the Fourteenth Air Force to concentrate increasingly on inland targets of importance, notably the Japanese communications corridor running north and south on the Hankow-Hengyang axis. Operations were so organized that in emergencies the Fourteenth could apply its entire striking power in direct cooperation with Chinese ground forces. Thus, both March drives of the Japanese ground armies, first on Hsian and Ankang and later toward Chihkiang, were successfully repulsed with the assistance of the Fourteenth Air Force. Japanese troops and positions were effectively and repeatedly attacked, and air power was the most vital factor in preventing the Japanese from capitalizing on their ground superiority.

"When the Japanese, in May, decided to give up their Greater East Asia corridor and to withdraw from southern China, they found their mobility and supply lines critically reduced by the attacks of the Fourteenth Air Force. No consecutive stretch of more than 50 miles on their main rail line was in operation at any one time. Rail movements were disrupted constantly. Even road convoys at night were heavily attacked. One of the Japanese commanders in China stated at this time that withdrawal would require one year if equipment were abandoned, and two years if an attempt were made to salvage their materiel.

"In its 1945 campaign against rail and road communications and river shipping throughout the length of China, the Fourteenth Air Force destroyed 632 locomotives, 930 railroad cars, 1,607 trucks, 427 bridges, and 2,114 sampans, junks and barges.

"The capture of Rangoon early in May, 1945, brought to a close one of the most difficult and original campaigns of the entire war. It was a campaign conducted over one of the world's most difficult terrains and in one of the world's most arduous climates. The conquest of Burma has brought to light some new concepts and tactics in warfare, particularly in regard to the use of air power. In the Burma campaign it was shown that whole armies can be transported, supported, evacuated and supplied entirely by air. Obviously, ground divisions could not have been moved rapidly about had we not achieved air supremacy. In Burma, by January, 1945, the transport of large units of men and equipment had become so commonplace, as well as so necessary, that the pattern of future operations was obvious. Apart from the movement of regular ground forces, airborne engineers captured or constructed one airfield after another in Central Burma. In addition to the normal air supply of the Fourteenth Army in Central Burma—a huge but routine commitment averaging at the time about 1,750 tons daily—our air forces continued to furnish accurate and indispensable fighter and fighter-bomber cooperation with the ground forces, often destroying enemy strong points within 100 yards of our front lines.

"By April the Burma campaign had resulted in the capture of

Heiktila and Mandalay, but the Fourteenth Army was still 400 miles from Rangoon and the sea supply vital to its maintenance during the monsoon season, only six weeks away. No less than 356,000 men were wholly on air supply at this time—a number steadily growing—and the problem of maintaining this huge commitment during the difficult flying weather just ahead loomed as the major factor in the campaign. To these troops it was Rangoon or Monsoon, or—as the RAF humorously expressed it—'Goon or Monsoon.'

"The RAF and AAF units were harmoniously integrated in the Eastern Air Command under Lieut. Gen. George E. Stratemeyer. On May 3, 1945, two British motorized divisions, which had been entirely supplied by air during their dash through Central Burma, rolled into Rangoon. There they joined a Gurkha paratroop battalion which had been dropped a few days earlier, and seaborne forces which had been supported by carrier aircraft and by the entire strength of Allied aircraft within reaching distance. A campaign without precedent in the entire war was over. During the entire conquest of Burma the Air Transport Command never faltered in its assigned job of hauling over the Hump an ever-increasing tonnage—in excess of 46,000 tons during May, 55,000 tons during June, to a maximum of 71,000 tons in July, 1945—for vital needs of the Fourteenth Air Force and Chinese.

"The Borneo campaign is an excellent example of the effectiveness of air cooperation as it prepares for and coordinates with amphibious operations, and of air cooperation with ground forces advancing over difficult terrain. In connection with Australian landings at Tarakan island, at Brunei bay, and at Balikpapan first attention was given to the neutralization of the enemy air force. On Borneo itself and in the Celebes and Java, the Japanese had approximately 100 aircraft capable of interfering with the Australian operations. The Tarakan landings were made on May 1, yet it was not until May 27, that the Japanese Air Force made its first attack on the Australian positions on Tarakan. During the entire period of operations, but three dozen unsuccessful attacks were made by the Japanese Air Force on all Australian positions.

"The heavy combined air and naval bombardments of the Japanese positions in the landing areas were equally successful. Japanese opposition to all the landings was slight; the Australians did not suffer a single casualty on the beaches of the Balikpapan area. The Thirteenth Air Force and the Royal Australian Air Force, which were responsible for the air effort, had to overcome handicaps of distance in all these operations. The nearest Thirteenth Air Force bases were at Sanga Sanga, Morotai, Zamboanga and Palawan, hundreds of miles away. However, excellent work was done by airdrome engineers in repairing captured airstrips; for example, at Tarakan, the airstrip was operational six days after the landings. The light

Australian casualties in the Borneo operations indicate the effectiveness of the air cooperation after the landings. The total Australian casualties in Borneo were 436 killed, 1,460 wounded, and three missing.

"Apart from air cooperation with amphibious operations—for example, the landings on Iwo Jima were preceded by 70 consecutive days of aerial bombardment—the mission of our air forces in the Central Pacific was to keep the numerous Japanese air bases in the bypassed islands neutralized, not only to prevent air attack on our own bases, but also to afford secure passage through the Central Pacific to our naval surface units, our convoys and our air transport traffic. Such Japanese island bases as those on Marcus and in the Bonins and Truk islands were policed regularly by B-24s and fighters, and toward the end of the war, by B-29s on shakedown training missions. The Japanese made several attempts to stage aircraft from Marcus to Truk for attacks on our Marianas bases, but because of the alertness of our intelligence and operations officers, the Marianas were never attacked by Japanese planes in 1945. During these last months the Central Pacific was, for all the Japanese Air Force could do, virtually an American lake over which our combat and transport planes flew unmolested.

"In the closing nine months of the war in the Far East, the Air Transport Command's Pacific Division doubled its aerial support of the final offensive. From January through August, 1945, this Division flew 262,248,900 ton-miles and 1,071,480,000 passenger-miles, and moved 26,000 air evacuees from all branches of the service to the United States. During the same period, 3,301 tactical aircraft were delivered to the Pacific theater. The ATC was called on frequently to deliver critical items to the fronts. Within a matter of hours after Lt. Gen. Buckner's appeal, it flew 200 tons of mortar shells to throw into the decisive offensive on Naha in Okinawa. More recently, ATC transports led the invasion of Japan with airborne troops and surrender-acceptance parties, and established regular air transport service into the defeated nation.

"Perhaps the main point about all our air operations in the war against Japan is that they were part of a vast, complex and coordinated whole. The role of air power was recognized and its potentialities were brilliantly exploited by the theater commanders, General of the Army MacArthur, Fleet Admiral Nimitz, Admiral Lord Louis Mountbatten, and Lieutenant General Wedemeyer. Our strategic bombardment was, as it should have been, directed by a central agency, the Joint Chiefs of Staff in Washington. Our tactical air forces, for their part, fitted flexibly into the patterns of individual campaigns. Personal prerogatives, military and naval protocol, were subordinated to the requirements of a common cause. Seabees built runways for Army aircraft, and Army Aviation Engineers for Navy and Marine fliers. An elaborate warning and alert system was set up by the Chinese for our airmen in China, and American fliers spear-headed and covered ground advances for Australian troops. To defeat Japan speedily and with a minimum loss of lives was the purpose uppermost in everyone's mind; the AAF is proud of its record in the struggle.

"This is a final report on the war activities of the Army Air Forces. I would also like to make it a document of some help to those entrusted with the future security of our country, as well as to the leaders of our Air Forces in the future. It is not possible to cover all the causes and effects from which timely lessons from the war may be drawn. A number of indicated steps, however, may be taken in the near future. Many of them are not so clear, and will require years of study and evaluation before they become apparent. Meanwhile, I offer herewith in both categories some of the personal conclusions which I have reached after my many years of service, and as a result of my experience in command of the Army Air Forces during World War II. It must be borne in mind that these conclusions are my own and may or may not reflect the views of the War Department.

"Wars are fought today not solely by ground, naval and air forces but by all citizens united in a joint effort which touches every phase of national and private life. The danger zone of modern war is not restricted to battle lines and adjacent areas but extends to the inner-most parts of a nation. No one is immune from the ravages of war. With present equipment, an enemy air power can, without warning, pass over all formerly visualized barriers or 'lines of defense' and can deliver devastating blows at our population centers and our industrial, economic or governmental heart even before surface forces can be deployed. Our own air force, when mobilized and deployed, would have a similar capability and might attack an enemy within hours instead of the days, weeks or months required by our surface forces. Future attack upon the United States may well be without warning, except what may be obtained from an active national intelligence agency.

"In any future war the air force, being unique among armed services in its ability to reach any possible enemy without long delay, will undoubtedly be the first to engage the enemy and, if this is done early enough, it may remove the necessity for extended surface conflict.

"It is entirely possible that the progressive development of the air arm, especially with the concurrent development of the atomic explosive, guided missiles, and other modern devices will reduce the requirement for or employment of mass armies and navies. These latter forces must have sufficient rapidity of movement or be sufficiently dispersed at all times to avoid location and destruction by future airborne power.

"Air superiority accordingly is the first essential for effective offense as well as defense. A modern, autonomous, and thoroughly trained air force in being at all times will not alone be sufficient, but without it there can be no national security.

"As a nation we were not prepared for World War II. Yes, we won the war, but at a terrific cost in lives, human suffering, and materiel, and at times the margin of winning was narrow. History alone can reveal how many turning points there were, how many times we were near losing, and how our enemies' mistakes often pulled us through. In the flush of victory, some like to forget these unpalatable truths. Our enemies' blunders, not likely to be repeated in the future, contributed materially to Allied victory. Among them were the following: *a*. Germany's underestimate of the power, technological resources, and the determination of the Royal Air Force in the Battle of Britain. *b*. The failure of Germany to invade England, which would have been possible after Dunkerque. *c*. Underestimation of the temper and power of the United States. *d*. The failure of Germany to appreciate the threat of the United States heavy bombers, and to understand and adopt the strategic uses of air power. *e*. Germany's incapacity to understand the Soviet Union's determination to maintain its integrity, and to realize the power with which it would back that determination. *f*. The failure of Japan to invade Hawaii after the Pearl Harbor attack. *g*. The failure of Japan to secure bases in Australia.

"Although we were woefully unprepared as a nation, we still had the time so essential to build a military force, time given us by our Allies fighting with their backs to the wall, and by the distance of oceans. That precious time without doubt will not be given us again. Today many modern war devices of great destructive power can be built piecemeal and under cover. Sub-assemblies might be secretly made in underground laboratories, and assembled into an annihilating war machine. War may descend upon us by thousands of robots passing unannounced across our shorelines—unless we act now to prevent them.

"Today, Japanese and German cities lie in ruins, but they merely suggest the vast destruction that can be done with the weapons of tomorrow. The first target of a potential aggressor might well be our industrial system or our major centers of population. If the United States is to be secure in the future, we must never relinquish the means of preventing such a blow. The AAF's size and power have been achieved only by tremendous efforts and expenses which, to a large extent, might have been unnecessary if as a nation we had been realistic about war from 1930 to 1940.

"What we shall lose in size as a peacetime air force, we must compensate for in the lessons we have learned in two world wars. Equally with the problems of today, the problems which may have to be faced in 1975 or 1985 will require imagination, boldness and the utilization of available skills, manpower and resources. It is recalled that at the outset of this war, some of the leading aircraft manufacturers in the country stated that they could not make the necessary number of airplanes in the time set. They also believed that only aircraft companies could manufacture aircraft because of the precision methods required. As it turned out, automobile, refrigerator, radio and other manufacturers quickly learned to produce aircraft and related equipment with precision methods.

"Certain strategic and critical materials necessary to the AAF might be difficult to procure in time of war. Such materials must be procured in time of peace and a sufficient stockpile maintained.

"The training of personnel in time of war, like the production of materials, can only be done in a wholesale manner by utilizing all available facilities and experienced operators wherever found. While we trained men in new skills, we also went to the shops, garages, laboratories and factories of the nation and adapted old skills to new military jobs. Ingenuity of this kind kept us going through a very critical period.

"As we think of the future, we would do well to remember that any United States preparation for preserving the peace would be incomplete without participation by other nations of this hemisphere. The American republics must work together in ever closer unity. To this end, military equipment, training and indoctrination should be standardized as much as possible among these nations, especially in the technical field of aviation.

"Since the birth of this nation, the people of the United States, peace-loving and hoping for world-wide acceptance of our concept of democracy, have never sponsored a strong peacetime military organization. History has demonstrated that we have thereby neither avoided war nor deterred others from going to war. We cannot measure the price which we have paid in lives and effort for the wars in which we have participated. We cannot know for certain to what extent the maintenance of a strong peacetime military organization would have reduced the price we have paid in past wars, nor to what degree such an organization would have worked toward the maintenance of world peace. We do know, however, that the course which we have followed in the past has not achieved the goal which we sought. Might it not now be wise to try the alternative course of action in the hope that it will bring us what we seek—world peace and our own security?

"Air power includes a nation's ability to deliver cargo, people, destructive missiles and war-making potential through the air to a desired destination to accomplish a desired purpose. Air power is not composed alone of the war-making components of aviation. It is the total aviation activity—civilian and military, commercial and private, potential as well as existing. Military air power—or air force—is dependent upon the air potential provided by industry which, in turn, thrives best in an atmosphere of individual initiative and private enterprise. Government can do much to increase this air potential by judicious use of its coordinating and planning powers.

"An air force is always verging on obsolescence and, in time of peace, its size and replacement rate will always be inadequate to meet the full demands of war. Military air power should, therefore, be measured to a large extent by the ability of the existing air force to absorb in time of emergency the increase required by war together with new ideas and techniques. National safety would be endangered by an air force whose doctrines and techniques are tied solely to the equipment and processes of the moment. Present equipment is but a step in progress, and any air force which does not keep its doctrines ahead of its equipment, and its vision far into the future, can only delude the nation into a false sense of security. Further, our concept of the implements of air power should not be confined to manned vehicles. Controlled or directed robots will be of increasing importance, and although they probably will never preclude some form of human guidance, reliance upon direct manual skills in pilotage will gradually decrease.

"In practical terms for the immediate future, the doctrine of air force growing out of the larger concept of air power can be expressed as a determination: 1. To maintain a striking air arm in being. 2. To keep the AAF and the aviation industry able to expand harmoniously as well as rapidly. 3. To maintain well-equipped overseas bases. 4. To support an alert and aggressive system of commercial air transportation—one of the foundations of American air power. 5. To remember that it is the team of the Army, Navy and Air Forces working in close cooperation that gives strength to our armed services in peace or war. 6. To make available to the United Nations organization, in accordance with the provisions of its charter, adequate and effective air force contingents for possible use by the Security Council in maintaining international peace and security. 7. To promote scientific research and development, and to maintain a close contact with industry.

"In accordance with its plan for transition from war to peace, the AAF will reduce its officer and enlisted personnel to less than one-fifth of its war strength. There will also be an orderly reduction in the number of installations, and the surplus airplanes will be disposed of in a manner which will not disorganize the aircraft industry. Prompt and speedy disposal of surpluses is a keystone to our postwar progress and a healthy aviation industry. Equally important at the present time is the retention of sufficient personnel, equipment and facilities to maintain adequate occupation air forces and to provide for the supply and rotation of personnel in Europe and the Pacific, the streamlining of domestic commands for peacetime functions and the adjustment of air transport to military needs. Our air force must be flexible in its basic structure and capable of successfully adapting itself to the vast changes which are bound to come in the foreseeable future. Whatever its numerical size may be, it must be second to none in range and striking power.

"The strategic theory, upon which were based the major air operations in World War II, was not new. Its application, however, was new, and in the course of the war the original concept was greatly extended.

"The strategic theory, as applied to the United States air warfare concept, postulates that air attack on internal enemy vitals can so deplete specific industrial and economic resources, and on occasion the will to resist, as to make continued resistance by the enemy impossible. To accomplish the strategic purpose, it is necessary to destroy only a small proportion of industry, probably not more than a fraction of the total required to conduct modern warfare on a large scale. Indiscriminately widespread destruction of enemy industry is simply a waste of effort.

"Examination of any national economy will disclose several specific industries or other national activities without which the nation cannot effectively carry on modern warfare. It is conceivable that there will always be one industry, such as the oil industry in Germany, so necessary to all phases of the national war-making ability that its destruction would be fatal to the nation. The real effect of our strategic air assaults, unlike that of tactical air attack, was seldom immediately apparent. Its effect was more like that of cancer, producing internal decay ultimately resulting in death. Strategic air assault is wasted if it is dissipated piecemeal in sporadic attacks between which the enemy has an opportunity to readjust defenses or to recuperate.

"The following principles should guide those who are responsible for planning and conducting strategic air warfare: *a.* Through a world-wide intelligence system, maintain constantly up-to-date information regarding all phases of the national life, economy and philosophy of potential enemy States. *b.* Maintain an analysis, continuously being revised to meet new conditions, to show the importance of all industries and other activities of potential enemies and to evaluate the relative importance of each of the units in each activity. *c.* To meet any emergency with the rapidity which survival in future wars will necessitate, prepare and maintain plans, in consonance with the latest information to provide for destruction of the decisive units of the key industries and other activities of each potential enemy nation. *d.* After a soundly conceived and carefully prepared strategic campaign has been launched, carry it through inexorably and without interruption. Diversion of effort to purposes of momentary importance will endanger the success of a whole air campaign.

"Operations of an air force can no longer be considered as being local in extent or limited in range. Bombers can now range the world, and we must have the necessary facilities such as well-equipped bases, meteorological information, communications and other devices, including radar, to provide for such employment. Long-range escort fighters, at one time considered impossible, are both practical and essential to bombing operations. Accurate day and night operations in all weather are essential in maintaining pressure on the enemy, magnifying his requirements for defense, interfering with his production, and attacking movements of troops and supplies which have been driven to rely on protection of darkness and bad weather. The searching and destructive power of aerial operations is so great that few targets on earth are safe in spite of armor or anti-aircraft guns or camouflage. Dispersion, active defenses and passive defenses, such as going underground, multiply the cost and provide protection only with tremendous expenditure of effort by the enemy.

"Regardless of the role that surface forces may play, the establishment of air superiority is a prerequisite to any successful ground or naval action. The basic planning, development, organization and training of the air force must be well rounded, covering every modern means of waging air war, and the techniques of employing such means must be continuously developed and kept up to date. The air force doctrines likewise must be flexible at all times and entirely uninhibited by tradition.

"Air force is a complex combination of many types of airplanes, weapons, personnel, units and tactics, supported by the industrial and scientific resources of the nation. New weapons and new developments, including the use of atomic energy, have not basically altered


THE REPUBLIC P47N THUNDERBOLT

this principle of modern war. This country must plan and build its military establishment with full knowledge that the methods of waging war now are changing at a rate never equalled in history. Air operations, once surface forces are near engagement, become more intimately related to the surface operations. In determining doctrine, organization and provision of equipment careful consideration must be given to this fact. Both photographic and visual air reconnaissance are essential to the efficient conduct of modern war. These are necessary to guard against surprise and to avoid wasteful expenditures in useless attacks on targets already destroyed, as well as to preclude omission of important military objectives and to provide briefing material for attack. Evaluation of the ultimate effect on enemy resources also comes in part from these activities.

"Airborne troops have become one of the most effective units of a modern fighting force and the development of equipment and techniques for their employment must be given continuous and imaginative attention. Cargo and passenger air transport, serving all arms and operating with airline precision and techniques, is an essential part of military operations.

"The air force must work vigorously for the provision of efficient rescue techniques and equipment and the training of personnel in methods of survival under emergency conditions. Joint efforts of the various services are desirable to avoid waste and to insure proper development in this important field. Weather service, an absolute essential of air operations, is comparable in importance to communications, and both must be developed to the maximum extent in peacetime. Accurate, large-scale up-to-date maps are a first essential to aerial warfare. Since they all cannot be produced in time of war, a major peacetime joint effort must be given to a mapping program covering all potential battle areas and the routes thereto. The efforts which have been so successful in reducing the accident rate in recent years must be continued and intensified.

"World War II required all major powers partially to mobilize their women into the armed forces. It was found in our country that these women in the jobs they were qualified to perform were more efficient than men. The next war in which the United States might participate may well require complete mobilization of all Americans. In consequence, a nucleus organization of female soldiers should be maintained in peacetime in order to provide for rapid and efficient expansion in time of national emergency.

"The speed with which a possible future war will start can be expected to allow little if any time for refresher training of reserves. Accordingly, a task of major importance in the peacetime air force is the attainment and maintenance of high standards in the training of reserve personnel who will be available in time of emergency. This is true in technical as well as in combat fields. The complexities of future wars, and the interrelationships of the several branches of the armed forces, require that joint training be begun early in an individual's career and progressively strengthened. In World War II, the AAF relied heavily upon nearly a half million civilian employees to perform all kinds of jobs from the highest type of scientific research to the simplest type of unskilled labor. The lessons learned from the use of civilians in the military establishment provide the basis for even more extensive use of their services in the future.

"Our past concept of intelligence needs was insufficient to cover the requirements of modern war. Detailed and moment-by-moment knowledge of all aspects of civilian and military activity within the territory of an enemy or a potential enemy is essential to sound planning in times of peace or war. Continuous knowledge of potential enemies, covering their entire political, social, industrial, scientific and military life is also necessary to provide warning of impending danger. Strategic air warfare can be neither soundly planned nor efficiently executed without a continuous flow of detailed information of this kind. In the future it will be suicidally dangerous to depend upon reports of military attaches and routine or casual sources of information regarding foreign States. There is a great need for a permanent national organization which not only deals with broad questions of policy but also collects, evaluates and disseminates a continuous stream of intelligence data. In addition, we must have a competent and active air intelligence organization within the air force working with such a national organization in times of peace and war. Only through specialized channels can we keep a constant check on the technological developments of potential enemies. We must in the future know in detail all conditions and be familiar with all facilities that may affect possible military operations. The targets of the future may be very large or extremely small—such as sites for launching guided missiles—requiring exact intelligence information as well as bombing accuracy to destroy them.

"A future air force developed in the light of the basic principles I have mentioned, together with provision for training and for constant supporting intelligence, will enable the United States to face the future with confidence. Such an air force will constitute a base from which required departures can be made with least loss of time or effectiveness.

"We must look at the future of aerial warfare in the light of the following considerations: 1. Aircraft, piloted or pilotless, will move at speeds far beyond the velocity of sound, well over 700 miles per hour. 2. Improvements in aerodynamics, propulsion and electronic control will enable unmanned devices to transport means of destruction to targets at distances up to many thousands of miles. However, until such time as guided missiles are so developed that there is no further need for manned aircraft, research in the field of conventional aircraft of improved design must be pursued vigorously. 3. Small amounts of explosive materials, as in atomic bombs, will cause destruction of many square miles. 4. Defense against present day aircraft may be perfected by target-seeking missiles. 5. Only aircraft or missiles moving at extreme speeds will be able to penetrate enemy territory protected by such defenses. 6. A communications system between control center and each individual aircraft will be established. 7. Location and observation of targets, take-off, navigation and landing of aircraft, and communications will be independent of visibility or weather. 8. Fully equipped airborne task forces will be able to strike at far distant points and will be supplied totally by air.

"The influence of atomic energy on air power can be stated very simply. It has made air power all-important. Air power provides not only the best present means of striking an enemy with atomic bombs, but also the best available protection against the misuse of atomic explosives. Use of atomic energy for propelling aircraft has also been suggested. This development seems rather far in the future, so that it is difficult today to predict the types of aircraft—or space craft—which may later be propelled in this fashion. The immediate danger to civilization raised by the very existence of atomic bombs is so great that we shall do better to concentrate our attention on the role of present-day power as a means of employing atomic bombs offensively, for instance for possible enforcement of decisions of the Security Council of the United Nations, and as a safeguard against their irresponsible use in aggression.

"The chief difference between an atomic bomb and the largest conventional type of bomb lies in the immense destructive power of a single atomic missile. This means that measures intended for protection against an atomic bomb attack must be highly efficient from the very start of a war if they are to be any good at all. Our experience in this war has shown that it is most difficult to attain this goal.

"Further, the great unit cost of the atomic bomb means that as nearly as possible every one must be delivered to its intended target. This can be done in one of several ways, all of which involve air power. For example, the following evolution may be suggested: *a.* Today, our Army Air Forces are the recognized masters of strategic bombing. Until others can match the present efficiency of our own anti-aircraft defenses, we can run a large air operation for the sole purpose of delivering one or two atomic bombs. Our experience in the war suggests that the percentage of failures in an operation of this kind would be low. *b.* When improved anti-aircraft defenses make this impracticable, we should be ready with a weapon of the general type of the German V-2 rocket, having greatly improved range and precision, and launched from great distances. V-2 is ideally suited to deliver atomic explosives, because effective defense against it would prove extremely difficult. *c.* If defenses which can cope even with such a 3,000-mile-per-hour projectile are developed, we must be ready to launch such projectiles nearer the target, to give them a shorter time of flight and make them harder to detect and destroy. We must be ready to launch them from unexpected directions. This can be done from true space ships, capable of operating outside the earth's atmosphere. The design of such a ship is all but practicable today; research will unquestionably bring it into being within the foreseeable future.

"Three types of defense against the atomic bomb can be conceived: First, we should attempt to make sure that nowhere in the world are atomic bombs being made clandestinely; second, we should devise every possible active defense against an atomic bomb attack, once launched; and third, we might redesign our country for minimum vulnerability to atomic bomb attack. All three could, of course, be combined. Complete dispersal of our cities and moving vital industries underground on a sufficiently large scale would be overwhelmingly expensive. In addition to the expense, the unsolved technological problems would present the greatest difficulty. Unceasing patrol of the entire world, possibly under the guidance of the United Nations organization, would do much to prevent the illegal manufacture of atomic bombs in their present form. This, however, would be only a partial solution of the problem. In any event, air patrol, supplemented under international agreements by ground inspection, should be employed to the maximum possible extent. The Air Forces used for patrol of this kind might very well be those air contingents which are made available to the Security Council for possible enforcement action.

"Although there now appear to be insurmountable difficulties in an active defense against future atomic projectiles similar to the German V-2 but armed with atomic explosives, this condition should only intensify our efforts to discover an effective means of defense. Meanwhile, the only known effective means of delivering atomic bombs in their present stage of development is the very heavy bomber, and that is certain of success only when the user has air superiority. This fact, although perhaps true only temporarily, points up the urgent necessity for the maximum effort on air defense, both in the air and on the ground. For the moment at least, absolute air superiority in being at all times, combined with the best anti-aircraft ground devices, is the only form of defense that offers any security whatever, and it must continue to be an essential part of our security program for a long time to come.

"While this country must employ all its physical and moral force in the cause of peace, it must recognize that real security against atomic weapons in the visible future will rest on our ability to take immediate offensive action with overwhelming force. It must be apparent to a potential aggressor that an attack on the United States would be immediately followed by an immensely devastating air-atomic attack on him. The atomic weapon thus makes offensive and defensive air power in a state of immediate readiness the primary requisite of national survival.

"Original research in rockets for the AAF was for the purpose of assisting take-off with heavy loads on short landing strips and as a short-duration speed boost to achieve high emergency performance in combat. Among new uses for rockets are winged missiles for extreme range; guided anti-aircraft missiles; launching supersonic, long-range pilotless, or manned aircraft; and deceleration devices for aircraft with high landing speeds. Jet propulsion is in its infancy despite the fact that this war has evolved six distinct methods of utilizing atmospheric oxygen for propulsion, such as (1) motorjet—or reciprocating engine plus ducted fan, (2) turboprop—a gas turbine plus propeller, (3) turbofan—a gas turbine plus ducted fan, (4) turbojet—a gas turbine plus jet, (5) ramjet—a continuous jet with compression by aerodynamic ram, and (6) pulsojet—or intermittent jet. These new and strange sounding words will be familiar ones in our speech in the near future, and right now they carry more meaning for Americans than any other six words I know.

"Radar is an outstanding contribution to the effectiveness of an air force. It is a device which enormously extends the range, power, capabilities and accuracy of human vision. Radar is a primary facility in an all-weather, 24-hour air force for bombing, gunfire, navigation, landing and control. The structure of the air force, the planning of its operation, its training program and its organization must take radar into account. In the final months of the B-29 bombardment of Japan the AAF had one Wing bomb by radar alone, to test out the possibilities. Greater accuracy was secured than by the best visual means, and it is fair to expect that the visual bombing which served us well in this war soon may be obsolete.

"Perhaps as important as modern weapons in winning the war was the application of science to the development of packaged and tinned foods which, while furnishing a balanced diet, also met the combat requirements of reduced bulk and ability to withstand extreme climatic conditions. After months without change, however, a diet of the best of these rations without any fresh foods was found to cause deficiency symptoms in personnel. The AAF, with its global operations, was perhaps more keenly aware of the problem, especially at isolated air bases in the South Atlantic and Pacific the volcanic or coral surfaces of which were devoid of soil for growing any sort of fresh vegetables. Science and initiative, however, found the answer in hydroponics—the growing of vegetables without soil by means of chemicals. By the end of the war, chemical gardens were flourishing on the desolate volcanic rock islands in the South Atlantic and on the barren wastes of several Pacific island bases. Ascension Island was picked as the first testing laboratory for large scale cultivation of vegetables by hydroponics. A party consisting of an officer, eight enlisted men, and a civilian expert landed on the 'rock' in January. A plot of land was taken over and engineers began construction of concrete beds which were filled with sifted volcanic gravel. Seedlings were planted, a nutrient solution, containing the chemicals necessary for the growth of plants, was passed through the beds from two reservoir tanks. Four months later these 'visiting farmers' were harvesting tomatoes, radishes, lettuce and cucumbers from an 80,000 square foot area of fertility. Today hydroponics is an accepted fact and will have its place in the postwar AAF along with other products of science and research. Chemical gardens will be established at all remote installations where fresh vegetables cannot be grown by ordinary methods. Important in itself, this development brings down to earth the need for a close partnership with science, and for the courage and foresight to translate experiment into practice.

"The preceding sections of this report demonstrate that the spectacular innovations in technological warfare, which appeared with ever increasing momentum in World War II and culminated with the atomic bomb, demand continuous scientific research to insure the maintenance of our national security and world peace. In the past, the United States has shown a dangerous willingness to be caught in a position of having to start a war with equipment and doctrines used at the end of a preceding war. We have paid heavily for this error. A repetition of this error in the future could mean annihilation. No war will be started unless the aggressor considers that he has sufficient superiority in weapons to leave his adversaries in a state of ineffective war-making capacity. Possession of large stocks of war equipment at the end of a war affords a serious temptation to continue to use that equipment in training peacetime forces. This is strikingly true in the case of the air force. We must depend on scientific and technological advances requiring us to replace about one-fourth of our equipment each year.

"The weapons of today are the museum pieces of tomorrow. So tomorrow, the B-29, the superfortress of today, will belong in the Smithsonian Institution, with the Wright and Lindbergh planes, its place on the line to be taken later by bombers that will carry 50 tons of bombs, planes with jet or rocket motors capable of flying around the world at supersonic speeds.

"In accomplishment of its fundamental responsibility for insuring that the nation is prepared to wage effective air warfare, the air force must be able to call on all talents and facilities existing in the nation and sponsor further development of the facilities and creative work of science and industry. The air force also must be authorized to expand existing research facilities and create and take advantage of new ones to accomplish applied research and to make such facilities available

THE NORTHROP P-61 BLACK WIDOW FIGHTER

This night fighter, with crew of two or three, carried four .50-cal. machine guns and four 20 mm. cannon, and was a terror to German and Jap pilots meeting it in combat.

to scientists and industrial concerns working on problems for the air force. Further, the air force must have the means of recruiting and training personnel who have full understanding of the scientific facts necessary to procure and use the most advanced equipment. Although basic scientific research should not be undertaken by the air force in its own organization, it must encourage and sponsor such basic research as may be deemed necessary for the defense of the nation.

"During this war the Army, the Army Air Forces and the Navy have made unprecedented use of scientific and industrial resources. When the countless aspects of air force operations requiring scientific and technical talent are considered, the conclusion is inescapable that we have not yet established the balance necessary to insure the continuance of teamwork among the military, other Government agencies, industry and the universities. The legislative and executive branches of the Government should determine the best form of organization and the most efficient scheme for uniting all efforts to create the best scientific facilities and utilize all available scientific talents. It is in the national interest to establish a national research foundation composed of the most highly qualified scientists in the United States and charged with the responsibility of furthering basic research and development in all fields of science and the scientific training of adequate numbers of highly qualified men. Scientific planning must be years in advance of the actual research and development work. The air force must be advised continuously on the progress of scientific research and development in view of the new discoveries and improvements in aerial warfare. A permanent scientific advisory group consisting of qualified officers and eminent civilian scientific consultants must be inducted in the air force organization to insure that equipment is kept abreast of the progress of research and development and to insure that all research required by the air forces is being undertaken by the appropriate agencies.

"We no longer can set up 'military characteristics' for a new weapon or airplane, award a contract, and expect to have delivered a finished article which can be put into use immediately. The entire process from development through production, training and operational use is a continuous one. Specialists must be at hand to give intelligent guidance at every turn. This will require adjustments in the military organization to provide for a group or corps of full-time scientists in uniform, and adjustments to provide adequate compensation for highly qualified civilians.

"Since military air power depends for its existence upon the aviation industry and the air-mindedness of the nation, the air force must promote the development of American civil air power in all of its forms, both commercial and private. However, in view of the national security responsibilities of the air force, and considering the adaptability of civil aviation facilities to military uses, it is in the national interest for the air force to have a voice in civil air matters.

"The rapid development of aviation, particularly in its ability to promote international understanding, has emphasized the need for an authoritative national air policy to guide American civil aviation for the common good. A policy of this kind cannot be static. Further, to be effective, it must be made known to all who are interested. Examples of principles which the air force should support as the basis for its participation in the formulation of civil air policies are as follows: *a*. No activity having to do with aviation in any form can be considered as being completely independent of national security. Civil aviation must be encouraged both internally and internationally, and all arrangements, plans, agreements and operations should be carried out with due regard for their military implications. *b*. The security of the United States as well as the performance of its responsibilities in the maintenance of world peace require the availability of an extensive system of air bases and airways outside the United States.

"The development of international air law and custom can be advanced materially by recognition of the similarity between aviation and maritime activities. Individual initiative, private enterprise, and free competition, at home and abroad, continue to be the essential elements of American progress. One national authority, capable of expressing comprehensive and basic aviation policies in the name of all interested Governmental departments, is a first essential for the sound development of American civil aviation.

"It is the American people who will decide whether this Nation will continue to hold its air supremacy. In the final analysis, our air striking force belongs to those who come from the ranks of labor, management, the farms, the stores, the professions, the schools and colleges and the legislative halls. Air power will always be the business of every American citizen. The Army Air Forces recognizes its duty in formulating intelligent programs of education to the end that the public will understand aviation in all of its forms as well as realize the danger of unpreparedness in the air. Propaganda has no place in this program. Public relations must give the public a thorough understanding of the general problems of war mobilization of aviation, and especially of military air power. The air force public relations policy and the educational program should be steered along sound lines by a directorate or committee composed of individuals trained not only as writers and reporters but also as technical specialists.

"The greatest lesson of this war has been the extent to which air, land and sea operations can and must be coordinated by joint planning and unified command. The attainment of better coordination and balance than now exists between services is an essential of national security. Unity of command alone is not sufficient. Unity of planning, unity of common item procurement and unity of doctrines are equally necessary. In addition, ground, naval and air forces each must have an equal voice as well as equal responsibility in all plans and policies. Maximum efficiency and economy cannot be attained when one type of force is subservient to another in planning or operational councils. The full capabilities of the subservient force never will be exploited efficiently and serious blunders are bound to follow. In order to secure the maximum effectiveness with the greatest economy, our fighting forces must be organized so as to provide soundly integrated command of three autonomous services, each of which has an equal and direct share of the total responsibility.

"The Joint Chiefs of Staff organization presided over by the Chief of Staff to the President, as developed during World War II, proved itself sound, and made coordination of effort possible not only among our own armed services but also with our Allies. This organization should be continued in time of peace when the absence of the compulsions of war makes cooperation and coordination of effort much more difficult to achieve.

"The following requirements, in my opinion, accordingly must be met: *A*. Organization. (1) One integrated, balanced United States military organization that will establish, develop, maintain and direct at the minimum expense the forces, including the mobile striking forces, required for peace enforcement and for national security with the capability for the most rapid expansion in case of all-out war. (2) Retention of the Joint Chiefs of Staff organization with a Chief of Staff to the President. (3) The size and composition of our striking forces to be based on: (a) Capabilities and limitations of possible enemies. (b) Effectiveness and employment of modern weapons of war. (c) The geographical position of the United States, its outlying bases and such other bases as it might control or use. (4) Maximum economy and efficiency to be secured by: (a) Ruthless elimination of all arms, branches, services, weapons, equipment or ideas whose retention might be indicated only by tradition, sentiment or sheer inertia. (b) Ruthless elimination of duplication throughout the entire organization. *B*. Principles. (1) The above organization, to attain its objectives, must adhere rigidly to the following principles: (a) Development of the intelligence (service) necessary for the effective application of our military force to whatever job it may be called upon to do. (b) Continuous planning for both offensive and defensive operations against all potential enemies, taking into account their capabilities and possible intentions. (c) Planning for, and direction of technical research to ensure that the most modern weapons are being developed, tested and service tested in order to retain for the United States military equipment its present pre-eminent position. (d) Development and application of the most effective tactics and techniques. (e) Realistic recommendations for Congressional appropriations for military purposes and for the distribution of these appropriations where they will produce the maximum benefit to the national security.

"The air forces also must assume their full responsibility, under the provisions of the Charter of the United Nations organization, to hold immediately available national air force contingents for combined enforcement action. These forces must be of sufficient strength, and their degree of readiness must be such as to make effective use of their inherent striking power and mobility. World War II brought unprecedented death and destruction to war-making and peace-loving nations alike, and as any future war will be vastly more devastating, the mission of the armed forces of the United States should be not to prepare for war, but to prevent war—to insure that peace be perpetuated."

One of the most valuable contributions to our knowledge of what air war can do to a nation was made by The U. S. Strategic Bombing Survey, established by the President in November, 1944, with these members, Franklin D'Olier, chairman; Henry C. Alexander, vice chairman; George W. Ball, Harry L. Bowman, John K. Galbraith, Rensis Likert, Frank A. McNamee, Paul H. Nitz, Robert P. Russell, Fred Searles, Jr. and Theodore P. Wright. Capt. Paul Johnstone, U.S.N.R., served as technical secretary. The Survey followed the advance of the Allied armies through Europe, and about 1,500 officers, enlisted personnel and civilians worked on the project, which embraced examination of hundreds of German cities, plants and other areas, interrogations of thousands of Germans including the surviving leaders, examination of enemy war records hidden everywhere, in safes, barns, caves, private homes and even in coffins. The Survey made two summary reports, one on Europe and the other on Japan. The Japanese report was not available at the time this edition of the Aircraft Year Book went to press. It is planned to publish it in the 1947 edition. The summary report on Europe is carried in the following pages in full because it is a document of lasting interest to everybody concerned with the security of the United States. Here is the complete text of the summary report on Europe:

"The new relation of air power to strategy presents one of the distinguishing contrasts between this war and the last. Air power in the last war (World War I) was in its infancy. The new role of three-dimensional warfare was even then foreseen by a few farsighted men, but planes were insufficient in quality and quantity to permit much more than occasional brilliant assistance to the ground forces. Air power in the European phase of this war (World War II) reached a stage of full adolescence, a stage marked by rapid development in planes, armament, equipment, tactics and concepts of strategic employment, and by an extraordinary increase in the effort allocated to it by all the major contestants. England devoted 40 to 50 per cent of her war production to her air forces, Germany 40 per cent, and the United States 35 per cent. Nevertheless, at the end of hostilities in Europe, weapons, tactics and strategy were still in a state of rapid development. Air power had not yet reached maturity and all conclusions drawn from experience in the European theater must be considered subject to change. No one should assume that because certain things were effective or not effective, the same would be true under other circumstances and other conditions.

"In the European war, allied air power was called upon to play many roles—partner with the Navy over the sea lanes; partner with the Army in ground battle; partner with both on the invasion beaches; reconnaissance photographer for all; mover of troops and critical supplies; and attacker of the enemy's vital strength far behind the battle line. In the attack by allied air power, almost 2,700,000 tons of bombs were dropped, more than 1,440,000 bomber sorties and 2,680,000 fighter sorties were flown. The number of combat planes reached a peak of some 28,000 and at the maximum 1,300,000 men were in combat commands. The number of men lost in air action was 79,265 Americans and 79,281 British. More than 18,000 American and 22,000 British planes were lost or damaged beyond repair. (All RAF statistics are tentative or preliminary.)

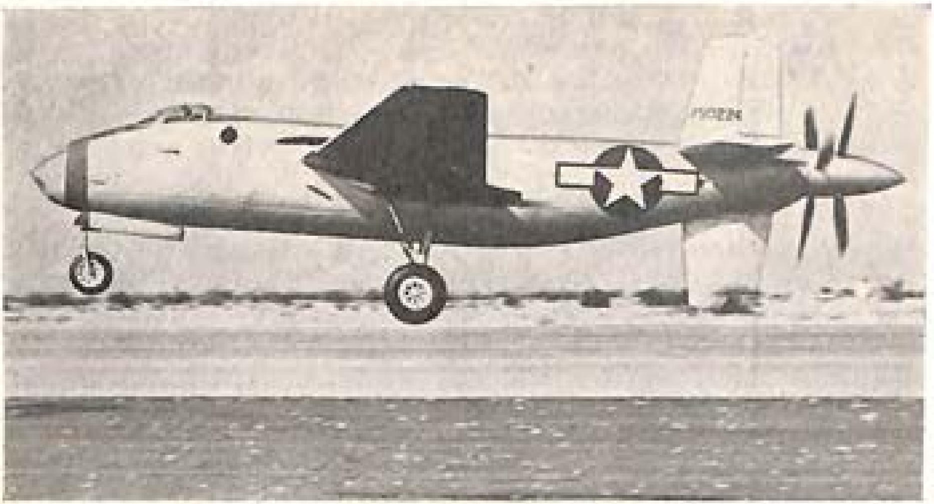
"In the wake of these attacks there are great paths of destruction. In Germany, 3,600,000 dwelling units, approximately 20 per cent of the total, were destroyed or heavily damaged. Survey estimates show some 300,000 civilians killed and 780,000 wounded. The number made homeless aggregates 7,500,000. The principal German cities have been largely reduced to hollow walls and piles of rubble. German industry is bruised and temporarily paralyzed. These are the scars across the face of the enemy, the preface to the victory that followed. How air supremacy was achieved and the results which followed from its exploitation are the subject of this summary report. The use of air power cannot properly be considered, however, except in conjunction with the broad plans and strategy under which the war was conducted.

"Interrogation of Hitler's surviving confidants and General Staff and field generals of the Wehrmacht confirms the view that prior to the winter of 1941, Hitler hoped to realize Germany's ascendancy over Europe, and possibly the world, largely by skillful strategy. Time and timing were the secret weapons in the German war plan that took shape after 1933. Hitler hoped to build Germany's strength more quickly than that of any potential opponent. By rapid mobilization of a powerful striking force, by exploiting the political and ideological strains that he conceived to exist in the rest of the world, and by overwhelming separately in lightning campaigns such of his enemies as chose to resist, he hoped to secure for Germany an invulnerable position in Europe and in the world.

"What Germany lacked in numbers of divisions, in raw materials and in basic industrial strength, it planned to compensate with highly trained ground units of great striking power. These were to be equipped and ready to march while Germany's enemies were merely preparing. Essential in this strategy was a technically well-developed air force in being. Emphasis was not placed upon the development of an air force that would destroy the sustaining resources of the enemy's economy. In the German plan it was anticipated that an enemy's entire country would be so quickly overrun that little concern need be had for industrial and war production that was merely potential. The air force was, primarily, an arm of the blitzkrieg.

"The success of Hitler's strategy, until the battle of Britain, was complete; his more cautious advisers and generals still confess to their astonishment. And by common report of the surviving Nazi leaders even the setback over Britain was considered of minor importance. The attack on Russia was next on the calendar—the decision to make this attack was taken in the autumn of 1940—and this, according to plan, was to be a brief four months' adventure. There would be time thereafter, if necessary, to deal with Britain. By September 1941, Hitler was so confident that he had succeeded in Russia that he ordered large scale cutbacks in war production.

"Study of German war production data as well as interrogation of those who were in charge of rearmament at the time, leaves no doubt that until the defeat at Moscow German industry was incompletely mobilized and that in fact Germany did not foresee the need for full economic mobilization. German arms production during 1940 and 1941 was generally below that of Britain. When the full meaning of the reverses at Moscow became apparent the German leaders called



THE DOUGLAS XB-42 BOMBER

It is powered by two Allison V-1710 engines in the fuselage and pushed by center-line propellers.

for all-out production. The conquests of the previous years had greatly strengthened Germany's economy; with the exception of oil and rubber, supplies of virtually all the previously scarce imported materials were or had become accessible. Great reserves of foreign labor only awaited voluntary or forced recruitment. The industrial plant of France, the Low Countries, Poland and Czechoslovakia had been added to that of Germany. After the defeat at Moscow early in 1942, armament production increased rapidly. However, such increase was more the result of improvements in industrial efficiency than of general economic mobilization. Studies of German manpower utilization show that throughout the war a great deal of German industry was on a single shift basis, relatively few German women (less than in the first war) were drawn into industry and the average work week was below British standards.

"Germany's early commitment to the doctrine of the short war was a continuing handicap; neither plans nor state of mind were adjusted to the idea of a long war. Nearly all German sources agree that the hope for a quick victory lasted long after the short war became a long one. Germany's armament minister Albert Speer, who assumed office in early 1942, rationalized German war production and eliminated the worst inefficiencies in the previous controls. A threefold increase in armament production occurred under his direction but the increase cannot be considered a testament to the efficiency of dictatorship. Rather it suggests the degree of industrial undermobilization in the earlier years. An excellent case can be made that throughout the war top Government management in Germany was not efficient.

"Because the German economy through most of the war was substantially undermobilized, it was resilient under air attack. Civilian consumption was high during the early years of the war and inventories both in trade channels and consumers' possession were also high. These helped cushion the people of the German cities from the effects of bombing. Plant and machinery were plentiful and incompletely used. Thus it was comparatively easy to substitute unused or partly used machinery for that which was destroyed. While there was constant pressure throughout for German manpower for the Wehrmacht, the industrial labor supply, as augmented by foreign labor, was sufficient to permit the diversion of large numbers to the repair of bomb damage or the clearance of debris with relatively small sacrifice of essential production.

"In both the RAF and the United States Army Air Forces there were some who believed that air power could deliver the knockout blow against Germany, and force capitulation. This view, however, was not controlling in the overall allied strategic plan. The dominant element in that plan was invasion of the Continent to occur in the spring of 1944. Plans called for establishing air superiority prior to the date of the invasion and the exploitation of such superiority in weakening the enemy's will and capacity to resist.

"The deployment of the air forces opposing Germany was heavily influenced by the fact that victory was planned to come through invasion and land occupation. In the early years of the war, to be sure, the RAF had the independent mission of striking at German industrial centers in an effort to weaken the German economy and the morale of the German people. However, the weight of the RAF effort, compared with tonnages later employed, was very small—16,000 tons in 1940 and 46,000 tons in 1941 compared with 676,000 tons in 1944. Soon after the United States entered the air war in 1942, replacements for our new (and still small) Eighth Air Force were diverted to support the North African invasion. During 1943, target selection for the Eighth Air Force and the Fifteenth Air Force (based on the Mediterranean) reckoned always with the fact that maximum contribution must be made to the invasion in the coming year. And our Ninth Air Force in Western Europe and Twelfth Air Force in the Mediterranean were developed with the primary mission of securing the sky in the theater of combat and clearing the way for ground operations. In the spring and early summer of 1944, all air forces based on England were used to prepare the way for the invasion. It was not intended that the air attacks against Germany proper and the German economy would be a subordinate operation, but rather a part of a larger strategic plan—one that contemplated that the decision would come through the advance of ground armies rather than through air power alone.

"The pioneer in the air war against Germany was the RAF. The

RAF experimented briefly in 1940 with daylight attacks on industrial targets in Germany but abandoned the effort when losses proved unbearably heavy. Thereafter, it attempted to find and attack such targets as oil, aluminum and aircraft plants at night. This effort too was abandoned; with available techniques it was not possible to locate the targets often enough. Then the RAF began its famous raids on German urban and industrial centers. On the night of May 30, 1942, it mounted its first thousand plane raid against Cologne and two nights later struck Essen with almost equal force. On three nights in late July and early August 1943, it struck Hamburg in perhaps the most devastating single city attack of the war—about one third of the houses of the city were destroyed and German estimates show 60,000 to 100,000 people killed. No subsequent city raid shook Germany as did that on Hamburg; documents show that German officials were thoroughly alarmed; and there is some indication from interrogation of high officials that Hitler himself thought that further attacks of similar weight might force Germany out of the war. The RAF proceeded to destroy one major urban center after another. Except in the extreme eastern part of the Reich, there is no major city that does not bear the mark of these attacks. However, no subsequent attack had the shock effect of the Hamburg raid.

"In the latter half of 1944, aided by new navigational techniques, the RAF returned with part of its force to an attack on industrial targets. These attacks were notably successful but it is with the attacks on urban areas that the RAF is most prominently identified. The city attacks of the RAF prior to the autumn of 1944, did not substantially affect the course of German war production. German war production as a whole continued to increase. This in itself is not conclusive, but the Survey has made detailed analysis of the course of production and trade in 10 German cities that were attacked during this period and has made more general analyses in others. These show that while production received a moderate setback after a raid, it recovered substantially within a relatively few weeks. As a rule the industrial plants were located around the perimeter of German cities and characteristically these were relatively undamaged.

"Commencing in the autumn of 1944, the tonnage dropped on city areas, plus spill-overs from attacks on transportation and other specific targets, mounted greatly. In the course of these raids, Germany's steel industry was knocked out, its electric power industry was substantially impaired and industry generally in the areas attacked was disorganized. There were so many forces making for the collapse of production during this period, however, that it is not possible separately to assess the effect of these later area raids on war production. There is no doubt, however, that they were significant.

"The Survey has made extensive studies of the reaction of the German people to the air attack and especially to city raids. These studies were carefully designed to cover a complete cross section of the German people in western and southern Germany and to reflect with a minimum of bias their attitude and behavior during the raids. These studies show that the morale of the German people deteriorated under aerial attack. The night raids were feared far more than daylight raids. The people lost faith in the prospect of victory, in their leaders and in the promises and propaganda to which they were subjected. Most of all, they wanted the war to end. They resorted increasingly to 'black radio' listening, to circulation of rumor and fact in opposition to the regime; and there was some increase in active political dissidence—in 1944 one German in every thousand was arrested for a political offense. If they had been at liberty to vote themselves out of the war, they would have done so well before the final surrender. In a determined police state, however, there is a wide difference between dissatisfaction and expressed opposition. Although examination of official records and those of individual plants shows that absenteeism increased and productivity diminished somewhat in the late stages of the war, by and large workers continued to work. However dissatisfied they were with the war, the German people lacked either the will or the means to make their dissatisfaction evident. The city area raids have left their mark on the German people as well as on their cities. Far more than any other military action that preceded the actual occupation of Germany itself, these attacks left the German people with a solid lesson in the disadvantages of war. It was a terrible lesson; conceivably that lesson, both in Germany and abroad, could be the most lasting single effect of the air war.

"The U. S. Army Air Forces entered the European war with the firm view that specific industries and services were the most promising targets in the enemy economy, and they believed that if these targets were to be hit accurately, the attacks had to be made in daylight. A word needs to be said on the problem of accuracy in attack. Before the war, the U. S. Army Air Forces had advanced bombing techniques to their highest level of development and had trained a limited number of crews to a high degree of precision in bombing under target range conditions, thus leading to the expressions 'pin point' and 'pickle barrel' bombing. However, it was not possible to approach such standards of accuracy under battle conditions imposed over Europe. Many limiting factors intervened; target obscuration by clouds, fog, smoke screens and industrial haze; enemy fighter opposition which necessitated defensive bombing formations, thus restricting freedom of maneuver; anti-aircraft artillery defenses, demanding minimum time exposure of the attacking force in order to keep losses down; and finally, time limitations imposed on combat crew training after the war began. It was considered that enemy opposition made formation flying and formation attack a necessary tactical and technical procedure. Bombing patterns resulted—only a portion of which could fall on small precision targets. The rest spilled over on adjacent plants, or built-up areas, or in open fields. Accuracy ranged from poor to excellent. When visual conditions were favorable and flak defenses were not intense, bombing results were at their best. Unfortunately, the major portion of bombing operations over Germany had to be conducted under weather and battle conditions that restricted bombing technique, and accuracy suffered accordingly. Conventionally the air forces designated as 'the target area' a circle having a radius of 1,000 feet around the aiming point of attack. While accuracy improved during the war, Survey studies show that, in the over-all, only about 20 per cent of the bombs aimed at precision targets fell within this target area. A peak accuracy of 70 per cent was reached for the month of February, 1945. These are important facts to keep in mind, especially when considering the tonnages of bombs delivered by the air forces. Of necessity a far larger tonnage was carried than hit German installations.

"Although our Eighth Air Force began operations August 17, 1942, with the bombing of marshalling yards at Rouen and Sotteville in northern France, no operations during 1942 or the first half of 1943 had significant effect. The force was small and its range limited. Much time in this period was devoted to training and testing the force under combat conditions. In November and December of 1942, the U-boat attack on allied merchant shipping was in its most successful phase, and submarine bases and pens and later construction yards became the chief target and remained so until June, 1943. These attacks accomplished little. The submarine pens were protected and bombs did not penetrate the 12-foot concrete roofs. The attack on the construction yards and slipways was not heavy enough to be more than troublesome.

"In January, 1943, at Casablanca, the objective of the strategic air forces was established as the 'destruction and dislocation of the German military, industrial, and economic system and the undermining of the morale of the German people to the point where their capacity for armed resistance is fatally weakened.' Specific target systems were named.

"In the Spring of 1943, allied naval and air power scored a definite victory over German submarines. Surface craft teamed with long-range patrol bombers equipped with radar raised German submarine losses to catastrophic levels in the Spring of 1943. Interrogation of members of the High Command of the German Navy, including Adm. Doenitz, has confirmed the scope of this victory. When the Allied Combined Bomber Offensive Plan was issued in June of 1943 to implement the Casablanca directive, submarines were dropped from first priority and the German aircraft industry was substituted. The German ball-bearing industry, the supplier of an important component, was selected as a complementary target. The German antifriction bearing industry was heavily concentrated. When the attack began, approximately half the output came from plants in the vicinity of Schweinfurt. An adequate supply of bearings was correctly assumed to be indispensable for German war production.

"In a series of raids beginning on August 17, 1943, about 12,000 tons of bombs were dropped on this target—about one-half of one per cent of the total tonnage delivered in the air war. In an attack on August 17 by 200 B-17s on Schweinfurt, the plants were severely damaged. Records of the industry taken by the Survey (and supplemented and checked by interrogation) show that production of bearings at this center was reduced sharply—September production was 35 per cent of the pre-raid level. In this attack 36 of our 200 attacking planes were lost. In the famous and much-discussed second attack on October 14, 1943, when the plants were again severely damaged, one of the decisive air battles of the war took place. The 228 bombers participating were strongly attacked by German fighters when beyond the range of their fighter escort. Losses to fighters and to flak cost the United States forces 62 planes, with another 138 damaged in varying degree, some beyond repair. Repeated losses of this magnitude could not be sustained; deep penetrations without escort, of which this was among the earliest, were suspended, and attacks on Schweinfurt were not renewed for four months. The Germans made good use of the breathing spell. A czar was appointed with unlimited priority for requisitioning men and materials. Energetic steps were taken to disperse the industry. Restoration was aided by the circumstance—which Survey investigations show to have been fairly common to all such raids—that machines and machine tools were damaged far less severely than factory structures. German equipment was redesigned to substitute other types of bearings wherever possible. And the Germans drew on the substantial stocks that were on hand. Although there were further attacks, production by the Autumn of 1944 was back to pre-raid levels. From examination of the records and personalities in the ball-bearing industry, the user industries and the testimony of war production officials, there is no evidence that the attacks on the ball-bearing industry had any measurable effect on essential war production.

"The heavy losses over Schweinfurt caused an important revision in the tactics of daylight bombing. Until then it had been believed that unescorted bombers, heavily gunned and flying in well designed formations, could penetrate this deeply over the Reich. At least, so far as a small force was concerned, this was proven wrong. For the remainder of 1943 after the Schweinfurt raids, daylight penetrations beyond fighter escort were sharply circumscribed. Meanwhile the U. S. heavy bomber force increased substantially in strength. In December of 1943, the P-51 Mustang long-range fighter first became available and in the early months of 1944 its numbers increased. With this plane, in some respects the most important addition to allied air power during the European war, augmenting the P-47 Thunderbolt escorts which in the meantime had materially increased their range, daylight operations in depth were again launched.

"The attack on the German aircraft industry—primarily on airframe plants—was opened in the Summer of 1943. The German aircraft industry had been well distributed over the Reich with a view to the possibility of air attack. Isolated raids early in 1941 and 1942 had caused some further shift in production to eastern territory but only limited steps had been taken to disperse individual plant units in order to reduce their vulnerability. The industry was found to have had substantial excess capacity. The efficiency of the industry was low. Unlike other armaments, procurement was not under the direction of the Speer ministry but under the Luftwaffe.

"Production in the early years of the war was small, primarily because Luftwaffe requirements were modest—in 1941 according to captured minutes of German staff conferences, Gen. Jeschonneck, then chief of the air staff, opposed a suggested increase in fighter plane production with the remark that he wouldn't know what to do with a monthly production of more than 360 fighters. However, in the Autumn of 1943 plans then current called for a steadily increasing output of fighters.

"In the 1943 attacks, 5,092 tons were dropped on 14 plants, primarily on airframe plants. The records show that acceptances of the ME-109, Germany's standard single-engine fighter, dropped from 725 in July to 536 in September and to a low of 357 in December. Acceptances of Focke-Wulf 190s dropped from 325 in July to 203 in December. As a result of the attacks the Germans began a more vigorous program of subdividing and dispersing aircraft plants and this caused part of the reduction in production. A further but undetermined part was the result of poor weather which cut down acceptance flights; it is probable that some planes produced but not accepted during these months were added to acceptance figures in the months following. The Germans as a result of these attacks decided to place increased emphasis on the production of fighter planes.

"The culminating attacks on the German aircraft industry began in the last week of February, 1944. With the protection of long-range fighter escort, 3,636 tons of bombs were dropped on German aircraft plants (again, airframe rather than engine plants) during that week. In that and succeeding weeks every known aircraft plant in Germany was hit. Detailed production data for this period, as for others, were taken by the Survey, and German air generals, production officials, and leading manufacturers, including Messerschmitt and Tank (of Focke-Wulf) were interrogated at length. Production was not knocked out for long. On the contrary, during the whole year of

1944 the German air force is reported to have accepted a total of 39,807 aircraft of all types—compared with 8,295 in 1939, or 15,596 in 1942 before the plants suffered any attack. Although it is difficult to determine exact production for any single month, acceptances were higher in March, the month after the heaviest attack, than they were in January, the month before. They continued to rise.

"Part of the explanation was the excess capacity of the airframe industry which, as noted, was considerable. Excess capacity in airframes was considerably greater than in engines. Studies of individual plants by the Survey show that although buildings were destroyed the machine tools showed remarkable durability. And the Germans showed capacity for improvising their way out. Immediately after the attacks, responsibility for production was shifted from the Luftwaffe to the Speer ministry. A special staff was organized for the reconstitution and dispersal of the industry. This staff (the Jaegerstab or Fighter-Staff) appears to have done an effective job of mobilizing unused capacity and undamaged machines, reorganizing inefficient managements, reducing the number of types of planes and, most important of all, in subdividing production into small units that were comparatively immune from attack. It was aided by previous plans for expansion and it cut sharply into available inventories of parts. Although the testimony on the point is conflicting, the Jaegerstab may have sacrificed quality and an adequate complement of spare parts, for quantity production. Nevertheless the attack on the aircraft plants, like the attack on the ball-bearing plants, showed that to knock out a single industry with the weapons available in 1943 and early 1944 was a formidable enterprise demanding continuous attacks to effect complete results. Recovery was improvised almost as quickly as the plants were knocked out. With the shift in priority for strategic attacks—first to marshalling yards and bridges in France in preparation for invasion, immediately followed by the air campaign against oil—the continued attacks on the aircraft industry were suspended.

"The seeming paradox of the attack on the aircraft plants is that, although production recovered quickly, the German air force after the attacks was not again a serious threat to allied air superiority. The attacks in the Winter of 1944 were escorted by P-51s and P-47s and with the appearance of these planes in force a sharp change had been ordered in escort tactics. Previously the escort planes had to protect the bomber force as their primary responsibility. They were now instructed to invite opposition from German fighter forces and to engage them at every opportunity. As a result, German fighter losses mounted sharply. The claimed losses in January were 1,115 German fighters, in February 1,118 and in March 1,217. The losses in planes were accompanied by losses in experienced pilots and disorganization and loss of the combat strength of squadrons and groups. By the

Spring of 1944 opposition of the Luftwaffe had ceased to be effective. German air generals responsible for operations in France stated under interrogation that on D-Day the Luftwaffe had only 80 operational planes with which to oppose the invasion. At no time between D-Day and the breakthrough at St. Lo did reinforcements offset losses and increase the size of this force.

"German fighter production continued to increase during the Summer of 1944, and acceptances reached a peak of 3,375 in September. Although it has studied the problem with considerable care, the Survey has no clear answer as to what happened to these planes; the differences of opinion between German air generals, it might be added, are at least as great as between those who have searched for the explanation. Certainly only a minority of the planes appeared in combat. Possibly the remainder were lost in transit from factory to combat bases, destroyed on the fields, or grounded because of a shortage of gasoline or pilots. Conceivably some are part of an inflation of German production figures. The answer is not clear.

"After September, German aircraft production declined gradually until December, when 3,155 planes were accepted, and in January, 1945, because of the shortage of gasoline, production of all except jet types was virtually discontinued. The jet planes, especially the ME-262, were the most modern planes which any belligerent had in general operation at the end of the war. According to manufacturers and other competent observers, their production was delayed because of the failure of the Luftwaffe to recognize in time the advantages of the type. It was also delayed because Hitler intervened in 1944 with an ill-timed order to convert the ME-262 to a fighter-bomber. Virtually every manufacturer, production official, and air force general interrogated by the Survey, including Goering himself, claimed to have been appalled by this order. By May, 1945, 1,400 jets had been produced. Had these planes been available six months earlier with good quality pilots, though they might not have altered the course of the war, they would have sharply increased the losses of the attacking forces.

"With reduction of German air power, oil became the priority target in the German economy. The bomber force for several months had been adequate for the task. A preliminary attack was launched on May 12, 1944, followed by another on May 28; the main blow was not struck, however, until after D-Day. In the months before D-Day and for a shorter period immediately following, all available air power based on England was devoted to insuring the success of the invasion. Virtually complete records of the German oil industry were taken by the Survey. In addition, major plants that were subject to attack and their records were studied in detail.

"The German oil supply was tight throughout the war, and was a controlling factor in military operations. The chief source of supply, and the only source for aviation gasoline, was 13 synthetic plants together with a small production from three additional ones that started operations in 1944. The major sources of products refined from crude oil were the Ploesti oil fields in Rumania and the Hungarian fields which together accounted for about a quarter of the total supply of liquid fuels in 1943. In addition, there was a small but significant Austrian and domestic production. The refineries at Ploesti were attacked, beginning with a daring and costly low-level attack in August, 1943. These had only limited effects; deliveries increased until April, 1944, when the attacks were resumed. The 1944 attacks, together with mining of the Danube, materially reduced Rumanian deliveries. In August, 1944, Russian occupation eliminated this source of supply and dependence on the synthetic plants became even greater than before.

Production from the synthetic plants declined steadily and by July, 1944, every major plant had been hit. These plants were producing an average of 316,000 tons per month when the attacks began. Their production fell to 107,000 tons in June and 17,000 tons in September. Output of aviation gasoline from synthetic plants dropped from 175,000 tons in April to 30,000 tons in July and 5,000 tons in September. Production recovered somewhat in November and December, but for the rest of the war was but a fraction of pre-attack output.

"The Germans viewed the attacks as catastrophic. In a series of letters to Hitler, among documents seized by the Survey, the developing crisis is outlined month by month in detail. On June 30, Speer wrote: 'The enemy has succeeded in increasing our losses of aviation gasoline up to 90 per cent by June 22. Only through speedy recovery of damaged plants has it been possible to regain partly some of the terrible losses.' The tone of the letters that followed was similar. As in the case of ball-bearings and aircraft, the Germans took the most energetic steps to repair and reconstruct the oil plants. Another czar was appointed, Edmund Geilenberg, and again an overriding priority on men and materials was issued. Geilenberg used as many as 350,000 men for the repair, rebuilding, and dispersal of the bombed plants and for new underground construction. The synthetic oil plants were vast complex structures and they could not be easily broken up and dispersed. The programs of dispersal and underground construction that were undertaken were incomplete when the war ended.

"The synthetic oil plants were brought back into partial production and in remarkably short time. But unlike the ball-bearing plants, as soon as they were brought back they were attacked again. The story of Leuna is illustrative. Leuna was the largest of the synthetic plants and protected by a highly effective smoke screen and the heaviest flak concentration in Europe. Air crews viewed a mission to Leuna as the most dangerous and difficult assignment of the air war. Leuna was hit on May 12 and put out of production. However, investigation of plant records and interrogation of Leuna's officials established that a force of several thousand men had it in partial operation in about 10 days. It was again hit on May 28 but resumed partial production on June 3 and reached 75 per cent of capacity in early July. It was hit again on July 7 and again shut down but production started two days later and reached 53 per cent of capacity on July 19. An attack on July 20 shut the plant down again but only for three days; by July 27 production was back to 35 per cent of capacity. Attacks on July 28 and 29 closed the plant and further attacks on August 24, September 11, 13, 28 and October 7 kept it closed down. However, Leuna got started again on October 14 and although production was interrupted by a small raid on November 2, it reached 28 per cent of capacity by the 20th. Although there were six more heavy attacks in November and December (largely ineffective because of adverse weather), production was brought up to 15 per cent of capacity in January and was maintained at that level until nearly the end of the war. From the first attack to the end, production at Leuna averaged nine per cent of capacity. There were 22 attacks on Leuna, 20 by the Eighth Air Force and two by the RAF. Due to the urgency of keeping this plant out of production, many of these missions were dispatched in difficult bombing weather. Consequently, the order of bombing accuracy on Leuna was not high as compared with other targets. To win the battle with Leuna a total of 6,552 bomber sorties were flown against the plant, 18,328 tons of bombs were dropped and an entire year was required.

"Consumption of oil exceeded production from May, 1944, on. Accumulated stocks were rapidly used up, and in six months were practically exhausted. The loss of oil production was sharply felt by the armed forces. In August the final run-in-time for aircraft engines was cut from two hours to one-half hour. For lack of fuel, pilot training, previously cut down, was further curtailed. Through the Summer, the movement of German panzer divisions in the field was hampered more and more seriously as a result of losses in combat and mounting transportation difficulties, together with the fall in fuel production. By December, according to Speer, the fuel shortage had reached catastrophic proportions. When the Germans launched their counter-offensive on December 16, 1944, their reserves of fuel were insufficient to support the operation. They counted on capturing allied stocks. Failing in this, many panzer units were lost when they ran out of gasoline. In February and March of 1945 the Germans massed 1,200 tanks on the Baranov bridgehead at the Vistula to check the Russians. They were immobilized for lack of gasoline and overrun.

"The attack on the synthetic oil plants was also found to have cost

Germany its synthetic nitrogen and methanol supply and a considerable part of its rubber supply. Germany, like other industrial countries, relied on synthesis for its supply of nitrogen and the synthetic oil plants were by far the largest producers. Sixty per cent of the nitrogen production and 40 per cent of the methanol production came from two synthetic plants. Monthly output of synthetic nitrogen in early 1944, before the synthetic plants were attacked, was about 75,000 tons. It had been reduced by the end of the year to about 20,000 tons. Nitrogen, besides being indispensable for explosives, is heavily used in German agriculture. Allocation for the 1943-44 crop year was 54 per cent of the total supply; allocation for 1944-45 was first planned at 25 per cent and later eliminated altogether. Nitrogen for munitions was maintained by reducing the allocation to agriculture, but by the end of 1944 this cushion had been substantially exhausted. The supply of explosives then declined with the reduction in supply of nitrogen. It became necessary to fill shells with a mixture of explosives and non-explosive rock salt extender. There was a general shortage of ammunition on all fronts at the end of the war. There was an equally serious shortage of flak ammunition; units manning flak guns were instructed not to fire on planes unless they were attacking the installations which the guns were specifically designated to protect and unless 'they were sure of hitting the planes!' It is of some interest that a few weeks before the close of hostilities the Germans reallocated nitrogen to agriculture at the expense of ammunition. This was the result, according to Speer, of an independent decision of his own that the war was lost and the next year's crop should be protected. Methanol production, necessary among other things for TNT, hexogen and other high explosives, was as severely affected as nitrogen production. Allocations to the principal consumers was heavily cut, and eventually the production of hexogen was abandoned. The loss of methanol coupled with the reduction in nitrogen was followed by a precipitate decline in production of explosives.

"The synthetic rubber industry also suffered from the attack on oil. Official German records on raw material supplies show that stockpiles of rubber were small at the beginning of the war—at the most sufficient for only two or three months consumption. Imports through the blockade were unimportant. The supply came from four synthetic plants, one of which was a small pilot plant; and two additional plants were under construction during the war. One of the major plants, located at Huels, was attacked as a primary target by the Eighth Air Force in June, 1943, and closed for a month; it required three months to get back to 72 per cent of capacity and seven months to get back to full production. However, it operated on gas from synthetic oil plants in the Ruhr; when these were knocked out in the Summer of 1944, production was again reduced substantially.

Production at Schkopau, the largest of the synthetic rubber plants, was lost because it was dependent on hydrogen from Leuna. Investigation of the two remaining plants revealed that production was largely eliminated because of attacks on oil plants of which they were a part. By the end of 1944 over-all statistics for the industry show that production of synthetic rubber had been reduced to 2,000 tons a month or about one-sixth the wartime peak. Had the war continued, Germany's rubber position would have become critical. No indication was found, however, that the rubber shortage had become a limiting factor on German war production or the movement of the German army before the war ended. Except for oil and associated nitrogen, methanol, and rubber production, no parts of the German chemical industry were a priority target of the Combined Bomber Offensive.

"By mid-1944 the air war had entered a new phase. Its most important feature, apart from mastery of the air, was the greatly increased weight of the attack that could be brought to bear. In the second half of 1944, 481,400 tons of bombs were dropped on Germany as compared with 150,700 in all 1943. The RAF and the United States Army Air Forces during this period were teamed in a fully coordinated offensive, and the RAF was returning to the attack of specific industrial targets. A target that was attacked with poor results in 1943 might have yielded major returns in 1944 for the simple reason that an attack in 1944 was certain to be enormously heavier. With improved bombing techniques it was also likely to be considerably more accurate. Increased weight was a major feature of the raids that reduced the German steel industry.

"Germany began the war with approximately 23,000,000 metric tons per year of steel capacity, about 69 per cent of which was in the Ruhr. The 1940 victories added another 17,000,000 tons principally in Lorraine, Belgium and Luxembourg. However, official records and those of the industry for the war years, supplemented by interrogation, show that the 40,000,000 tons theoretical capacity was never reached. Production in the occupied countries was always troublesome and deficient. In spite of the considerable efforts to develop low-grade ores in Germany proper and medium grade ores in Austria, Germany throughout the war continued to be primarily dependent on Swedish, Norwegian and French ores. Unlike the United States, Germany did not have to find steel to build a large merchant fleet or for a program of heavy naval construction. Nor did she have to build a complete munitions industry in the middle of the war. For these reasons the German steel supply for finished munitions was only slightly less liberal than that of the United States. Although steel was considered a bottleneck by the Germans, a detailed examination of the control machinery together with interrogation of officials in the Speer ministry and its predecessor organizations, reveals that the trouble was partly an inefficient allocation system and partly, in the early years of the war especially, an unwillingness to cut out non-essential construction and civilian consumption. German industrialists were also found to have had a marked propensity to hoard steel.

"Throughout the war there was considerable debate whether the German steel industry was a desirable target—and especially whether steel mills were vulnerable to the type of attack that could be made. In 1943 the RAF made a modest attack on the steel industry of the Ruhr but the attack was given up because it was believed to have been too costly for the results achieved. Production records taken by the Survey show, in fact, that it had some effect; production in the Ruhr declined by approximately 10 per cent during the attack and did not fully recover during the remainder of the year. German steel producers were required by the government to keep records of production losses and their causes. These records show that air raid alerts in 1943 were a more serious cause of the lost production than the actual damage from the raids.

"During the last half of 1944 both the cities and the transportation system of the Ruhr were the targets of extremely heavy attack, primarily by the RAF. Production of steel in the Ruhr was reduced by 80 per cent between June and the end of the year. Loss of production of high-grade steel in the Ruhr was greater than the loss of Bessemer steel, and high-grade steel became a bottleneck by the middle of 1944. German steel production for all the Reich and occupied countries declined from 2,570,000 metric tons in July to 1,000,000 metric tons in December. Of this loss about 490,000 tons was the result of loss of territory.

"Examination of the steel plants showed that, although the attack damaged some blast furnaces, open hearths and rolling mills, it was primarily effective through damage to utilities (electricity, gas and water) and communications within the plants and to utilities and transport supplying the plants. Although steel production had been reduced to critical levels by the end of 1944 and continued to fall until the end of the war, Survey studies do not indicate that the steel shortage (unlike the oil shortage or even the ammunition shortage) was decisive. It might have been decisive if the war had continued, and if this specific shortage had not been overshadowed by the disintegration of the whole economy. As it developed at the end of the war, certain German industries had inventories of steel that ranged from comfortable to generous.

"During the course of the air war, and particularly during 1944 and 1945, a number of other German industries were attacked, some of them in force and others merely as secondary targets, or as targets of opportunity when the main objective could not be reached or found. The Survey has examined each of these industries. Individual plants and records were examined and analyzed in conjunction with over-all industry data which were also located.

"Plants producing tanks and armored vehicles were attacked occasionally in 1943 and early 1944. They were attacked more strongly in August, September and October, 1944, in an effort to provide direct support to ground operations. Between October, 1943, and July, 1944, the period of the first attacks, the industry produced 14,000 tanks and related vehicles. Analysis of production schedules suggests that these attacks cost the Germans several hundred units. By the time of the heavier attacks, production, especially production of engines and components, had been considerably expanded and dispersed. The effect again may have been to cause the industry to fall short of achievable production. Production dropped from 1,616 in August to 1,552 in September. However, it rose to 1,612 in October and to 1,770 in November, and reached its wartime peak in December, 1944, when 1,854 tanks and armored vehicles were produced. This industry continued to have relatively high production through February, 1945.

"In the last half of 1944 German truck production was attacked. Three plants produced most of Germany's truck supply. One of these, Opel at Brandenburg, was knocked out completely in one raid on August 6, 1944, and did not recover. Daimler Benz was similarly eliminated by attacks in September and October. Ford at Cologne, the third large producer, was not attacked, but records show that production was sharply curtailed during the same period by destruction of component suppliers and the bombing of its power supply. By December, 1944, production of trucks was only about 35 per cent of the average for the first half of 1944.

"In November, 1944, the allied air forces returned to an attack on the submarine building yards. In the months that had elapsed since the Spring of 1943, the Germans had put into production the new Types 21 and 23 designed to operate for long periods without surfacing and so escape radar equipped aircraft patrols as well as surface attack. And an ambitious effort had been made to prefabricate submarine hulls and turn the slipways into mere points of final assembly. The program was not working smoothly. Though nearly two hundred had been produced, difficulties with the new type, together with the time required for training crews, had prevented all but eight from becoming operational. These delays cannot be attributed to the air attack. The attacks during the late Winter and early Spring of 1945 did close, or all but close, five of the major yards, including the great Blohm and Voss plant at Hamburg. Had the war continued these attacks, coupled with the attack on transportation, would have removed the threat of further production of the new submarine.

"Many more German industries were hit—mostly in the course of the city attacks of the RAF, but some as secondary targets of daylight attacks, or in spill-overs from the primary target. Industries so attacked included optical plants, power plants, plants making electrical equipment, machine tool plants, and a large number of civilian industries. There were also special enterprises. The bombing of the launching sites being prepared for the V weapons delayed the use of V-1 appreciably. The attacks on the V-weapon experimental station at Peenemunde, however, were not effective; V-1 was already in production near Kassel and V-2 had also been moved to an underground plant. The breaking of the Mohne and the Eder dams, though the cost was small, also had limited effect. Certain of the attacks—as for example the Berlin raids that cost the Germans a good half of their clothing industry—caused the Germans manifest discomfort and may have delayed war production. Also, in the aggregate, they caused some diversion of resources from essential war production, although this effect was minimized by the substantial cushion in Germany's war economy until the closing months of the war.

"The attack on transportation was the decisive blow that completely disorganized the German economy. It reduced war production in all categories and made it difficult to move to the front what was produced. The attack also limited the tactical mobility of the German army. The Survey made a careful examination of the German railway system, beginning as soon as substantial portions were in Allied hands. While certain important records were destroyed or lost during the battle of Germany, enough were located so that together with interrogation of many German railroad officials, it was possible to construct an accurate picture of the decline and collapse of the system. Germany entered the war with an excellent railway system; it had general overcapacity in both lines and yards (built partly in anticipation of military requirements), and, popular supposition to the contrary, the system was not undermaintained. Standards of maintenance were higher than those general in the United States. The railway system was supplemented by a strong inland waterways system connecting the important rivers of northern Germany, crisscrossing the Ruhr and connecting it with Berlin. The waterways carried from 21 to 26 per cent of the total freight movement. Commercial highway transport of freight was insignificant; it accounted for less than three per cent of the total.

"Although the investigation shows that the railroad system was under strain—especially during the winter campaign in Russia in 1941-42 when there was a serious shortage of cars and locomotives—it was generally adequate for the demands placed upon it until the Spring of 1944. New construction and appropriation of equipment of occupied countries remedied the locomotive and car shortage. The Reichsbahn had taken no important steps to prepare itself for air attack.

"The attack on German transportation was intimately woven with the development of ground operations. In support of the invasion a major assignment of the air forces had been the disruption of rail traffic between Germany and the French coast through bombing of marshalling yards in northern France. At the time of the invasion itself a systematic and large-scale attempt was made to interdict all traffic to the Normandy beachhead. These latter operations were notably successful; as the front moved to the German border the attack was extended to the railroads of the Reich proper. Heavy and medium bombers and fighters all participated.

"Although prior to September, 1944, there had been sporadic attacks on the German transportation system, no serious deterioration in its ability to handle traffic was identified by the Survey. The vastly heavier attacks in September and October, 1944, on marshalling yards, bridges, lines, and on train movements, produced a serious disruption in traffic over all of western Germany. Freight car loadings, which were approximately 900,000 cars for the Reich as a whole in the week ending August 19 fell to 700,000 cars in the last week of October. There was some recovery in early November, but thereafter they declined erratically to 550,000 cars in the week ending December 23 and to 214,000 cars during the week ending March 3. Thereafter the disorganization was so great that no useful statistics were kept.

"The attack on the waterways paralleled that on the railways; the investigation shows that it was even more successful. On September 23, 1944, the Dortmund-Ems and Mittelland canals were interdicted stopping all through water traffic between the Ruhr and points on the north coast and in central Germany. By October 14, traffic on the Rhine had been interdicted by a bomb that detonated a German demolition charge on a bridge at Cologne. Traffic in the Ruhr dropped sharply and all water movement of coal to south Germany ceased. The effect of this progressive traffic tie-up was found, as might be expected, to have first affected commodities normally shipped in less-than-trainload lots—finished and semi-finished manufactured goods, components, perishable consumer goods and the less bulky raw materials. Cars loaded with these commodities had to be handled through the marshalling yards and after the September and October attacks this became increasingly difficult or impossible. Although output of many industries reached a peak in late Summer and declined thereafter, total output of the economy was on the whole well-maintained through November. Beginning in December there was a sharp fall in production in nearly all industries; week by week the decline continued until the end of the war.

"Although coal traffic (about 40 per cent of all the traffic carried by the German railways) held up better than miscellaneous commercial traffic, the decline was both more easily traceable and more dramatic. The September raids reduced coal-car placements in the Essen Division of the Reichsbahn (the originator of most of the coal traffic of the Ruhr) to an average of 12,000 cars daily as compared with 21,400 at the beginning of the year. Most of this was for consumption within the Ruhr. By January, placements in the Ruhr were down to 9,000 cars a day and in February virtually complete interdiction of the Ruhr District was achieved. Such coal as was loaded was subject to confiscation by the railroads to fuel their locomotives; even with this supply, coal stocks of the Reichsbahn itself were reduced from 18 days supply in October, 1944, to 4½ days supply in February, 1945. By March some divisions in southern Germany had less than a day's supply on hand, and locomotives were idle because of lack of coal. The German economy was powered by coal; except in limited areas, the coal supply had been eliminated.

"Military (Wehrmacht) traffic had top priority over all other traffic. During the period of attack this traffic came to account for an ever-increasing proportion of the declining movement. Through 1944 the air attack did not prevent the army from originating such movements although the time of arrival or even the arrival of units and equipment became increasingly uncertain. Couriers accompanied detachments and even shipments of tanks and other weapons; their task was to get off the train when it was delayed and report where it could be found. After the turn of the year even military movements became increasingly difficult. The Ardennes counter-offensive, the troops and equipment for which were marshalled over the railroads, was probably the last such effort of which the Reichsbahn would have been capable in the west.

"The German power system, except for isolated raids, was never a target during the air war. An attack was extensively debated during the course of the war. It was not undertaken partly because it was believed that the German power grid was highly developed and that losses in one area could be compensated by switching power from another. This assumption, detailed investigation by the Survey has established, was incorrect. The German electric power situation was in fact in a precarious condition from the beginning of the war and became more precarious as the war progressed; this fact is confirmed by statements of a large number of German officials, by confidential memoranda of the National Load Dispatcher, and secret minutes of the Central Planning Committee. Fears that their extreme vulnerability would be discovered were fully discussed in these minutes. The destruction of five large generating stations in Germany would have caused a capacity loss of 1.8 million kw. or 8 per cent of the total capacity, both public and private. The destruction of 45 plants of 100,000 kw. or larger would have caused a loss of about 8,000,000 kw. or almost 40 per cent, and the destruction of a total of 95 plants of 50,000 kw. or larger would have eliminated over one-half of the entire generating capacity of the country. The shortage was sufficiently critical so that any considerable loss of output would have directly affected essential war production, and the destruction of any substantial amount would have had serious results.

"Generating and distributing facilities were relatively vulnerable and their recuperation was difficult and time consuming. Had electric generating plants and substations been made primary targets as soon as they could have been brought within range of allied attacks, the evidence indicates that their destruction would have had serious effects on Germany's war production.

"A word perhaps should be added on the effect of the air war on the German civilian and on the civilian economy. Germany began the war after several years of full employment and after the civilian standard of living had reached its highest level in German history. In the early years of the war—the soft war period for Germany—civilian consumption remained high. Germans continued to try for both guns and butter. The German people entered the period of the air war well stocked with clothing and other consumer goods. Although most consumer goods became increasingly difficult to obtain, Survey studies show that fairly adequate supplies of clothing were available for those who had been bombed out until the last stages of disorganization. Food, though strictly rationed, was in nutritionally adequate supply throughout the war. The Germans' diet had about the same calories as the British.

"German civilian defense was examined by Survey representatives familiar with U. S. and British defenses. The German system had been devised as protection against relatively small and isolated attacks. The organization had to be substantially revised when the attacks grew to saturation proportions. In particular, arrangements were made by which a heavily bombed community might call on the fire-fighting and other defensive resources of surrounding communities and, as a final resort, on mobile reserves deployed by the central Government through the more vulnerable areas. In the attacks on German cities incendiary bombs, ton for ton, were found to have been between four and five times as destructive as high explosive. German fire defenses lacked adequate static and other water reserves replenished by mains independent of the more vulnerable central water supply. However, in the more serious fire raids, any fire-fighting equipment was found to have been of little avail. Fire storms occurred, the widespread fires generating a violent hurricane-like draft, which fed other fires and made all attempts at control hopeless.

"German shelters, so far as they were available, were excellent. In England the policy was to build a large number of shelters which protected those taking refuge from bombs falling in the area and from falling and flying debris but which were not secure against a direct hit. The Germans, by contrast, built concrete bunkers, some of enormous size, both above and below ground, designed to protect those taking shelter even against a direct hit. One such shelter in Hamburg, named the "Holy Ghost" for its location on Holy Ghost Plaza, sheltered as many as 60,000 people. There were not, however, enough such shelters; at the close of the war shelter accommodation was available for only about eight million people. The remainder sheltered in basements, and casualties in these places of refuge were heavy. After raids the Germans did not attempt systematic recovery of all bodies or even of all trapped persons. Those that could not readily be removed were left.

"Official German statistics place total casualties from air attack—including German civilians, foreigners, and members of the armed forces in cities that were being attacked—at 250,253 killed for the period from January 1, 1943, to January 31, 1945, and 305,455 wounded badly enough to require hospitalization, during the period from October 1, 1943, to January 31, 1945. A careful examination of these data, together with checks against the records of individual cities that were attacked, indicates that they are too low. A revised estimate prepared by the Survey (which is also a minimum) places total casualties for the entire period of the war at 305,000 killed and 780,000 wounded. More reliable statistics are available on damage to housing. According to these, 485,000 residential buildings were totally destroyed by air attack and 415,000 were heavily damaged, making a total of 20 per cent of all dwelling units in Germany. In some 50 cities that were primary targets of the air attack, the proportion of destroyed or heavily damaged dwelling units is about 40 per cent. The result of all these attacks was to render homeless some 7,500,000 German civilians.

"It is interesting to note some of the effects of air attack upon medical care and military casualties during the war. The aerial warfare against Germany forced the German military and civilian authorities to recognize that national health and medical problems were a joint responsibility. The destruction of hospital equipment, pharmaceutical production, and medical supplies, incident to area raids, forced a dispersal of medical supply installations and the removal of hospitals from city to suburban and country sites. This program came in late 1943 at a time when air raids on cities were causing increased casualties among civilians and resulted in shortages in ether, plasters, serums, textiles, and other medical supplies. At the same time the increased tempo of tactical air action was having an effect on military casualty rates, and is reflected in the fact that, according to German reports, war casualties from aerial weapons moved from third place in 1942 to first place in late 1943, 1944, and 1945, followed in order by artillery fire and infantry weapons. The casualty effects of air action are shown by the fact that the proportion of wounded to killed shifted from a ratio of eight to one in 1940 and 1941 to a ratio of three to one in 1944 and 1945. Personnel wounded by air action suffered as a rule multiple wounds and shock, resulting in longer periods of hospitalization and convalescence, and in a decided reduction in the number of patients who could be returned to either full or limited military duty.

"The foregoing pages tell of the results achieved by allied air power, in each of its several roles in the war in Europe. It remains to look at the results as a whole and to seek such signposts as may be of guidance to the future. Allied air power was decisive in the war in Western Europe. Hindsight inevitably suggests that it might have been employed differently or better in some respects. Nevertheless, it was decisive. In the air, its victory was complete. At sea, its contribution, combined with naval power, brought an end to the enemy's greatest naval threat—the U-boat; on land, it helped turn the tide overwhelmingly in favor of allied ground forces. Its power and superiority made possible the success of the invasion. It brought the economy which sustained the enemy's armed forces to virtual collapse, although the full effects of this collapse had not reached the enemy's front lines when they were overrun by allied forces. It brought home to the German people the full impact of modern war with all its horror and suffering. Its imprint on the German nation will be lasting.

"The German experience suggests that even a first class military power—rugged and resilient as Germany was—cannot live long under full-scale and free exploitation of air weapons over the heart of its territory. By the beginning of 1945, before the invasion of the homeland itself, Germany was reaching a state of helplessness. Her armament production was falling irretrievably, orderliness in effort was disappearing, and total disruption and disintegration were well along. Her armies were still in the field. But with the impending collapse of the supporting economy, the indications are convincing that they would have had to cease fighting—any effective fighting—within a few months. Germany was mortally wounded.

"The significance of full domination of the air over the enemy—both over its armed forces and over its sustaining economy—must be emphasized. That domination of the air was essential. Without it, attacks on the basic economy of the enemy could not have been delivered in sufficient force and with sufficient freedom to bring effective and lasting results.

"As the air offensive gained in tempo, the Germans were unable to prevent the decline and eventual collapse of their economy. Nevertheless, the recuperative and defensive powers of Germany were immense; the speed and ingenuity with which they rebuilt and maintained essential war industries in operation clearly surpassed allied expectations. Germany resorted to almost every means an ingenious people could devise to avoid the attacks upon her economy and to minimize their effects. Camouflage, smoke screens, shadow plants, dispersal, underground factories, were all employed. In some measure all were helpful, but without control of the air, none was really effective. Dispersal brought a measure of immediate relief, but eventually served only to add to the many problems caused by the attacks on the transportation system. Underground installations prevented direct damage, but they, too, were often victims of disrupted transportation and other services. In any case, Germany never succeeded in placing any substantial portion of her war production underground—the effort was largely limited to certain types of aircraft, their components, and the V weapons. The practicability of going underground as the escape from full and free exploitation of the air is highly questionable; it was so considered by the Germans themselves. Such passive defenses may be worth while and important, but it may be doubted if there is any escape from air domination by an enemy.

"The mental reaction of the German people to air attack is significant. Under ruthless Nazi control they showed surprising resistance to the terror and hardships of repeated air attack, to the destruction of their homes and belongings, and to the conditions under which they were reduced to live. Their morale, their belief in ultimate victory or satisfactory compromise, and their confidence in their leaders declined, but they continued to work efficiently as long as the physical means of production remained. The power of a police state over its people cannot be underestimated.

"The importance of careful selection of targets for air attack is emphasized by the German experience. The Germans were far more concerned over attacks on one or more of their basic industries and services—their oil, chemical, or steel industries or their power or transportation networks—than they were over attacks on their armament industry or the city areas. The most serious attacks were those which destroyed the industry or service which most indispensably served other industries. The Germans found it clearly more important to devise measures for the protection of basic industries and services than for the protection of factories turning out finished products.

"The German experience showed that, whatever the target system, no indispensable industry was permanently put out of commission by a single attack. Persistent re-attack was necessary.

"In the field of strategic intelligence, there was an important need for further and more accurate information, especially before and during the early phases of the war. The information on the German economy available to the United States Air Forces at the outset of the war was inadequate. And there was no established machinery for coordination between military and other governmental and private organizations. Such machinery was developed during the war. The experience suggests the wisdom of establishing such arrangements on a continuing basis.

"Among the most significant of the other factors which contributed to the success of the air effort was the extraordinary progress during the war of allied research, development, and production. As a result of this progress, the air forces eventually brought to the attack superiority in both numbers and quality of crews, aircraft, and equipment. Constant and unending effort was required, however, to overcome the initial advantages of the enemy and later to keep pace with his research and technology. It was fortunate that the leaders of the German Air Force relied too heavily on their initial advantage. For this reason they failed to develop, in time, weapons, such as their jet-propelled planes, that might have substantially improved their position. There was hazard, on the other hand, in the fact that the Allies were behind the Germans in the development of jet-propelled aircraft. The German development of the V weapons, especially the V-2, is also noteworthy.

"The achievements of allied air power were attained only with difficulty and great cost in men, material, and effort. Its success depended on the courage, fortitude, and gallant action of the officers and men of the air crews and commands. It depended also on a superiority in leadership, ability, and basic strength. These led to a timely and careful training of pilots and crews in volume; to the production of planes, weapons, and supplies in great numbers and of high quality; to the securing of adequate bases and supply routes; to speed and ingenuity in development; and to cooperation with strong and faithful allies. The failure of any one of these might have seriously narrowed and even eliminated the margin.

"The air war in Europe was marked by continuous development and evolution. This process did not stop on VE-Day; great strides have been made since in machines, weapons, and techniques. No greater or more dangerous mistake could be made than to assume that the same policies and practices that won the war in Europe will be sufficient to win the next one—if there should be another. The results achieved in Europe will not give the answer to future problems; they should be treated rather as signposts pointing the direction in which such answers may be found. The great lesson to be learned in the battered towns of England and the ruined cities of Germany is that the best way to win a war is to prevent it from occurring. That 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 come from 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.

"Suggestions for assuring the 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. In maintaining our strength and our security, the signposts of the war in Europe indicate the directions in which greater assurances may be found. Among these are intelligent long-range planning by the armed forces in close and active cooperation with other government agencies, and with the continuous active participation of independent civilian experts in time of peace as well as in war; continuous and active scientific research and technical development on a national scale in time of peace as well as in war; a more adequate and integrated system for the collection and evaluation of intelligence information; that form of organization of the armed forces which clarifies their functional responsibilities and favors a higher degree of coordination and integration in their development, their planning, their intelligence, and their operations; and, finally, in time of peace as well as in war, the highest possible quality and stature of the personnel who are to man the posts within any such organization, whatever its precise form may be—and in this, quality, not numbers, is the important criterion.

"The air has become a highway which has brought within easy access every point on the earth's surface—a highway to be traveled in peace, and in war, over distances without limit at ever-increasing speed. The rapid developments in the European war foreshadow further exploration of its potentialities. Continued development is indicated in the machines and in the weapons which will travel the reaches of this highway. The outstanding significance of the air in modern warfare is recognized by all who participated in the war in Europe or who have had an opportunity to evaluate the results of aerial offensive. These are facts which must govern the place accorded air power in plans for coordination and organization of our resources and skills for national defense. Speed, range, and striking power of the air weapons of the future, as indicated by the signposts of the war in Europe must—specifically—be reckoned with in any plans for increased security and strength. The combination of the atomic bomb with remote-control projectiles of ocean-spanning range stands as a possibility which is awesome and frightful to contemplate. These are some of the many factors which will confront our national leaders who will have primary responsibility for correctly reading the signposts of the past."

On January 31, 1946, the War Department announced that the Army Air Forces had activated The First Experimental Guided

Missiles Group, stating: "The functions of the group, to be commanded by Col. Harvey T. Alness, former commander of the Seventh Bomb Group in India, will be development of tactics and techniques of guided missile operations, training of personnel, development of organizational and equipment requirements of the group and demonstration of guided missiles in the AAF program. It is anticipated that guided missiles, not fully enough developed for operational use until the latter months of the war, will play a very important part in future weapons of aerial warfare. The primary purpose of the present guided missiles is to supplement and augment strategic bombardment by creating a greater degree of accuracy through devices enabling control over the bomb from the time it leaves the aircraft until it reaches the target. The first guided missile developed, and the only one used in combat, is the Azon bomb, a standard 1,000 M-65 bomb with a special tail that enables it to be steered to the left or right on receipt of radio signals from the plane dropping it.

"Although the only fully developed American guided missiles at the present time are of the air-to-ground types, that is, dropped from an aircraft, extensive plans have been made for the development of other original types, including ground-to-air and ground-to-ground missiles. The German V-2 rocket is an example of ground-to-ground type of missile. Further possibilities of guided missile development include retrievable missiles for reconnaissance and automatic photographic sorties and other similar long-distance missions. The First Experimental Group was activated January 26 and now is in the process of choosing personnel and establishing a headquarters at Eglin Field, Fla. Personnel for the group, to be composed of 715 enlisted men and 130 officers, consist almost entirely of highly trained specialists. The men are being selected for their knowledge of radar, television, infra-red, aerodynamics, control systems, and other scientific devices connected with guided missiles. Under the present organization table, the group will consist of a headquarters squadron, an air-to-ground squadron, and a service squadron. It is anticipated that personnel will be expanded and that additional squadrons, including ground-to-air and ground-to-ground squadrons, will be activated later as the program develops. The group will not participate in origination or technical developments of guided missiles, but will be charged with the responsibility of developing their tactical use and determining the best methods of employing them in combat. In addition, the First Experimental Group will aid in determining the best structure, number of personnel and types of equipment to be used in future groups.

"Under the present program are six objectives: (1) Development of tactics and techniques of guided missile operations. The unit will receive the missiles after they have been designed, tested, and perfected as far as possible for operational use. It then will be the responsibility of the group to determine the best manner in which they can be employed in combat. That will involve extensive tests to determine such factors as, in the case of an air-to-ground missile, the type and number of aircraft employed, best release altitude, and distance from release point to target. (2) Unit testing of guided missiles organizations and equipment. As the guided missiles program is fairly new, it will be necessary to determine the number and types of personnel and equipment necessary to be added to an ordinary bombardment or other combat unit to render it capable of using guided missiles. (3) Development of training requirements and training standards, and (4) Training of individuals. The AAF Training Command at this time does not have facilities to provide instruction in guided missile operation. It will be necessary for the Experimental Group to provide an adequate program outline to the Training Command for instruction of future personnel entering the guided missile field. Until the Training Command can be provided with that program and is equipped to assume the responsibilities of training the personnel, that instruction will have to be provided by the Group. (5) Development of personnel and organizational requirements for employment of guided missiles. The Experimental Group will serve as a test organization to determine the number and types of personnel that can be employed most efficiently by such a unit, thus eliminating personnel and classification problems when additional groups are formed. (6) Demonstration of guided missiles in the AAF program. As tests of new weapons are completed, the group will demonstrate the improvements over older types of weapons as it affects the general AAF offensive and defensive program. The new organization will not be lacking weapons with which to begin operations. Several missiles have been developed and now are ready for tactical experiments. Others, which already have been proved suitable for combat, are being improved upon.

"The Azon bomb was first used successfully in combat by the Seventh Bomb Group under the direction of Col. Alness in India and

THE NORTHROP ARMY F-15 REPORTER

REAR VIEW OF REPUBLIC P-84 JET FIGHTER

Burma. It proved highly successful against bridges. When Rangoon was denied the Japanese as a port of entry, they constructed the Burma-Siam railway, which served as a vital supply link for the Jap forces in Burma. Its continued interdiction was a high priority task for many months. Early in 1945, the Seventh, under the direction of Col. Alness, developed a new method of attack on bridges, employing the Azon bomb in combination with ordinary low-level bombing. Col. Alness requested and obtained permission to use the new Azon method against that important railway. In April, 1945, the Seventh dispatched a force of 40 B-24 Liberators carrying Azon bombs. Ranging up and down the railway for a distance of 200 miles, they destroyed 30 bridges, damaged six more, severely damaged the approaches of seven, and caused track damage at four other points. Statistics on the overall use of Azon bombs on attacks against bridges reveal that one bridge was destroyed for each four sorties, a greatly increased efficiency percentage over ordinary non-guided bombs.

"A further development of the Azon bomb completed just before the end of the war, was the Razon bomb. Razon, controllable in both azimuth and range, was ready for operational use but the war ended before it could be used in combat. Other guided missile projects include Felix, a bomb attracted to heat, and the Roc, a standard 1,000-pound bomb equipped with television to scan the target and relay vital information back to the aircraft.

"Col. Alness began drawing up plans for the First Experimental Group late in December. All men accepted for the original experimental unit will be combat veterans and will be technicians. As a separate unit, guided missiles work is fairly new in the Air Force program. It originally consisted of a section of three men under the

Airways Communications Office, serving only in an advisory capacity. As the importance of guided missiles was realized, the section was expanded to a branch and later to a division. The set-up now consists of a Guided Missiles Division, under Headquarters Army Air Forces, and the First Experimental Group, which is under the Air Forces Center, a tactical experimental and testing organization. The specifications and requirements of guided missiles now originate with the Division. They, in turn, send the specifications to Wright Field, where experimental contracts are let to civilian firms concerned. After the weapon has been constructed and tested, it undergoes acceptance tests at Wright Field. If accepted there, it is turned over to the Guided Missiles Group for tactical experiments. The present guided missiles originated with the National Defense Research Committee. In the future, that function of the AAF program will be the responsibility of the Guided Missiles Division."

On March 1, 1946, the War Department revealed that experiments with "moon radar" and other devices would be carried on in 1946. It stated: "Danger of atom bombardment of our great cities and industrial centers by long-range stratosphere rockets may be considerably lessened if Army Air Forces' efforts to 'track' captured German V-2's by the use of 'moon radar' and other devices are successful in experiments to be held this Summer. White Sands proving ground in New Mexico will provide a desert setting for tests in which the AAF will pit its 'radar brains' against the V-2's. These rockets will be sent streaming 90 miles into the stratosphere by Army Ordnance; and the AAF, in cooperation with the Signal Corps, will attempt to plot their course from the moment of discharge to the moment of impact. Every known means of radar detection, including those devices used recently in reaching the moon, will be utilized by the AAF in an effort to 'keep a finger' on these 3,000-miles-per-hour missiles as they arch across the sky. If this tracking is successful, according to AAF experts, it then will be possible to devise some means of exploding the V-2's harmlessly in mid-air before they can reach their targets—probably by interception with 'counter-attack' rockets.

"Officers and civilians from Watson laboratories, the ground radar laboratory of the Air Technical Service Command at Wright Field, and, if practicable, enlisted personnel from the European occupational air force, will man the radar equipment for the AAF. In attempting to track the rockets in flight from every possible angle, AAF technicians hope to determine which radar devices are best able to trace the aerial route of these sky-torpedoes against which no highly effective means of defense now is available. 'A means must be found,' said Brig. Gen. William L. Richardson, Chief of the Guided Missiles Division, Air Staff-3, 'to defend our country against a sudden enemy rocket attack, and this must be done as quickly as possible. We want to develop a means whereby we can intercept incoming enemy rockets in mid-air. We cannot hope to do this, however, until we discover a method of tracing their course through the sky and predetermining their arc of flight. Once we accomplish this, it will be possible to design a counterattack rocket which will be controlled by radar and will be capable of intercepting the enemy rocket at a predetermined point in its course. The Air Force has been working on rocket defense ever since the first German V-2 landed accidentally in Sweden back in the Autumn of 1943. We hope to come to some definite conclusions this Summer concerning radar's ability to track these rockets effectively. Whatever these conclusions may be, the AAF will go on with its research until a way is found to stop the V-2's, either by interception or by some other means.' "

U. S. Navy photo

U. S. NAVY HEADQUARTERS ON GUAM

The Navy built more than 400 bases after it seized Guam in June, 1944, some of them as large as an industrial city. This photo shows the headquarters of Fleet Admiral Chester W. Nimitz, commander-in-chief, U. S. Pacific Fleet and Pacific Ocean areas. His home was in looped area upper right center, and his offices in the building heading the echelon of five dark structures at lower left center.

## CHAPTER IV

# NAVAL AVIATION IN WAR AND PEACE

Incredible Achievements in Every Over-Water Campaign of the War—The War Strength of Naval Aviation—The Navy Dominates the Pacific—Combat Sorties—Navy Losses Compared to Those of the Enemy—Aircraft Equipment Proves Adequate in Numbers and Quality—Secretary of the Navy Forrestal's Comments—Our Aircraft Carrier Strength—Plans for Technical Developments Explained in Detail—Adm. Ernest J. King's Report.

THE aviation achievements of the U. S. Navy during the war were incredibly effective contributions to victory. As the eyes of the Fleet, as a striking force leaping out ahead of the warships, as an aerial guard ever alert against surprise attack and as general utility whenever fast transport was required, Naval Aviation hurled men and planes against the enemy in every over-water campaign of the war, from the Atlantic to the Mediterranean and in all the island hopping campaigns of the vast Pacific on the long road to Tokyo. At no time anywhere near as large or as numerically strong as the Army Air Forces, Naval Aviation embraced the air arms of the Marine Corps and the Coast Guard. At all times, both in general assignments and in tactical deployment, it was part of the overall organization structure of the Navy. Its activities generally were so merged with surface operations that they were as one, by and large, as for example, the air attacks that preceded landing operations or the air battles that took place incident to the clashes between giant ships. In the Army, this was termed ground cooperation, but in the Navy, whether on land or sea or in the air, it was naval operations. On the other hand, the highest authorities in the Navy agreed that aviation had become a major consideration in the naval establishment, a fact developed elsewhere in this chapter by Secretary of the Navy James Forrestal and Adm. Ernest J. King, whose brilliant record as chief of all naval operations during the war will live in history. The complete statistical tables on Naval Aviation in the section Flying Facts and Figures also will show the magnitude of the task performed by our Navy airmen.

At no time during the war did Naval Aviation personnel reach the half million mark. When the Japs struck at Pearl Harbor on December 7, 1941, there were available for aviation duty 7,724 officers and 21,678 enlisted men, including 6,961 officers and 15,622 enlisted men of the Navy, 679 officers and 5,788 enlisted men of the Marine Corps and 84 officers and 268 enlisted men of the Coast Guard. All told, there were available only 5,900 officer pilots and 850 enlisted pilots including 5,225 officer pilots and 774 enlisted pilots in the Navy, 610 officer pilots and 49 enlisted pilots in the Marine Corps and 65 officer pilots and 27 enlisted pilots in the Coast Guard. How the Navy succeeded in training new personnel and developing strength steadily from Pearl Harbor to V-J Day—despite the setbacks and losses early in the war—is one of the most fascinating chapters of the entire conflict. No other naval organization attempted it on the scale of the Navy program. It was excelled numerically only by the Army Air Forces.

The Navy's development of its aviation branch never was relaxed until the Japs surrendered. In August, 1945, Naval Aviation had a total of 437,524 personnel, which included 93,100 officers, 60,273 of them pilots, and 344,424 enlisted personnel, 474 of them pilots. The first women officers in American history to perform duties as part of a military air crew were 80 officers of the Waves designated as naval air navigators in June, 1945.

Of the total aviation personnel at the end of the war, 77,233 were Navy officers, including 49,615 pilots, and 249,177 enlisted personnel, 335 of them pilots. The Marine Corps had 109,527 aviation personnel, including 15,385 officers of whom 10,224 were pilots, and 94,142 enlisted personnel with 46 pilots. The Coast Guard had a total personnel of 1,587, with 482 officers, including 434 pilots, and 1,105 enlisted personnel with 93 pilots.

The Navy trained 6,610 graduate pilots in 1942, 20,842 in 1943, 21,067 in 1944 and 7,147 in 1945—a total of 55,666 pilots. It trained 28,087 enlisted personnel in aviation ratings in 1942, 70,637 in 1943, 72,945 in 1944 and 24,490 in 1945—a total of 196,159 aviation specialists trained in the enlisted grades during the war. There also were thousands of others, including officers, trained in navigation and other general aviation duties.

The excellent training given to Navy airmen produced fine results in action against the enemy. Artemus L. Gates, Assistant Secretary of the Navy for Air, in his report of June 30, 1945, stated that "more than half of the (German) submarines sunk by the Navy were sunk by naval aircraft," and further on in his report, "Because of the continuing high quality of naval aviators, combat losses have remained constantly small and consistently under the expected attrition rate. Of those pilots forced down, approximately 65 per cent are saved.

"By the early part of this year, we had complete domination of the air in all naval theaters of operation in the Pacific," reported Mr. Gates, "from our own West Coast and that of South America to the East Indies, to China, and up to the very door of Japan. At this moment (June, 1945) Navy search and patrol planes are operating over the South China Sea, East China Sea, Yellow Sea, Korea, the Sea of Japan, the Inland Sea, the southern approaches to the home islands, and over the Kuriles to the north. The battle for the control of the air over Japan itself is under way. In the virtual elimination of the Japanese carrier-based air force and in the decimation of the Japanese Army and Navy air forces, more than 17,000 enemy planes have been destroyed since Pearl Harbor by Navy and Marine planes, against Fleet combat losses of approximately 2,700, a combat ratio of better than 6 to 1. Preliminary figures for the first quarter of this year indicate that approximately 2,800 Japanese aircraft were destroyed by Fleet planes against combat losses of about 300, a combat ratio of over 9 to 1. The most recent campaign, that for the possession of Okinawa, has been the most intense of any so far encountered. From the beginning of the campaign in mid-March up to and into June, more than 3,700 enemy planes were destroyed by Navy and Marine units; 460 by our Fleet anti-aircraft gunners, 457 by Marine pilots of the Tactical Air Force, 2,605 by carrier-based aircraft, 216 in the course of suicide tactics, and 38 by patrol planes. Navy and Marine airborne combat losses amounted to more than 650; a combat ratio of approxi-

U. S. Navy photo

THE BATTLESHIP MISSOURI

This photo was taken at the time the Japanese signed the surrender documents on board the battleship. The two planes are Curtiss SC-1 Seahawks.

mately 6 to 1. Our air-sea team will undoubtedly meet even stiffer tests as it progresses to the home islands of Japan, where we can expect to encounter increased use of the Kamikaze Corps suicide pilots, who attempt to crash their planes or Baka bombs against our ships, as well as increased use of suicide boats, suicide swimmers, and similar tactics born of desperation. So far, however, no fast carrier, battleship, or cruiser has been sunk by Japanese suicide tactics, although extensive damage has been done. The extent and diversity of our naval air power now at the gates of Japan may be measured by the fact that more than 26,000 aircraft of all types were deployed to the Fleet in 1944, a number nearly one half of all Navy aircraft built since Pearl Harbor. This accelerated delivery to the fighting fronts is continuing this year, and improvements in the operational performance of all types of aircraft have been and are being accomplished. New models are either in production or on the way.

"Our carrier fleet now approximates 100 aircraft carriers of all classes—27 of them of the 'fast' or 'first-line' types. Another 69 are of the escort class now proved effective as combat types in close support of amphibious operations as well as in anti-submarine warfare. In addition, we have two of a new class of carrier, the battle carrier, which have recently been launched; these are the 45,000 ton carriers representing the most formidable vessels of their type afloat. Our carrier tonnage, exclusive of more than 150,000 tons of seaplane tenders, now approximates 1,250,000, and it is the largest single portion of the total combat Navy tonnage. The aeronautical naval shore establishment supporting Naval Aviation now represents, in terms of investment, one and a third billion dollars in contrast with an investment of a quarter of a billion dollars at the start of the war, and this in spite of the reassignment, consolidation, or decommissioning of some stations in the interest of economical and efficient employment. The number of naval air stations has grown from 43 in 1941 to 177 at the present time, when our shore construction program is virtually concluded."

Naval Aviation, the official statistics show, made a total of 283,755 combat sorties during the war, nearly all against the Japs. The carrier-based aircraft made 2,673 sorties in 1941-42, 5,129 in 1943, 68,807 in 1944 and 70,166 in 1945. The Navy's land-based planes made 2,604 sorties in 1941-42, 16,145 in 1943, 66,915 in 1944 and 51,316 in 1945. Carrier-based planes thus made 146,775 sorties while Navy land-based planes made 136,980.

Together, they destroyed a total of 15,503 enemy planes. Carrier-based planes shot down 382 in 1941-42, 300 in 1943, 3,296 in 1944 and 2,499 in 1945, a total of 6,477. Land-based planes of Naval Aviation shot down 476 enemy planes in 1941-42, 939 in 1943, 728 in 1944 and 662 in 1945, a total of 2,805. The combined total shot down by carrier-based and land-based planes was 9,282. Our carrier-based planes also destroyed 5,893 enemy planes on the ground or water or aboard carriers, and Navy land-based planes destroyed 328 on the surface, a combined total of 6,221.

Naval Aviation losses, the official statistics show, were relatively low throughout the war. While the fighters and float planes from our surface craft shot down 179 enemy planes in 1941-42, our carrier-based bombers shot down 203, making the total of 382. Our losses were 114—a ratio of 3.4 enemy planes to one of ours. In 1943, our ship-based fighters and float planes shot down 169 enemy planes and our ship-based bombers, shot down 131, a total of 300. Our losses were only 34—a ratio of 8.8 to 1 in our favor. In 1944, the enemy lost 2,396 planes in aerial combat with fighters and float planes from our ships and 900 others in combat with our ship-based bombers, a total of 3,296, against our loss of 184—a ratio of 17.9 to one. In 1945, aerial combat with fighters and float planes from our ships cost the enemy 1,736, besides 763 lost in aerial combat with our ship-based bombers, a total of 2,499 against our loss of 120—a ratio of 20.8 to one. The average ratio for the war was 14.3 to one.

Land-based fighter and float planes of Naval Aviation knocked

U. S. Navy photo

RYAN FIREBALL FIGHTERS ON THE RANGER

Navy Fighter Squadron 66 warming up FR-1 planes on the carrier prior to training flights.

down 283 enemy planes in 1941-42. Navy land-based bombers brought down 193, making a total of 476 against our loss of 152—a ratio of 3.1 to one. In 1943, the fighters brought down 762 and the bombers 177, a total of 939 against our loss of 199—a ratio of 4.7 to one. In 1944, our fighters shot down 635, our bombers 93, a total of 728 against our loss of 77—a ratio of 9.5 to one. In 1945, it was 367 enemy planes to our land-based fighters and 295 to the land-based bombers, a total of 662 against our loss of 26—a ratio of 25.5 to one. The average ratio for the war, for our land-based Navy planes was 6.2 to one.

Total enemy losses in aerial combat as compared to our Navy planes shot down were 858 against our 266 in 1941-42—a ratio of 3.2 to one. In 1943, it was 1,239 enemy to our 233—a ratio of 5.3 to one. In 1944, it was 4,024 enemy to 261 of ours—a ratio of 15.4 to one. In 1945, it was 3,161 enemy to our 146—a ratio of 21.6 to one. The total of 9,282 enemy planes shot down during the war as compared to our loss of 906 in aerial combat was a ratio of 10.2 to one, which is a fine testimonial to our airmen and their equipment.

While we lost only 906 Navy planes in aerial combat during the war, we lost 1,980 to enemy anti-aircraft fire, and our operational losses added 1,345, to make a grand total of 4,231 planes lost during 283,755 action sorties. The complete table in the section Flying Facts and Figures contains a breakdown of sorties and losses by years and by types of plane.

Naval Aviation, the records show, had readily available all the planes and other equipment that it needed throughout the war. Secretary of the Navy Forrestal, in his 1945 report, stated: "The extent of naval air power is demonstrated by the fact that by mid-1945 about 11,000 planes, including planes in pools and in transit, were deployed in the Pacific. To channel the requisite aeronautical resources in the most practical and efficient manner, the 'Integrated Aeronautic Material Program' was created, assuring a steady flow of planes and related aeronautical equipment to the Pacific. New combat planes were arriving off Okinawa within three months after leaving the factory. The average age of Navy fighters in the Pacific was cut in half during the 12 months ending in June, 1945. Supporting the Fleet as well as Naval Aviation, the Naval Air Transport Service flew nearly 104 million miles during that period. Along with constant improvements in production 'know-how,' technological progress made rapid strides. Among the more notable achievements were jet-assisted-take-off propulsion (JATO), the successful application of rockets to aircraft, improvements in radar, the development of 'mock-up' training devices, new equipment and technique in air-sea rescue and the development of jet-propelled aircraft. After 12 years of experimentation in which the Bureau of Aeronautics took part, the first successful anti-blackout suit was produced for combat in 1944. As a result of continued research and development, by the middle of 1945 the Corsair and Hellcat night fighters had established themselves among the Navy's air weapons. The first few Ryan Fireballs, utilizing one engine and one jet, had been delivered to the Navy, and the McDonnell FD-1 Phantom fighter with two jets was under procurement. Production of the Grumman two-engine Tigercat was rising; as the Navy's swiftest and most powerful fighter, the Tigercat could climb steeply at more than a mile a minute and carry two tons of bombs. The on-hand strength of the Naval air force grew from 1,741 service planes on July 1, 1940, to more than 39,700. Moreover, the average weight of new planes increased from 2,740 pounds in 1940 to 7,140 pounds in the first half of 1945. The Navy accepted for all users 13,500 aircraft in the first half of 1945, compared with fewer than 10,000 during the entire year following Pearl Harbor. Of the total of 80,300 planes accepted by the Navy in the five years which began with July, 1940, Lend-Lease received 7,500 and the AAF more than 600. While the number of naval planes lost in the Okinawa campaign would have required eight months to produce in 1941, those losses amounted to only 12 days output at the production rate of June, 1945."

At the time of Pearl Harbor, the Navy had 5,233 aircraft on hand and 3,499 acceptances. Between July, 1940, and August 31, 1945, Naval Aviation received a total of 73,711 airplanes, including 56,695 combat planes of which 1,683 were heavy bombers, 4,693 were medium bombers, 20,703 light bombers, 27,163 fighters and 2,453 were reconnaissance planes. The rest included 2,702 transports, 13,859 trainers and 455 communications planes.

On November 30, 1945, the Navy had been able to make a fairly accurate survey of its remaining flying equipment. It had 32,410


U. S. Navy photo

THE VOUGHT F4U-4 CORSAIR FIGHTER
Here it is shown landing on the new battle carrier Midway.

planes on hand and 16,393 acceptances. They included 22,080 combat planes on hand, of which 10,320 were fighters, 3,441 scout bombers, 4,320 torpedo bombers, 819 scout observation, 855 patrol four-engine land bombers, 865 two-engine land bombers, 30 four-engine flying boat bombers and 1,430 two-engine flying boat bombers. The Navy also had 15,246 combat acceptances including 8,189 fighters, 2,039 scout bombers, 2,968 torpedo bombers, 539 scout observation, 486 four-engine land bombers, 525 two-engine land bombers and 500 two-engine flying boat bombers.

The Navy also had 193 four-engine transports on hand and 106 acceptances, 707 two-engine land transports on hand and 56 acceptances, 852 medium utility planes on hand and 314 acceptances, 1,085 light utility with 236 acceptances, and 7,388 trainers on hand with 435 acceptances.

The Navy lost during the war the carriers Hornet, Lexington, Yorktown and Wasp, the light carrier Princeton and the escort carriers Liscome Bay, Block Island, Gambier Bay, St. Lo, Ommaney Bay and Bismarck Sea. It had left, ready for service in any part of the world, 106 carriers, as shown by the tables in the section Flying Facts and Figures, with combined complements of 4,550 planes.

After the war, the Navy did not relax its efforts to maintain its aviation technically abreast of other air powers which were carrying on developments with utmost secrecy. In March, 1946, it sent to the Arctic a task group, headed by the Midway, one of the three new 45,000-ton battle carriers, to conduct exacting cold weather operating tests and research into requirements for aircraft operations in the frozen North.

An official Navy announcement some months after the surrender of Japan contained this encouraging comment: "Research in Naval Aviation, which enabled the Navy to keep vital distances ahead of the enemy during the war, will be continued in peacetime experiments in radically new types of piloted aircraft, related aircraft of all types, methods of propulsion, fuels and aerodynamic principles. The Navy is vigorously pursuing the development of jet-propelled aircraft, pilotless aircraft and guided missiles. With improvements in the turbo-jet engines now in sight, and with high speed a prime characteristic of a fighter airplane, future Navy fighters probably will be jet-powered, possibly with rocket assistance for short bursts of extremely high speed. Also of great promise is the composite power plant, a combination of conventional reciprocating engine and jet. This is particularly effective for dive-bombers, torpedo bombers and long-range patrol land planes. A transition arrangement, it is probable that the ultimate in these categories will be the gas turbine driving a propeller, rather than the pure turbo-jet. A completely new field of propulsion is being investigated in the realm of guided missiles. Power plants to give supersonic speeds of more than 700 miles per hour are under study. Resojets, ramjets, liquid-jets and turbo-jets are viewed with favor by Naval aviation planners.

"An extensive pilotless aircraft program was already underway by V-J Day. Successful developments which can now be revealed include devices with the odd names of 'glomb,' 'Gorgon' and 'Gargoyle.' The 'glomb,' or glider bomb, carries a 4,000-pound bomb and can be towed by a Navy fighter plane in fully automatic tow. When released, it can be directed into a target through radio control and television. The 'Gorgon' is a jet-propelled missile which can be carried by a bomber and sent into an enemy aircraft by radio control or by its own automatic target-seeking device. The 'Gargoyle,' also jet-propelled, carries a 1,000-pound armor-piercing bomb which, when released, automatically seeks and collides with a ship target. As early as 1940, successful demonstrations of pilotless aircraft had been made with a torpedo plane which was radio-controlled and television-directed from a control plane 10 miles distant. It launched the 'ghost' plane's torpedo squarely into a maneuvering destroyer. Similarly, a dive-bomber was made to plunge through the center of a moving target. From these experiments several types of assault drones were developed, a number of which were used against the Japanese base at Rabaul.

"The use of pilotless aircraft also has been important in the advancement of the design of piloted planes. Ability to transmit test data to a control station on the ground or in another plane has enabled test engineers to obtain data under flight conditions which it would be impossible to set up in a wind tunnel, and at speeds approaching those which would be expected to produce structural failure or injury to the pilot. The pilotless aircraft of the future, controlled by electronics, will 'home' electronically on its target. Electronic 'brains' will guide the counter-missile with precision. Out of research and development programs will come airborne radars which can initiate defense, and automatic circuitry which instantly can release the airborne counter-missile. Man will be too slow for combat of the future, but man's mind can devise the defense.

"The Navy's Bureau of Aeronautics, which has the overall responsibility for research, development and testing of new aircraft and equipment, will lean heavily upon electronics for future offensive and defensive weapons. It will have the assistance of the Navy's new Office of Research and Inventions, which already has initiated the enlargement of the airborne electronic facility at the Naval Research Laboratory. Approximately 25 per cent of the efforts of this vast laboratory and its eminent technical and scientific personnel will be directed toward airborne electronic developments required for the particular purposes of Naval Aviation.

"The Bureau of Aeronautics and the Office of Research and Inventions had by the war's end, perfected electronic listening devices which were dropped from aircraft over wide areas of the seas. The lurking enemy submarine, in turn, tried to listen electronically for searching aircraft. The Navy retaliated with a tricky radar gadget which convinced the submarine that the approaching airplane was really departing. Then came the underwater intake valve which enabled the harrassed sub to hide below for longer periods. The Navy increased the sensitivity of its radar to detect even this small object. It was a losing game for the submarine, for the cooperation of American scientists and Navy planners always kept one step ahead of the enemy.

"Naval combat planes are equipped, as appropriate, with such items as complete electronic systems for searching out targets, ascertaining whether they are friends or enemies, bombing through darkness and zero visibility, denying the enemy effective use of his own radio and radar, communicating reliably, and navigating back to base under all-weather conditions. A patrol bomber, for example, now carries more than 27 items of electronic equipment weighing nearly a ton. By far the most important airborne electronic equipment in the first two years of the war was the 'Baker' radar. The Naval Research Laboratory had developed this first American airborne radar, and production had been initiated prior to the war. Some 30,000 of these 'Baker' radars were used by Naval aircraft, many of which saw service in the patrol of the night seas of the Southwest Pacific. Even at Guadalcanal the raiding Jap pilots found the night offered no safety if a Navy plane happened to pass within 40 or 50 miles.

"Utilizing new electronic tools, Navy pilots rapidly learned to pick their way between islands, to 'home' electronically on the carrier, to use the radar altimeter for safe approaches and low flying, and to identify friend or foe. As a consequence, electronic equipment was produced and men thoroughly trained to accomplish attacks on shipping and shore installations through complete cover with rockets, bombs or torpedoes, as a daily occurrence.

"Electronics was not the exclusive property of the allied powers. With German assistance, the Japanese frequently countered aircraft with radar-controlled searchlights and anti-aircraft fire. Allied counter-measures were quickly developed. On Navy raids over Japan, drifting Christmas tree foil, termed 'window,' or special jamming equipment, persuaded the perplexed Jap to shut down his radar for a trouble check. Too late he found his radar was still working. It was simply jammed, but his airfield was in smoking ruins by the time he discovered that fact.

"The Navy also pioneered in night fighting and by mid-war was rapidly producing the war's only single-place night fighters, which made night carrier operation possible. The ingenious night fighter radar maintains a search over a large sector of the forward night sky. Picking up any enemy plane at five miles, the pilot is able to close and fire at his unseen enemy with deadly accuracy. The vision and drive of the late Vice Adm. John S. McCain was applied to the introduction of carrier night operations. The results were apparent in the later task force operations, particularly at Okinawa. In one nine-week period, 91 enemy aircraft were splashed by Navy night fighters alone.

"Early in the war, the Navy initiated an innovation in communications for aircraft. The Bureau of Aeronautics moved out of the customary long waves into ultra-high frequencies which the Japs never entered. There the Navy fliers enjoyed real privacy. An example of the dozens of other electronic devices produced for special purposes is the radar corner reflector developed to provide for the long-range detection of tiny life rafts the occupants of which might otherwise be lost.

"Fire control is one of the most vital parts of the aircraft armament installation. Upon it hinges the success or failure of the mission. It must be completely integrated to permit effective use of any weapon carried and to avoid duplications. Moreover, extreme accuracy under any weather conditions, through overcasts and at night, is vital. Systems to achieve these ends automatically, and to fly the airplane and fire or release the weapons at precisely the correct moment and position, are being developed. Protective armor will be improved ballistically, and the use of material, other than steel, will be studied. Emphasis will be placed upon protection against fragmentation, because the universal use of proximity fuses can be expected to increase the hazards from anti-aircraft bursts.

"Continual refinements are being made in the .50-cal. gun, acknowledged to be the best aircraft gun used by any air force. The eventual need for a better gun also is being anticipated. Larger caliber guns are under development. Muzzle velocities, rates of fire and damage effect will be increased greatly. In particular, guns with no


CURTISS NAVY HELLDIVER, SB2C-5

Latest model of the powerful Navy dive bomber produced at the Curtiss-Wright Columbus, O., plant, had over 35 major changes over the "dash four" model, and was the last to be assigned to carrier duty in the war against Japan.

recoil and of smooth bore design offer great promise. The airplane structural weight necessitated by present types of guns could then be reduced considerably. Ammunition feed systems, case and link ejection systems and adjustable mounts will be improved to keep pace with the development of the guns.

"Aircraft rockets came into use during the recent war. In a remarkably short time, this device has become a weapon of major importance. Its tremendous possibilities will be exploited fully by future development programs, as will other explosive 'pay-loads' of the airplane.

"One of the closely guarded secrets of the war was the use of catapults for launching aircraft from all classes of carriers. On the relatively slow escort carriers, this practice alone made possible the round-the-clock operation of heavily loaded bombers which so effectively removed the scourge of the German submarine in the Atlantic. Similarly, on the large carriers, all types of airplanes were launched by catapult as a routine means of facilitating flight operations.

"Mechanical launching is expected to be essential in the future for take-off of piloted or pilotless aircraft from ships because of high speeds and heavy loads. Future development of improved launching equipment for shipboard use, therefore, becomes a vital necessity. Launching equipment will stress light weight, dependability and simplicity, but will have launching speeds, launching rates and capacities in excess of anticipated airplane requirements. Development of this equipment will continue through a research program which includes the exploration of new and radically different mechanical processes, various types of energy sources and extensive testing. The aircraft carrier is of great value as it supplies its own offensive and defensive planes, and is a self contained base. This mobile base must and will be complemented with aircraft capable of carrying the most modern implements of war. They must be designed to meet and destroy opposing aircraft whether ship or shore-based. The ship which carries such planes must have facilities which permit the operation of conventional planes or future designs of the pilotless type.

"At present the conventional reciprocating engine is competing vigorously with its newer rivals, the turbo-jet and the propeller-driving gas turbine. Although the gas turbine for jet propulsion offers the possibility of flight speeds now unattainable by aircraft powered by reciprocating engines driving propellers, the pure turbo-jet engine is not yet developed to the degree of reliability found in the reciprocating engine. The gas turbine driving a propeller is of utmost interest for Naval applications because of its potentialities for balanced high performance, exceeding the turbo-jet in fuel efficiency and take-off performance.

"Improvements in propellers, power plant accessories, and the various systems essential to the operation of the power plant must keep pace with the progress in aircraft engines. Developments in the fuel system, carburetion, ignition and lubrication systems permit operation of Naval aircraft up to 40,000 feet without malfunctioning. Power plant controls produced during the war govern and limit power application to prevent inadvertent damage to the engine without distracting the pilot during combat. Water injection permits the pilot to obtain greatly increased engine power for short periods under combat conditions. This feature alone greatly improved the military effectiveness of combat aircraft. The perfection of exhaust flame dampers prevented aircraft detection from otherwise readily visible exhaust flame during extensive night operations. New features have been added to propellers such as constant speed, feathering and reverse pitch, with the propeller performing some of the functions on an airplane in the air which the gear shift, clutch and brake perform on an automobile.

"The global nature of Naval warfare also has resulted in improvements to the air induction and other power plant systems for satisfactory operation of aircraft under extreme weather conditions, ranging from a desert sandstorm to tropical humidity to arctic ice and snow. Cooling of the power plant under all conditions is one of the major problems of the airplane manufacturer. Refinements in the engine cowling, ducting and finning, and development of exhaust ejector cooling have solved these problems to a great extent while the cooling drag has been reduced at least 75 per cent in the last few years. This is reflected directly in increased aircraft performance.

"The Navy's postwar development program in reciprocating engines, turbines, and turbo-jets will produce engines for aircraft with top speeds below the speed of sound, while other Navy programs for special types of jet propulsion and rocket-assist give promise of reaching speeds above the speed of sound. Future plans provide for continuing development of improved equipment for pilot safety, and the development of search procedures to insure early rescue of air crews forced down at sea. Likewise, research must go forward aggressively in the field of protection for fuel and oil systems.

"As one of the pioneers in the use of light alloys for the construction of airplanes, the Navy does not propose to relax its leadership in this field. Research will continue for lighter weight, higher strength and corrosion-resistant alloys, and improved fabricating processes for the construction of airplane structures. The development of 'sandwich' type materials, i.e., materials with wood or plastic cores and high strength alloy outer faces, is well under way. The high and uniform rigidity in relation to weight and the aerodynamic smoothness of parts fabricated from them make these materials an interesting possibility for use in the consideration of future high performance aircraft. In addition, research is in progress toward the availability of heat resistant alloys necessary to the efficiency and increased life of engines operating on the jet principle. The extremely high temperatures developed by jet engines may even result in the development of entirely new and different metals than those now available."

That part of Adm. King's report dealing with Naval Aviation follows:

"The epic advance of our united forces across the vast Pacific, westward from Hawaii and northward from New Guinea, to the Philippines and to the shores of Japan, was spearheaded by Naval Aviation and closely supported by the power of our fleets. In these advances, some of the steps exceeded 2,000 miles, and the assaulting troops often had to be transported for much greater distances. The Navy moved them over water, landed them and supported them in great force at the beaches, kept them supplied and, particularly at Okinawa, furnished air cover during weeks of the critical fighting ashore. The outstanding development of this war, in the field of joint undertakings, was the perfection of amphibious operations, the most difficult of all operations in modern warfare. Our success in all such operations, from Normandy to Okinawa, involved huge quantities of specialized equipment, exhaustive study and planning, and thorough training as well as complete integration of all forces, under unified command.

"The final phase of the Pacific naval war commenced with the assault on Iwo Jima in February, 1945, closely followed by that on Okinawa in April. These two positions were inner defenses of Japan itself; their capture by United States forces meant that the heart of the Empire from then on would be exposed to the full fury of attack, not only by our carrier aircraft but also by land-based planes, the latter in a strength comparable to that which had wreaked such devastation against the better protected and less vulnerable cities of Germany. After Okinawa was in our hands, the Japanese were in a desperate situation, which could be alleviated only if they could strike a counterblow, either by damaging our fleet or by driving us from our advanced island positions. The inability of the Japanese to do either was strong evidence of their increasing impotence and indicated that the end could not be delayed long. As March opened, fierce ground fighting on Iwo Jima was still in progress. The front line ran roughly parallel to the short axis of the island, the northeastern third of which was still held by the enemy. Our right flank (4th Marine Division) extended inland from the beach just beyond the east boat basin and faced the enemy's skillfully prepared defense positions in steep and rough terrain, which made progress difficult; our left flank (5th Marine Division) rested on Hiraiwa Bay directly across the island; in the center the 3rd Marine Division had pushed a salient along the central Motoyama plateau to occupy Motoyama village and the near end of Airfield No. 3. By nightfall of March 2, this last airfield and the whole of the Motoyama tableland were under our control, leaving the enemy in possession of a diminishing horseshoe-shaped area fringing the northeastern end of the island. Airfield No. 1 for some days had been in use by light artillery spotting planes, but on March 3 it came into its own when a B-29, after a strike against the Japanese mainland, made a successful forced landing at Iwo Jima. More of such landings followed as the tempo of air strikes against Japan was stepped up. On March 6 the first land-based fighter planes came in, made patrol flights the following day, and relieved carrier aircraft in close support of troops on the third day after arrival. Airfield No. 2 was operational on March 16.

"Progress during the first week of March was slow despite daily artillery preparation, supplemented by naval gunfire and air strikes before each ground attack. On the night of March 7-8 the 4th Marine Division killed about 1,000 enemy troops who had organized a major infiltration. Subsequently the resistance to our attacks diminished somewhat, and during the next three days control was secured of all the eastern coastline to a distance of approximately 4,000 yards south of Kitano Point at the northeastern extremity of the island. On March 16 the northwest shore had been reached and Kitano Point isolated. Much mopping up remained to be done, particularly of a small stubborn pocket of resistance in one of the rugged gulches running southwest to the beaches from Kitano Point; but on March 16 all organized resistance was declared ended, and the 4th Marine Division started re-embarking.

"The capture of the island had taken 26 days of actual combat; over 20,000 enemy troops were destroyed; and our casualties ashore, as reported on March 17, were 20,196, of whom 4,305 were killed in action. The diminutive size of Iwo Jima and its general barrenness, lack of natural facilities and resources should lead no one either to minimize the importance of capturing it or to deprecate as unreasonable and unnecessary our heavy losses in doing so. It was important solely as an air base, but as such its importance was great. Not only was the pressure of air attack by our Marianas-based B-29s materially intensified by the availability of Iwo for topping them off with fuel and for supplying them with fighter cover from there on, but also there was an increase in combat effectiveness of the B-29s due to the heightened morale of personnel, heavier bomb loads and decrease in abortive flights. There was, moreover, a substantial saving in valuable life in the number of B-29s which would have been shot down over Japan had there been no fighter cover, and in the number which would have been lost at sea had Iwo Jima not been available for emergency landings. It is estimated that the lives saved through this latter factor alone, subsequent to the capture of Iwo Jima, exceeded the lives lost in the capture itself. This loss of life during the capture resulted inevitably from the strength of Iwo Jima as a defensive position and from the readiness of the enemy. Neither strategic nor tactical sur-

THE GRUMMAN F6F HELLCAT

prise was possible in our landing since, with Luzon and the Marianas in our hands, the seizure of some point in the Nanpo Shoto chain was obviously our next move, and Iwo Jima was by its location and the character of its terrain the most profitable objective.

"As a whole the operation affords a striking illustration of the inherently close relation between land, sea and air power. The fleet with its ships and planes delivered and supported the land forces. The Marines took an air base from which our land-based planes could operate with effectiveness far beyond that possible from our other bases in the rear. The same general pattern marked our long progress all the way across the vast central and western Pacific. Our capture of the Marianas and Philippines had placed us on a strategic line some 1,300 miles from the Japanese homeland and across its direct routes of communication to the south. The occupation of Iwo Jima had advanced this line to within 640 miles of Tokyo at the eastern end. The next step directed by the Joint Chiefs of Staff was to secure a position in the Nansei Shoto chain, which extends in a shallow loop from Kyushu, the southernmost of the main Japanese islands, down to Japanese held Formosa. Okinawa, the largest and most populous island in this chain, offered numerous sites for airfields from which almost any type of plane could reach industrial Kyushu, only 350 miles distant, and attack the enemy's communications to Korea, to the Chinese mainland, and to the Indo-China and Singapore areas. Since Okinawa also contained several excellent naval anchorages, it was chosen as the objective; the operations against it followed immediately on those for the capture of Iwo Jima.

"From many standpoints the Okinawa operation was the most difficult ever undertaken by our forces in the Pacific. It was defended by about 120,000 men (including native Okinawans serving with the combat forces) with tanks and artillery. As possible reinforcements there were some 60,000 troops in various other positions in the Nansei Shoto chain, plus much larger forces in nearby Formosa, Kyushu and the Shanghai area. Also of great importance was the large native population, which afforded the enemy an unlimited supply of labor, and which might easily become a serious problem to us by clogging roads and imposing a burden of relief.

"The most serious threat to us, however, lay in the very factor for which we had initiated the operation, namely the short distance from Okinawa to the Japanese homeland, where lay the main reserves of air and naval power. Just as we would be able to strike Japan to better effect after securing Okinawa, the Japanese could strike us while we were attacking that island. Japan's naval strength had been so reduced that it could not hope for success against our own in a decisive action; but hit-and-run raids, or perhaps forlorn-hope, honor-saving attempts, were a possibility. Air attack, particularly of the suicide variety, was the greatest menace, since the Japanese airfields within easy range of Okinawa were too numerous to permit more than their partial and temporary interdiction by our own air strikes against them. Severe damage and losses, therefore, had to be expected and accepted as the price of our success.

"The operations for the capture of Okinawa were under the command of Adm. R. A. Spruance, Commander Fifth Fleet. Major forces participating under him were the Joint Expeditionary Force (all elements engaged directly in the landings), Vice Adm. R. K. Turner; the Expeditionary Troops (all ground forces engaged), the late Lt. Gen. S. B. Buckner, USA; the Fast Carrier Force, Vice Adm. M. A. Mitscher (including the battleships and other fire support vessels of the late Vice Adm. W. A. Lee's Striking Force); the British Carrier Force, Vice Adm. H. B. Rawlings; the Logistic Supply Group (tankers and cargo vessels which serviced the fleet under way close to the combat areas), Rear Adm. D. B. Beary; Service Squadron Ten (the repair, supply and service vessels of all kinds, based on Leyte Gulf, the Marianas, etc.), Commodore W. R. Carter; the Amphibious Support Force (comprising escort carriers, mine sweepers, underwater demolition teams, gun-boats, and the gunnery ships assigned to bombardment missions), Rear Adm. W. H. P. Blandy; and the Gunfire and Covering Force (the battleships and other gunnery vessels not with the fast carriers), Rear Adm. M. L. Deyo. About 548,000 men of the Army, Navy and Marine Corps took part, with 318 combatant vessels and 1,139 auxiliary vessels, exclusive of personnel landing craft of all types.

"The greater part of the intelligence information required for the operation was obtained from photographic coverage. Adequate small

U. S. Navy photo

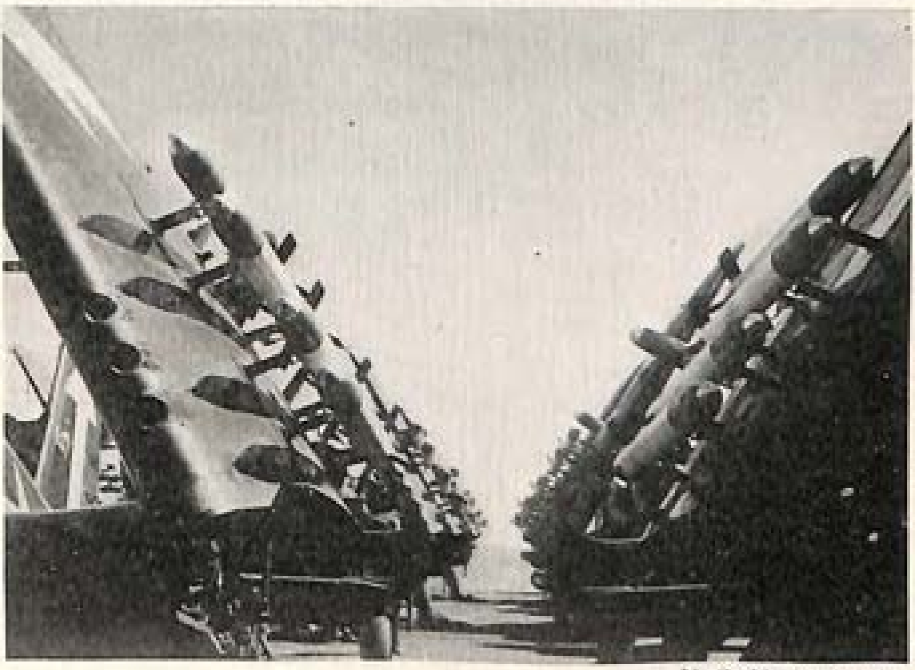
CORSAIR USES JET-ASSISTED TAKE-OFF

Jet units, reducing normal take-off runs from 33 to 60 per cent or allowing for increase in loads, augment the take-off power of this Chance Vought F4U-1 Corsair fighter as it roars down the deck of an aircraft carrier. JATO, as these jet-assisted take-offs are known in the Navy's air arm, were of particular value on the restricted areas of carrier decks. Resembling bombs, except that they are affixed to the fuselage of the plane rather than under the wings or enclosed in bays, jet units contain solid propellant which includes oxygen, and are ignited by electrically-controlled spark plugs. The escaping stream gives the plane its thrust.

scale coverage for mapping purposes was first obtained on September 29, 1944, by B-29s of the XXI Bomber Command; from then on until the conclusion of the operation, additional photographing was done at frequent intervals by Army planes and planes of the Fast Carrier Force. The prompt developing, printing, and interpreting of these photos, and the early and wide distribution of the prints and of the information gleaned from them, was an important feature of the operation. The island of Okinawa, which is about 65 miles long, is roughly divided into almost equal northern and southern parts. The northern area is generally rugged, mountainous, wooded and undeveloped. The southern area, which is generally rolling but frequently broken by deep scarps and ravines, is the developed part of the island, containing the greater number of towns, roads and cultivated areas, the capital city of Naha, all five of the island's airfields, and the strongest defenses.

"The preferred plan called for our ground forces to land on six miles of beach on the southwest shore, protected from the prevailing northeast trade winds and closely bordering the island's Yontan and Kadena airfields. Four divisions were to be landed abreast on these beaches. With the two center divisions advancing directly across the island to the east coast, and with the left and right flank divisions pivoting toward the north and south respectively, the Japanese forces in the southern part of the island would be isolated by these maneuvers, and were then to be overcome by attack from the north. Coincident with the main troop attack, there was planned for the southeast coast a demonstration, and an actual landing, if necessary. Planned operations preliminary to, and in support of the main landings, included the following: the seizure of the islands of the Kerama Retto group, 20 miles to the southwest, in order to establish therein a logistics supply and naval repair base and a seaplane base; the seizure of the small island of Keise Shima, about 20,000 yards from the landing beaches and 11,000 yards from Naha city, and landing army artillery there to command the lower end of Okinawa; mine sweeping on a scale greater than in any previous operation; the usual work by underwater demolition teams; and the intensive bombardments by air and naval forces.

"On L-minus-6 day the assault on Kerama Retto was commenced, and by L-minus-1, March 31, these islands and also Keise Shima had been occupied against minor resistance. Nets were immediately laid to protect the anchorages, and the seaplane base was established. Tankers, ammunition ships and repair vessels were brought directly to this anchorage, which assumed a progressively more important role as the principal haven for ships damaged by 'kamikaze' attacks of



U. S. Navy photo

ROCKET-LADEN VOUGHT CORSAIRS

Their wings studded with rocket missiles, the fighters line a carrier deck just before a strike against the Japs.

suicide planes. Since March 25, Okinawa itself had been under intermittent bombing and gunfire, and on L-day, April 1, preceded by intense naval and air bombardment, the Tenth Army landed according to schedule over the Hagushi beaches on Okinawa against light enemy resistance. The assault waves, embarked in amphibious vehicles, hit the beach at 8:30 a.m. moved rapidly inland, and by 12:30 noon had captured both Yontan and Kadena airfields with light losses. Prior to dark the Tenth Army, with approximately 50,000 troops ashore, had gained a beachhead 4,000 to 5,000 yards in depth. Proceeding rapidly against initially weak resistance, our troops crossed the island to the east shore, and on April 4 the Yontan-Kadena segment of the island was in our hands.

"The Japanese had made no serious attempt to stop us at the beaches where we had landed; as the attack progressed from day to day, it was evident that they had withdrawn most of their forces into the southernmost part of the island, and had established their defenses in depth on terrain admirably suited for defense and delaying action tactics. The enemy defenses consisted of blockhouses, pillboxes, and caves, protected by double apron barbed wire and minefields. Here the enemy used his artillery unstintingly, and his defensive tactics were described as 'artful and fantastic.' In the north progress was rapid against scattered opposition; on April 22 all organized resistance in the northern two-thirds of the island had ceased, though patrolling and mopping up continued. In the south our advance was stubbornly contested. From April 4 to May 26 our lines had advanced only about four miles, and it took from May 26 to June 21 to cover the remaining 10 miles to the southern tip of the island. On June 21, after 82 days of bitter fighting, organized resistance was declared to have ended, although mopping up of two small enemy pockets remained to be done.

"On June 18, while observing the attack of the Marine 8th Regimental Combat Team, Lt. Gen. Buckner, Commanding General of the Tenth Army and the Ryukyus Forces, was instantly killed by a shell burst. Command of the ground forces was then assumed by Major Gen. Roy S. Geiger, USMC, until after the capture of the island, when he was relieved by Gen. Joseph W. Stilwell, USA, on June 23.

"The general pattern of the operation for the capture of Okinawa was similar to those for the capture of Iwo Jima, the Marianas, the Marshalls, etc.; it differed mainly in the size of the air, naval, and ground forces employed, the length of time required to secure it after the initial landing, and the number of naval vessels damaged or sunk at the scene of operations by air attack, mainly of the suicide variety. Having been experienced in previous operations, this form of attack was not new, but the shorter distance from numerous air bases in Japan, and the desperate situation which would threaten the Japanese if our assault on Okinawa were successful, stimulated them to their greatest and most fanatical effort.

"The first enemy air attack at Okinawa occurred on March 24, when the mine sweepers arrived; the first damage was done on March 26; and by June 21, when organized resistance had ceased, about 250 (U. S.) vessels of all classes, from battleships and carriers down to destroyers and landing ships, had been hit by air attack, by far the greatest proportion of them in suicide crashes. Some 34 destroyers or smaller craft were sunk. Early warning of impending attacks proved to be the best countermeasure and for this purpose destroyers and other small vessels were stationed as pickets at appropriate distances from the concentrations of heavier shipping. These pickets took the heaviest losses themselves, but in so doing they undoubtedly saved many bigger and more valuable vessels during a critical three months.

"After the supporting operations for the Iwo Jima campaign were completed, Vice Adm. Mitscher proceeded with his fast carrier task force in support of the forthcoming Okinawa campaign. First he went toward the Nansei Shoto in order to obtain photographic coverage of that area. Planes were launched on March 1, and excellent photo reconnaissance was obtained for use in planning the Okinawa cam-

U. S. Navy photo

WARDING OFF A JAP ATTACK

U. S. Navy ships setting up an anti-aircraft and rocket barrage against Jap planes coming in low in Kerama Retto, Ryukyu.

paign. While in this area, cruisers of the force bombarded Okino-Daito-Shima on March 2, starting numerous fires and providing valuable training for the ships participating. The force then proceeded to Ulithi for a 10-day period of regrouping and logistic replenishment. On March 14, the task force departed from Ulithi and proceeded toward Japan to carry out its part in the invasion of Okinawa. On March 18-19, from a position 100 miles southeast of Kyushu, air strikes were launched against airfields on that island in order to eliminate future airborne resistance to our Okinawa invasion forces. Fleet units at Kure and Kobe were also attacked with considerable success.

"On the morning of the 19th the carrier Franklin was damaged badly by fires started when she was hit by two bombs from an enemy plane. Outstanding rescue operations saved 850 men from the water, but our dead and missing totalled 772. During that afternoon the task force retired southward, launching additional sweeps against enemy airfields to forestall an organized attack on the slowly moving damaged ships and escorts. On March 21, 48 enemy planes were intercepted 60 miles from the force by 24 carrier-based planes. In the ensuing battle all the Japanese planes were shot down with a loss of only two of our fighters.

"In a four-day period Vice Adm. Mitscher's forces destroyed 528 enemy planes, damaged 16 enemy surface craft, and either destroyed or damaged scores of hangars, factories and warehouses. Our own plane losses were 116. As a result of this operation, the enemy was unable to mount any strong air attack against our forces on Okinawa for a week after the initial landings.

"On March 21, under the command of Vice Adm. Lee, battleships of the task force bombarded the southeastern coast of Okinawa. This was part of a diversionary move to cover up the actual location of our landing beaches; apparently the ruse was successful. When the invasion of Okinawa began on April 1, planes from our fast carriers began a series of almost continuous strikes and combat air patrols in direct support of the operation. For a few days enemy air opposition was almost nonexistent, but on April 6, the Japanese finally struck with fury against our ground and supporting forces. All units of our carrier force performed admirably during the day's attack, knocking down 248 planes, while losing only two. Our carrier task force then proceeded northward, and on April 7, attacked strong Japanese fleet units which had been located in the East China Sea off Kyushu. Heavy weather handicapped our airmen, but in spite of this they sank the battleship Yamato, the cruiser Yahagi, and four destroyers. Fires were started on two other destroyers, and only three destroyers in the entire force escaped without damage.

"While our planes were otherwise occupied in striking the Yamato and those ships, the enemy resumed the heavy assaults of the previous day against the carrier force. Combat air patrols destroyed 15 planes over the force, and ships' gunfire knocked down three more. One suicide plane penetrated our anti-aircraft fire, however, and dropped a bomb on the carrier Hancock; it then crashed on her flight deck, killing 28 men, and badly damaging the carrier.

"On April 11, the enemy resumed the air attacks on the fast carrier task force. The number of Japanese planes participating was not large, but their pilots were determined to destroy themselves by diving their planes directly on the chosen target. Fortunately there were no direct hits, but eight near misses caused some damage. During the day our carrier-based planes shot down 17 of these suicide planes, and ships' gunfire destroyed 12 more, but they still constituted a serious threat to our forces. The next day the enemy shifted the weight of his suicide attacks to the ships anchored at Okinawa, and our combat air patrols from both fast and escort carriers had little difficulty in shooting down 151 enemy planes over the islands.

"On April 15, the carriers launched a surprise attack against southern Kyushu airfields, destroying 51 enemy planes on the ground and setting numerous ground installations afire. The Japanese managed to launch some planes in opposition, and 29 of these were shot down before our aircraft returned to the carriers. Fighter sweeps again were launched against Kyushu on April 16, in an effort to break up an obvious major enemy air attack. They shot down 17 airborne planes and destroyed 54 on the ground. In spite of our success, how-


CURTISS NAVY SC-1 SEAHAWK

ever, the enemy launched heavy air attacks during the day against our Okinawa forces and the fast carrier task force. All ground support was cancelled, and every effort was concentrated on a successful defense of the task force. The final score for the day was 210 enemy aircraft shot down, against a loss of nine of our planes. Heavy damage was caused to the carrier Intrepid when a suicide plane crashed on her flight deck at the height of the battle.

"On April 19, Vice Adm. Lee commanded a division of fast battleships in the bombardment of the southeastern coast of Okinawa. This action coincided with the beginning of the Tenth Army's all-out offensive. The bombardment not only destroyed important military installations, but it assisted in making a feint landing at that point appear authentic. On April 29, suicide planes again attacked our task force in strength, hitting and badly damaging two destroyers. The enemy paid for them, however, with 25 aircraft knocked out of the air by planes and guns of the task force.

"After several days of relative calm, enemy aircraft returned in large numbers on May 4 to attack our land and amphibious forces in the Okinawa area. This attack was apparently part of a counter-landing operation to aid their own ground forces. Our fast carrier task force was not attacked, however, and its fighters were free to defend the Okinawa area, shooting down 98 enemy aircraft, while losing only five planes. On May 11, another major air battle was fought over Okinawa and the ships of the task force. Carrier-based planes shot down 69 enemy aircraft, ships' gunfire accounted for three more, while two were destroyed in suicide dives on the carrier Bunker Hill. This ship was badly damaged, and 373 of her personnel were killed, with 19 missing.

"The fast carriers moved northward on May 12, and launched additional air strikes against Kyushu airfields on May 13-14. Few planes were found and virtually no air opposition was encountered over the fields. On the morning of the 14th, however, the enemy managed to launch a force of 26 planes against the ships of the task force. Of these, six were shot down by ships' gunfire and 19 by combat air patrol; the remaining plane was destroyed in a damaging suicide crash on our Enterprise. On May 24, the fast carriers launched a clean-up sweep by 98 planes against airfields in southern Kyushu. Except on Kanoya airfields little activity was found, and it was evident that the previous strikes against this area had been very effective. The score for the day was 84 enemy planes destroyed, while our losses were confined to three planes lost to anti-aircraft fire off Kanoya. On May 28, the late Vice Adm. J. S. McCain relieved Vice Adm. Mitscher as commander of the fast carrier task forces.

"On June 2-3, further long-range sweeps were launched against Kyushu, but bad weather impaired their effectiveness. Only 30 enemy planes were destroyed, while our losses were 16. By June 4, the bad weather had developed into a typhoon, and the ships of our task force spent the next 24 hours attempting to avoid the storm's center. Serious damage to three cruisers, two carriers, and one destroyer resulted. Operations were resumed on June 8 when a final attack was made on southern Kyushu. It was well executed, but previous raids had so reduced Japanese air strength in this area that only 29 enemy planes could be destroyed. Only four of our carrier planes were lost. On June 8-9, cruisers and battleships from Vice Adm. McCain's task force bombarded Okino-Daito and Minami-Daito to the east of Okinawa. These attacks terminated the supporting action of the fast carrier task force, and on June 10, course was set for Leyte Gulf, where they anchored on June 13 for a period of replenishment and repair.

"For a period of nearly three months, our fast carriers and their escorts had operated in and near the Okinawa area, giving invaluable support to our occupation forces. During this time the task force had destroyed 2,336 enemy planes, while losing 557 of its own aircraft. In addition, widespread damage had been inflicted upon shore installations in Japan, the Nansei Shoto, and upon important units of the Japanese fleet. This remarkable record detracted considerably from the ability of the enemy to oppose our landing forces on Okinawa, thereby contributing notably to our final success.

"A fast British carrier task force, under the command of Vice Adm. Rawlings, was assigned to Adm. Spruance's Fifth Fleet to assist in the air support operations for the Okinawa assault. From March 26 to April 20, and again from May 4 to 25, planes from this force rendered valuable service in neutralizing enemy air installations on Sakishima Gunto, southwest of Okinawa. Carriers of the force were


THE GRUMMAN F8F BEARCAT

subjected to frequent attacks by suicide planes, but none was put out of action. Battleships and cruisers of the force bombarded Miyako Jima on May 4 with satisfactory results.

"The operations against Borneo, which began in May, 1945, were designed to deny the enemy the fruits of his conquests in the Netherlands East Indies and his use of the approaches to those areas. These included the capture of Tarakan to obtain its petroleum resources and to provide an airfield for support of the Balikpapan operation; the seizure of Brunei Bay to establish an advance fleet base and protect resources in that area; and the occupation of Balikpapan to establish naval air and logistic facilities and to conserve petroleum installations there. Vice Adm. D. E. Barbey was designated the commander of the Borneo attack force. The first Borneo operation was directed against the island of Tarakan, approximately 185 miles southwest of Tawi Tawi, to overcome some 3,000 Japanese that were estimated to be on the island, and to develop facilities for future operations. Australian and American cruisers and destroyers began shelling the island on April 27, and continued through May 1. At the same time the mine-sweeping group cleared the necessary approaches. Numerous neutralizing air raids had been made on airfields in the area. On May 1, the attack group under Rear Adm. Royal moved in. Units of the 9th Australian Division were landed on schedule with only small arms opposition.

"In the second Borneo operation the 9th Australian Division, reinforced, was transported from Morotai to the Brunei Bay area of northern Borneo. Three separate landings were made at Labuan Island and on the mainland at Bintang and Cape Polompong. Air support was furnished by the U. S. Army Thirteenth Air Force and the Australian First Tactical Air Force. For 10 days preceding the target date air strikes neutralized enemy airfields and harassed troop movements and shipping in Borneo, with emphasis on Brunei Bay targets the last three days. Mine sweeping began on June 7, under the protection of Rear Adm. Berkey's covering force of cruisers and destroyers. The mine sweeper Salute struck a mine and sank with many casualties. Beginning on June 9, a distant covering group of cruisers and destroyers under Rear Adm. Riggs patrolled 50 miles west of Brunei Bay to prevent enemy surface interference. The attack group commander was again Rear Adm. Royal. On June 10, after an hour of heavy bombardment which caused the enemy to retreat from the beaches, the assault waves landed without opposition and moved inland against slight resistance.

"When the landings had been successfully executed and one of the two Japanese cruisers in the area had been sunk off the Malay coast by a British submarine, the distant cover group was withdrawn on June 11. Throughout the operation motor torpedo boats rendered valuable assistance strafing shore targets and patrolling the area. One hundred twenty miles to the south at Miri-Lutong a supplementary landing was made by combined forces after a week of mine sweeping in which 458 mines were swept. The operations against Balikpapan were carried out under Rear Adm. Noble as commander of the attack group, and Rear Adm. Riggs as commander of the cruiser covering group. In preparation for the attack heavy air strikes had been made for a month using the Army, Navy and Australian air forces with as many as 100 sorties a day. The target date was set for July 1. Sixteen days prior to this, mine sweeping and underwater demolition activities began with covering fire from cruisers and destroyers. This was met with intense reaction from enemy coastal guns. Three mine sweepers were damaged by enemy fire and three were sunk and one damaged by exploding mines. There was some doubt as to whether the target date could be met, but finally on June 24, destroyers were able to get close enough inshore to smother the enemy guns before the landing. An escort carrier group under the late Rear Adm. W. D. Sample provided day and night air cover, since land planes were based too far distant to assure their presence in the case of bad weather.

"The attack force consisted of the largest number of ships used in the Southwest Pacific area since the Lingayen landings. In the cover and carrier groups were nine cruisers (including two Australian and one Dutch), three escort carriers and destroyer escorts. The attack group was of comparable scale. After an intense two-hour bombardment on July 1, the assault waves moved ashore. In spite of enemy artillery, mortar and small arms fire, 17 assault waves landed without a single casualty.

"After nearly three weeks of replenishment in Leyte Gulf, subsequent to their support of the Okinawa operation, the fast carrier forces of Adm. Halsey's Third Fleet, comprising the greatest mass of sea power ever assembled, proceeded northward on July 1 toward Japan. This huge armada was to complete the destruction of the Japanese fleet, conduct a pre-invasion campaign of destruction against every industry and resource contributing to Japan's ability to wage war, and maintain maximum pressure on the Japanese in order to lower their will to fight. On July 10, the force arrived in the launching area, 170 miles southeast of Tokyo. On that day strikes were made against airfields and industrial plants in the Tokyo area; 72 planes were destroyed on the ground and extensive damage inflicted on other targets. No attempt was made to conceal the location of our fleet but, despite this, little enemy air opposition was encountered. Adm. Halsey then moved north to attack northern Honshu and southern Hokkaido on July 14-15. Aerial strikes dealt a severe blow to critical water transportation facilities between Hokkaido and Honshu, when five railroad ferries were sunk and four others damaged. Again, little air opposition was encountered by our planes. Simultaneously with these air strikes heavy units of the force shelled Kamaishi and Muroran, causing damage to the steel mills and oil installations in those cities.

"On July 17, the Third Fleet moved south and was joined by units of the British Pacific Fleet under the command of Vice Adm. Rawlings. Adm. Halsey was in over-all command and, on that day, ordered the first combined American-British bombardment of the Japanese homeland. Battleships fired 2,000 tons of shells into the coastal area northeast of Tokyo and encountered no enemy opposition during the operation. On the following day American and British carrier-based planes struck at enemy fleet units concealed at the Yokosuka naval base in Tokyo Bay. The Nagato, one of two remaining Japanese battleships, was badly damaged. Numerous shore installations and transportation facilities also were hit. On July 24-25, the combined British and American naval forces launched extensive air strikes against targets in the Inland Sea area. The planes concentrated on the major fleet units still afloat at the Kure naval base. Six major ships were badly damaged and, in all, 22 naval units totalling 258,000 tons were either sunk or put out of action, sounding the death knell of Japanese sea power. Intensive anti-aircraft fire was met, and for the first time the enemy mounted aggressive, airborne opposition. A total of 113 enemy aircraft were destroyed during the two-day attack, while only 12 British and American planes were lost.

"A follow-up attack was made on Kure and the Inland Sea area by the carrier-based planes on July 28. Reconnaissance indicated that enemy fleet units had been reduced effectively by previous strikes, but additional bombs were dropped for good measure. Extensive damage also was done to merchant shipping and to vital shore installations, particularly railroad facilities. Strong air opposition was encountered once more, but our aircraft knocked down 21 Japanese planes airborne and destroyed 123 on the ground for a total of 144 for the day, while our forces lost 36. On July 30, the Tokyo area was harassed for the third time in three weeks by aircraft from the fast carriers, our airmen destroying 121 enemy planes during the day, and inflicting severe damage on lighter enemy fleet units found in the region. Meanwhile, our fast battleships were shelling the port of Hamamatsu on the east coast of central Honshu, spreading havoc in that area.

"For the first eight days of August the harassed Japanese homeland was given a temporary respite (from Navy operations) while Adm. Halsey's fleet was riding out a heavy typhoon. On August 9-10, however, the offensive was renewed with another air attack on northern Honshu. It was known that the enemy had withdrawn a large part of his air force to fields in this area, and the strikes were designed to destroy as many of them as possible. The plan was partially successful, for during the two days 397 enemy planes were destroyed and 320 others damaged. Almost no airborne opposition was encountered, and all but 10 of the destroyed planes were caught on the ground. The British and Americans lost only 34 planes. While these air strikes were in progress, battleships from the Third Fleet bombarded the coastal city of Kamaishi for a second time, inflicting further heavy damage on the steel mills in the area.

"Adm. Halsey's final blow was delivered against Tokyo on August 13. Airfields and other military installations were the primary targets, with 46 planes being destroyed on the ground. The Japanese tried to get through to the surface ships, but 21 planes were shot down in the futile attempt. The strong protective screen around our fleet was too much for the fading enemy air strength. On August 15, the order of Fleet Adm. Nimitz to 'cease fire' was received too late to stop the first of the day's air strikes planned for Tokyo. It knocked 30 enemy planes out of the air and destroyed 10 more on the ground. The second strike had also been launched, but it was recalled in time; its pilots were ordered to jettison their bombs and return to their carriers.

"Since July 10, the forces under Adm. Halsey's command had destroyed or damaged 2,804 enemy planes, sunk or damaged 148 Japanese combat ships, sunk or damaged 1,598 enemy merchant ships, destroyed 195 locomotives, and damaged 109 more. In addition, heavy blows had been struck at industrial targets and war industries, effectively supplementing the bombing by B-29s. This impressive record speaks for itself and helps to explain the sudden collapse of Japan's will to resist. Naval air power, acting in close conjunction with naval surface power and Army bombers, had beaten enemy land-based air power, besides inflicting critical losses on naval ships and seriously damaging many shore targets. Although somewhat obscured by the more spectacular amphibious assaults and carrier force operations which marked our major advances toward the Japanese homeland, there were many other vital and necessary activities which by their nature had more the form of a continuous pressure than of major individual operations against the enemy. Outstanding parts were played by the submarines, by the land-based air forces, and, to a lesser extent, by the Northern Pacific forces.

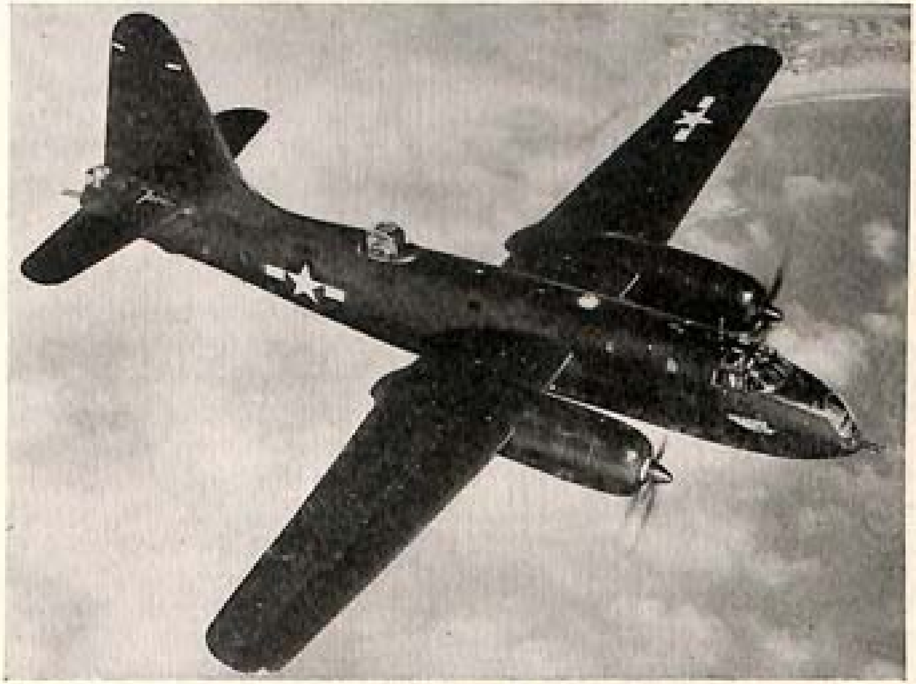
"Although usually hampered by foul weather, which ran the gamut of fogs, rain, gales, snow and floating ice fields, naval and air forces of the Northern Pacific continued to exert pressure against the Japanese-held northern Kurile Islands, posing a constant threat to the enemy's northern flank. Army and Navy aircraft flew such searches as weather permitted, bombed and rocketed Japanese shipping and bases in the Kuriles several times each month, and maintained photographic coverage to detect any increase in enemy installations. Light naval task forces, usually consisting of three of the older cruisers and from five to seven destroyers, bombarded coastal positions in the Kuriles once in March, once in May, twice in June, and once in July, and even penetrated the Okhotsk Sea in search of enemy shipping. On August 11-12, cruisers and destroyers commanded by Rear Adm. J. H. Brown, Jr., combining a high-speed anti-shipping sweep on both sides of the central and northern Kuriles with bombardments of enemy shore installations, intercepted two enemy convoys and destroyed 10 trawlers and a subchaser.

"With the exception of the B-29s of the Army's Twentieth Air Force, the principal missions of land-based air forces of the Pacific Ocean Areas were support of the Iwo Jima and Okinawa operations, attacks on Japanese shipping, and continued neutralization of by-passed enemy bases. During the period of this report, the greatest expansion of land-based air forces took place in the Twentieth Air Force. Airfields in the Marianas were constantly increased to accommodate greater numbers of B-29s. When Iwo Jima became available for emergency landings, greater bomb loads were carried safely, and fighter support became possible. From that time until the end of hostilities, strategic bombing against vital Japanese industries and cities was constantly stepped up, coordinating with bombing by fleet planes, and many thousands of mines were dropped in Japan's harbors and sea lanes. Destruction resulting from these raids, and the final blows dealt with two powerful atomic bombs, undoubtedly were a major factor in forcing Japanese capitulation.

"Of less spectacular nature, yet also important in their effect on the war, were the operations of other land-based air forces against enemy shipping and by-passed islands in the Pacific. With the capture and development of airfields on Okinawa, Army and Marine Corps bombers and fighters of the Tactical Air Force and Fleet Air Wings One and Eighteen were brought within easy range of the China coast, Korea, Shikoku, Kyushu, and even Honshu, and were enabled to bring Japanese shipping in these waters to a virtual standstill. Okinawa, as did Iwo Jima, returned rich dividends for the investment involved in its capture by hastening the war's end. Support of the Iwo Jima and Okinawa campaigns, routine searches, and constant neutralizing attacks against the many islands of the Pacific still in the hands of enemy garrisons, were tasks which absorbed much of the time and effort of Army, Navy and Marine Corps land-based aviators throughout the Pacific, and were well coordinated with the air operations of the fast carrier task forces in the advance toward Japan. The last night of the war saw the first and only offensive mission carried out from Okinawa against Japan by the B-29s of the recently deployed Army Eighth Air Force, with their target the industrial city of Kumagaya in northern Honshu.

"Our access to the Japanese homeland gave opportunity at last for securing reliable information as to conditions there, both by our own observation and by conversation with Japanese officials who no longer had the incentive or the ability to deceive either their enemies or their own people. It was at once apparent that while the damage to their cities and production centers by strategic bombing was fully as great as photographic reconnaissance had indicated, the strangulation from our less obvious but relentlessly effective surface and submarine blockade and from our carrier-based air attacks, had been a decisive factor in the enemy's collapse. Their merchant marine had been reduced to a fraction of its former size; of the few remaining ships, mostly small ones, only half were still operable. Their food situation was critical, and their remaining resources in fuel and all strategic materials were not less so. It had been known that their few remaining carriers and heavy naval vessels had been damaged, but it appeared that the fury of our carrier strikes had forced them to withdraw all but a handful of men from these ships, practically abandoning them. Never before in the history of war had there been a more convincing example of the effectiveness of sea power than when a well-armed, highly efficient and undefeated army of over a million men surrendered their homeland unconditionally to the invader without even token resistance.

"True, the devastation already wrought by past bombings, as well as the terrible demonstration of power by the first atomic bombs, augured nothing less for the Japanese than total extinction; yet without sea power there would have been no possession of Saipan, Iwo Jima and Okinawa from which to launch these bombings. True, the



THE LOCKHEED NAVY P2V PATROL BOMBER

Japanese homeland might have been taken by assault in one final amphibious operation of tremendous magnitude, yet without sea power such an assault could not have been attempted.

"Before the conclusion of the war, plans were maturing for the invasion and occupation of the main Japanese islands. Two major operations were projected: the first, with the code name of Olympic, against southern Kyushu; after consolidation there the next—Coronet—into the Tokyo plain area which is the industrial heart of Japan. The amphibious parts of these operations—involving the preparation of landing beaches by mine sweeping, underwater demolition teams, bombardment and bombing; the transportation of the assault troops; and the initial landing for the establishment of firmly held beachheads—were to have been the responsibility of Fleet Adm. Nimitz.

"The large-scale bombardments and bombings of the Third Fleet that began on July 10 were actually in preparation for operation Olympic. In mid-August, as the war ended, the United States Navy had in the Pacific 90 per cent of its combatant vessels of submarine size or larger and 42 per cent of its combatant aircraft. These ships, aircraft, support auxiliaries and landing craft included:

| | |
|---|---|
| Battleships | 23 |
| Aircraft carriers | 26 |
| Escort carriers | 64 |
| Cruisers | 52 |
| Destroyers | 323 |
| Escort vessels | 298 |
| Submarines | 181 |
| Mine craft | 160 |
| Auxiliary vessels | 1,060 |
| Large landing craft | 2,783 |
| Combat aircraft | 14,847 |
| Transport, training and utility aircraft | 1,286 |

"All six Marine divisions, or 100 per cent of the Marine Corps combat strength, were also available for Pacific operations. The Olympic and Coronet operations as planned would have been the largest amphibious operations in history. While the Third Fleet provided strategic cover and support for the amphibious forces making the invasion, the Fifth Fleet was to have executed the amphibious phases of the invasions of Kyushu and Honshu by transporting their troops and equipment to the attack position on shore. By the application of naval force they would have established the necessary ground troops in positions favorable for further maneuvers to complete the destruction of Japanese ground forces.

"In discharging its responsibilities for the amphibious phase of the Kyushu or Olympic operation the United States Navy would have employed 3,033 combatant and noncombatant vessels of a size larger than personnel landing boats. Although the application of our sea power in its various forms proved sufficient to bring Japan to terms without the necessity of invading her home islands, the possibility of invasion on the scale contemplated indicates the amazing progress in matters of supply and support that has been made in less than four years of war.

"In this evolution advance bases have played a vital role. The 1940 Navy had no properly equipped advance bases other than Pearl Harbor. More than 400 have since been established in the Atlantic and Pacific areas in order to maintain the fleet and air forces in the forward areas where there was fighting to be done. As we progressed across the Pacific, islands captured in one amphibious operation were converted into bases which became spring boards for the next advance. These bases were set up for various purposes depending upon the next operation. At first they were mainly air bases for the support of bombers and for the use of protective fighters. This gradually changed to the establishment of staging bases for the anchoring, fueling and refitting of armadas of transports and cargo ships, and for replenishing mobile support squadrons which actually accompanied the combat forces and serviced them at sea. Further advances made necessary the development of repair and refitting bases for large amphibious forces. As we progressed further and further across the Pacific, it became necessary to set up main repair bases for the maintenance, repair and servicing of larger fleet units. The first of such large bases was set up at Espiritu Santo in the New Hebrides and was followed by a main repair base at Manus in the Admiralty Islands. It then was determined that so long as ships were in condition to function in the battle line, minor battle damage and derangements should be rectified in the forward area, thus eliminating the necessity of returning ships to continental bases or even to the Hawaiian Islands.

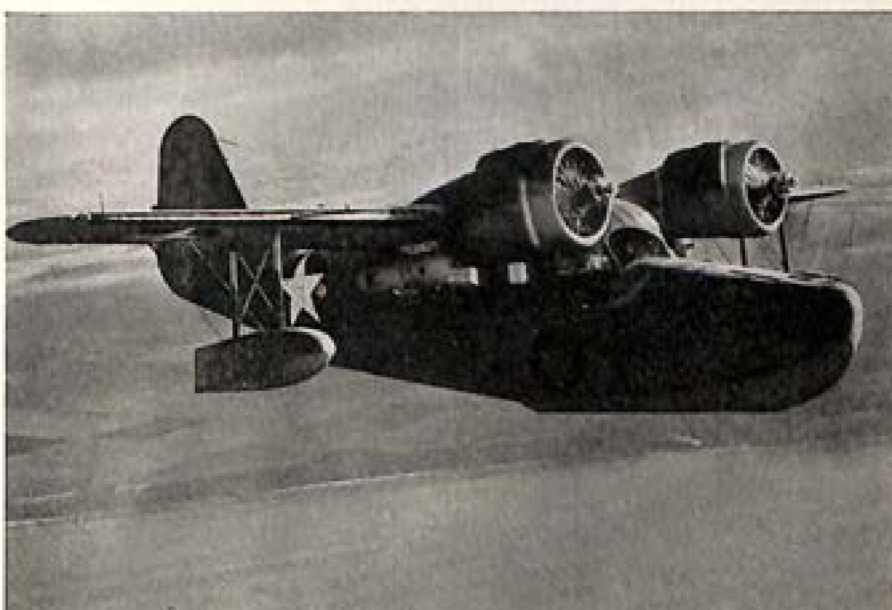
"These conditions were recognized and steps were taken to support the entire fleet in the Marianas, Philippines and Okinawa areas. A very large base, capable of supporting one third of the Pacific Fleet, was set up at Guam; another large base was established at Leyte-Samar; a third was in process of construction at Okinawa when the war ended. Each of these bases was designed to dock ships of various sizes, some being able to take ships of the heaviest tonnage. All of the bases could repair major battle damage to hull and equipment. Facilities were established ashore with piers, roads and machine shops, in large measure duplicating the type of facilities found at any of our navy yards. There also was provided the replenishment storage necessary to restock every type of vessel with fuel, ammunition and consumable supplies as well as food. The stocks currently on hand at Guam would have filled a train 120 miles long. The magnitude of the fuel supply alone is indicated by the total of 25,026,000 barrels of bulk fuel which was shipped to the Pacific in June, 1945, for military purposes. At Guam alone one million gallons of aviation gas were used daily. As these bases were pushed gradually forward, assault forces were brought two to five days' steaming nearer the enemy. By proper selection of the strategic points necessary to accomplish the advance, we were able to by-pass and ignore many bases established by the Japanese which they could no longer use because of their loss of command of the sea.

"But for this chain of advance bases the fleet could not have operated in the western reaches of the Pacific without the necessity for many more ships and planes than it actually had. A base to supply or repair a fleet 5,000 miles closer to the enemy multiplies the power which can be maintained constantly against him and greatly lessens the problems of supply and repair. The scope of the advance base program is indicated by the fact that the personnel assigned directly to it aggregated almost one fifth of the entire personnel of the Navy—over half a million men, including almost 200,000 Seabees. In the concluding months of the war 82 per cent of the Seabees were in the Pacific, the vast majority of them at work on bases. In the Naval Supply Depot at Guam there were 93 miles of road. At Okinawa alone there were more than 50 naval construction battalions building roads, supply areas, airfields and fleet facilities for what would have been one of the gigantic staging areas for the final invasion of Japan. In the period covered by this report almost two million measurement tons of materiel were shipped in connection with the advance base program.

"An essential element in the facilities of our advance bases was floating drydocks, which were capable of receiving vessels ranging from small craft to the battleship Missouri. One hundred fifty-two of these docks were produced.

"When the collapse of Germany was imminent, a review in conjunction with the Army of our policy of maximum west coast utilization was necessary. . . . While defensive operations became secondary, the responsibility of the Western Sea Frontier to regulate the movement of ships and aircraft through frontier waters was increased greatly. The eastern Pacific had become a network of channels for the passage of traffic to the forward areas. These channels were the most heavily traveled military highways on and above the sea. In the period covered by this report there were over 17,000 sailings of vessels large and small through the six million square miles of Western Sea Frontier waters. In the same period an average of one aircraft arrived on or departed from the west coast each 15 minutes on the longest over-water flight lane in the world.

"Comparisons between standard Navy aircraft types at the beginning of the war and the end vividly illustrate the outstanding technical advances accomplished in less than four years of fighting. At the war's end we had the best airplanes of every kind, both ashore and afloat, but newer and better planes were on the production lines and would soon have taken their place against the enemy. Among these were the Grumman Tigercat, a twin-engine, single-seat fighter plane with heavy firepower and bomb-carrying characteristics. Although this plane had arrived in the Pacific, it never got into actual combat. Three other fighter planes, faster and possessing higher tactical performance than standard existing types, had satisfactorily passed the long period of experiments and flight tests and were in production. These included the Ryan Fireball, the Navy's first fighter plane to use jet propulsion. The others were Grumman's Bearcat and Goodyear's F2G (to which no popular name has yet been given) both high-speed, highly maneuverable and fast climbing planes. The latter was the first naval fighter to use the new Pratt and Whitney 3,000 horsepower engine. The Grumman Wildcat, which was a new fighter at the time of Pearl Harbor, had an approximate speed of 300 miles an hour and mounted four .50-cal. machine guns. The Curtiss Hellcats and Vought Corsairs, which were both carrier and shore-based on V-J Day, have speeds of more than 400 and 425 miles an hour, respectively, and mount six .50-cal. machine guns, or proportionate numbers of 20-millimeter cannon, in addition to rockets. Bombs weighing up to 2,000 pounds could also be carried by these planes when they were assigned fighter-bomber missions. These planes played the leading role in our tactical development of fighter-bombing, a World



THE GRUMMAN GRAY GOOSE

War II innovation. Other technical developments, primarily airborne radar, helped to bring into existence the Navy's night-fighting force. The Wildcat, greatly improved by various modifications by General Motors to give it greater speed and climb, continued to be used on the escort carriers.

"Our dive-bomber, the Helldiver, has a speed of more than 250 miles an hour, can carry 2,000 pounds of bombs, and is equipped with eight rocket launchers, two 20-millimeter cannon and two .30-cal. machine guns. These characteristics were developed through five modifications. The Douglas Dauntless was the standard dive-bomber when the war began, and delivered heavy blows against the enemy before it was retired as a first line plane. Its top speed was 230 miles an hour; it carried 1,000 pounds of bombs, and mounted two .30-cal. and two .50-cal. machine guns. Our torpedo bomber at the start of the war was the Douglas Devastator, a plane which had a speed of about 150 miles an hour and was very lightly armed. The Grumman Avenger, and later modifications of this plane by General Motors, gave us a plane with a speed of more than 250 miles an hour, capable of carrying 2,000 pounds of bombs or a torpedo, four machine guns and rockets. One modification of the Avenger was a carrier-based night bomber to operate with night fighters.

"Development and research in the dive-bomber and torpedo bomber field during the war yielded designs by Consolidated, Douglas and Glenn L. Martin. A few production models had been turned out by Consolidated and Douglas and several experimental models by Martin when V-J Day came.

"The standard scout-observation plane based aboard battleships and cruisers became the Curtiss Seahawk, replacing the Chance Vought Kingfisher and Curtiss Seagull. The Seahawk and Kingfisher played no small part in air-sea rescues. The Consolidated Catalina, the veteran twin-engine patrol plane, was in operation at the start of the war and has proved to be one of the most valuable all-purpose planes. Planes of the sixth modification—or sixth major change—giving it greater range and speed are now with the fleet. The Martin Mariner, a larger, heavier plane, has taken over many of the patrol duties formerly handled by the Catalinas. Both of these planes also have performed outstanding service in air-sea rescue work.

"For our four-engine, land-based search plane, we have replaced the Consolidated Liberator with the Consolidated Privateer, a plane with a range of well over 3,000 miles, heavy armament and a wealth of new navigational, radio and radar equipment, enabling it to fly long hours of reconnaissance over trackless oceans. These planes, which carry bombs and depth charges, have made impressive records against isolated Japanese ships, small convoys, submarines and enemy-held islands in their search areas. Our newest twin-engine search plane is the Lockheed Harpoon, which took over the duties of the Lockheed Ventura. It carries bombs and rockets and has 10 .50-cal. machine guns with which to protect itself. The range of the Harpoon is in excess of 2,000 miles and its speed is more than 300 miles an hour.

"The Naval Air Transport Service utilizes as its standard transport planes the Martin Mars, Douglas Skymasters (R5D) and Skytrains (R4D), and Consolidated Coronado flying boats, while Marine Corps air transport groups use the Curtiss Commandos in large numbers. Established on December 1, 1943, the Naval Air Transport Service routes extend over approximately 80,000 miles, covering three quarters of the globe. In addition to carrying freight and passengers, the Service flew whole blood daily from the west coast to combat areas in the Pacific and evacuated wounded during the Okinawa campaign.

"Improved cooling and other changes have increased the horsepower of standard combat engines 10 per cent with little or no increase in weight. Thus it has been possible to translate added power into increased climb and speed. New superchargers make it possible to hold high take-off horsepower to higher altitudes than was possible before. The adoption of water injection for engines to give pilots greater speed in emergencies also has become general for all combat

U. S. Navy photo

A SECTION OF APRA ON GUAM

Part of the Naval Operating Base at Apra Harbor.

RYAN FR-1 FIGHTER PRODUCTION

Final assembly on the Navy's new Fireball carrier fighter at the plant of the Ryan Aeronautical Company, San Diego, Calif.

types. Our requirement for the utmost in reliability and our long-held conviction that an aircooled power plant installation was less vulnerable to damage than a liquid-cooled, has caused us to devote primary attention to the development of aircooled engines, and hence, has contributed substantially to the aircraft program of the country. It can be claimed without exaggeration that the aircooled aircraft engine of today would not have been developed effectively had it not been for the Navy's continued interest.

"Other technological advances in naval aircraft have included the development of jet-assisted take-off (which makes it possible for seaplanes to carry much heavier loads), the largest helicopter yet flying, and radio-controlled target drones and missiles.

"Fighter-plane speed was increased greatly during the war. At the end an experimental model ready for combat use had a speed of over 550 miles an hour. This plane was powered with turbo-jet engines, little known before 1941. Development of the conventional aircraft engine also had progressed; whereas initially the maximum size was 1,000 horsepower, improved types of 3,000 horsepower are now in use. Torpedo bombers, scout bombers, patrol bombers and scout observation planes all have been developed rapidly during the period. Carrier-borne aircraft with increased speed, range and armament carried the battle to the Japanese homeland, and patrol aircraft with high speed, long-range and greater offensive power aided in supplying the information necessary to the success of those operations. Development of the arresting gear, launching catapults and handling equipment of our surface ships kept pace with the increasing weights of planes, and allowed more planes per ship to be carried than had been possible in peacetime.

"Our aircraft were a focus for developments in many fields. Radar opened new possibilities for search, night combat and operations under poor visibility conditions. Aircraft guns were increased in size from the .30-cal. World War I weapon to 20-, 37-, and 75-millimeter guns. Airborne rockets up to 11.75 inches in diameter radically increased the striking power of conventional aircraft, with little penalty on performance. Rocket power also was used on seaplanes for assistance in take-off with heavy loads and in high seas, making possible the rescue of many downed aviators and thereby reducing our combat losses. Development of the fire bomb further extended the tactical versatility of aircraft.

"Research on air problems has been devoted in the main to perfection of tactics designed to minimize flak hazard to naval aircraft attacking gun-defended targets, and to analysis of accuracy and effectiveness of aerial weapons, primarily against sea-borne targets. Bombs, rockets, and torpedoes are designed for distinct uses, conditioned by the accuracy of launching and by their lethal effectiveness. Studies of the peculiarities of these weapons have led to recommendations for tactics and training procedures. Studies were carried out by

MARTIN NAVY MARS ASSEMBLY LINE

Showing the huge flying boats under construction in the plant of The Glenn L. Martin Company, Baltimore, Md.

other subgroups on defense of task forces against suicide attacks, on the effectiveness of anti-aircraft fire, and on problems of naval gunfire as a support for amphibious landings.

"The assistance and cooperation of industry and science have been indispensable. Without this assistance, many of the weapons which have come into being as the result of intensive wartime research and development otherwise never would have been completed and introduced into the fleet.

"It had often been predicted that in a national emergency the totalitarian countries would have a great technical advantage over the democracies because of their ability to regiment scientific facilities and manpower at will. The results achieved by Germany, Italy and Japan do not bear out this contention. Studies made since the close of the war indicate that in none of these countries was the scientific effort as effectively handled as in the United States. The rapid, effective and original results obtained in bringing science into our war effort are proof of the responsiveness of our form of government to meeting emergencies, the technical competence of American scientists, and the productive genius of American industry."

United Air Lines photo

HOMEWARD BOUND FROM SOUTH PACIFIC

Made comfortable in litters and attended by Army Air Forces flight nurses, these wounded soldiers start from an Australian base in a United Air Lines Douglas C-54 transport operated for the Air Transport Command.

## CHAPTER V

### AIR TRANSPORTATION

Our Wounded Are Flown Back Safely from Europe and Asia—The Air Transport Command of the Army Air Forces—The Navy Air Transport Service—Record Operations of Air Express —Rapid Growth of Airline Services—Developments in Passenger, Mail and Freight Traffic—The Trans-ocean Services—New Equipment.

WHEN hundreds of thousands of passengers, many of them wounded soldiers and sailors, were flown across the continents and oceans during the war it marked the beginning of a new age in which air transportation was to grow with breathless rapidity, taking people and things across the United States in a few hours, spanning the Atlantic in a single day and the vast Pacific in a very few days. The whole world, in fact, could be traversed in a brief vacation. More than 80 per cent of the people of the United States were living within 25 miles of a station stop on the great air transport system which was beginning to spread out into all corners of the earth. But nothing exemplified the practicability of our airlines operations more than the safety with which our wounded were flown back home from the war-torn hells of Europe and Asia. Here is a War Department statement:

"A perfect record in flying thousands of patients from Europe and China, India and Burma by the AAF Air Transport Command in 1945 is reported by the War Department. A total of 43,496 patients, litter and walking, were evacuated from overseas over routes of ATC's North Atlantic Wing with only two deaths enroute, and in neither case could the trip be considered either the cause of or a contributory factor in the patients' deaths. The figures take on additional significance, it was pointed out by the Chief Surgeon, when it is realized that a total of 186,747,436 patient miles were flown during 1945. The average distance travelled per patient was approximately 4,300 miles. Evacuations of the sick and wounded were as follows: United Kingdom, 14,145; Paris, 24,166; Casablanca, 3,144; Naples, 646; India-Burma, 580; China, 401; other, 414. Since the beginning of aerial evacuation in 1943—an important medical factor considered to have saved a great number of lives because of the speed with which they are handled—up to January 1, 1946, a total of 64,318 patients were returned to the United States by air over the Atlantic routes. During the first year 687 patients were flown. Only ATC's giant four-motored C-54s were employed for the long over-water hops, and every care and safety precaution was exercised to insure the success of each mission. A maximum of 30 litter cases were transported each trip, except in cases of extreme distances, when fewer patients were carried to permit greater gasoline loads. This enviable record compares with ATC's Green Projects program during the summer of 1945 when hundreds of transports shuttled 150,000 passengers to the United States in four months without a single loss."

Between January, 1944, and August 31, 1945, the Air Transport Command carried here and abroad a total of 2,957,454 passengers, 92,597 tons of mail and 1,000,479 tons of other cargo. Between July, 1942, and V-J Day, the ATC had flown 2,369,400,000 ton miles, 6,937,330,000 passenger miles and 935,000,000 airplane miles. ATC operations involved a total of 5,638,200 hours of flying. In ATC operations inside the United States 330,822 passengers, 120 tons of mail and 51,758 tons of other cargo were carried between January, 1944, and August 31, 1945. Between July, 1942, and V-J Day, ATC domestic operations amounted to 187,300,000 ton miles, 576,500,000 passenger miles, 114,000,000 airplane miles and 735,900 hours of flying. ATC foreign operations during the same period amounted to 2,182,100,000 ton miles, 6,360,800,000 passenger miles, 821,000,000 airplane miles and 4,902,300 hours of flying.

Air Transport Command operations over the Himalayan Hump between India and China were the most spectacular of the war because of altitude, the nature of the country traversed and the prevailing bad weather. Here is some of the record. A grand total of 685,304 tons of cargo, including 392,362 tons of gasoline and oil, was flown into China. From December, 1943, to August 31, 1945, 156,977 flights were made over the Hump to China, including 3,138 in December, 1943, 54,926 in 1944 and 98,913 up to the end of August, 1945. The average number of transports assigned grew from 165 to 640, and the percentage in service rose from 57 per cent in December, 1943, to 84 per cent at the peak. A total of 373 transports were lost in the Hump operations, losses running as high as eight planes for every 1,000 China trips in January, 1944, and decreasing to one for each 1,000 trips during the last two months of the war.

Ferrying operations of the Air Transport Command were carried on throughout the United States and abroad. From July, 1942, until V-J Day, the ATC flew 49,761 aircraft overseas in a total of 2,048 flying hours, covering 329,562,000 miles, in the course of which 594 aircraft were lost.

The Naval Air Transport Service flew an estimated 8,927,174 ton miles in 1942, an estimated 68,900,000 in 1943, 209,473,181 in 1944 and 344,668,941 ton miles in 1945. NATS planes in operation were 94 during the peak month of 1942, 179 in 1943, 351 in 1944 and 435 in 1945. Passengers totalled 25,151 in 1942, 184,719 in 1943, 549,393 in 1944 and 776,745 in 1945. Cargo and mail amounted to 4,527 tons in 1942, 32,397 in 1943, 76,665 in 1944 and 100,258 tons in 1945. The routes traversed by NATS operations rose from 37,400 miles in 1942 to 63,250 miles in 1945.

Complete air transport statistical tables will be found in the section Flying Facts and Figures.

New air express records were made in 1945 on our domestic and international routes. Handled for domestic airlines by the Air Express Division of Railway Express Agency, nation-wide air express passed the two million shipment mark in 1945 for the first time, with a total of 2,165,132. This marked a rise of 22.06 per cent over 1944 which rang up a record-breaking total of 1,773,823 shipments. Gross revenue on this traffic cleared the mark set in 1944 by 19.2 per cent, with $13,645,806 reported for 1945, compared with $11,447,715 the year before.

Air express traffic, consisting mainly of war-essential machine parts, drugs and printed matter in the earlier part of 1945, and recon-

U. S. Navy photo

NAVY WOUNDED HOSPITAL-BOUND

Casualties from a South Pacific battle aboard a Navy Douglas Skytrain on their way to a base hospital. This aerial ambulance service was operated by the South Pacific Casualty Air Transport, U. S. Navy.

LOCKHEED CONSTELLATION AS ARMY TRANSPORT

version machinery, household appliances and store merchandise in the latter part, weighed about 40,745,100 pounds as against the all-high war year of 1944, which reached the 34,276,834 pound mark. Additional cargo space rapidly became available as the year wore on, with new and reconverted planes entering the commercial field.

In its 18th year of operation, air express moved its shipments over 63,000 miles of air routes, an increase of about 5,000 miles over the previous year. It served through the facilities of Railway Express Agency about 728 points with direct air delivery and about 23,000 express offices throughout the country with coordinated air-rail-truck delivery.

A new record also was made at LaGuardia Field when the New York department of the Agency reported a total of 888,862 shipments for the year. This figure held two new records with an all-time top monthly average of 74,072 and a new monthly peak reached in December with 101,712. No month ran under the 50,000 shipment mark at New York throughout 1945. Gross revenue for the year's business set a new mark with $3,993,961, compared with the 1944 $3,401,105. Gross revenue for the peak month of December was $467,116, compared with $435,363 for the same month the year before.

Over-the-border business also soared to new heights, with international air express totaling 324,461 shipments, marking a 30.5 per cent rise over the 248,541 recorded in 1944. Handled by the Railway Express Agency for Pan American World Airways, Braniff Airlines and American Airlines System, a record-smashing monthly average of 27,035 shipments were reported, as against 20,700 in 1944. Charges paid by shippers on the international traffic in 1945 came to $1,499,-947, a 41.2 per cent gain over 1944. High month for international air shipping was December, with 36,725 shipments, hurdling the peak month of 1944 by 36.7 per cent. Revenue for this month amounted to $133,271, a new monthly record.

Throughout 1945, outgoing traffic maintained a better than two to one balance over incoming traffic. Airport cities included in these reports of international business were Miami, New York, New Orleans, San Francisco (Mills Field), Seattle, Fort Worth, San Antonio, Los Angeles, Brownsville, Laredo and El Paso. Featuring the international traffic during 1945 were these shipments, a ton of mining replacement parts from New York to Botwood, Newfoundland, to keep an essential mine in production; 11,000 pounds of ball bearings from Ford Motor Company to its plant in Degenham, England; about 60,000 Easter Lily buds; an air express shipment from Buenos Aires, marked mysteriously "Hydroxymercuripropanolamide Orthocabosyphenoryacetique," identified as a chemical product; the first Soviet commercial air express shipment to Seattle, rare rose oil and tobacco samples; nearly 1,100 sexed leghorn pullet baby chicks from New Paltz, N. Y., to Havana, Cuba; 1,500 sets of false teeth monthly to Central and South America.

Added incentive for this historic development of air shipping was given by a succession of commodity rate tariffs substantially reducing costs of air expressing specified articles between specified points. The year concluded with an announcement of national overall rate reductions ranging up to 13 per cent, which started the new year off in high gear. To keep the express business rolling and flying to new records in 1945, the Railway Express Agency employed 60,000 men and women, 16,000 motor vehicles, and through its contracts with all transportation systems, forwarded shipments over the swiftest railroad, water and air lines available.

Operations of the 24 domestic and international airlines of the United States broke all records in 1945. All categories of traffic registered unprecedented gains over 1944, ranging from 55 per cent in revenue passenger miles to about 31 per cent in ton miles of express and freight.

The increase in civilian operations occurred during the period while the commercial carriers still were partially engaged in contract war operations for the Army and Navy both in this country and overseas. The period also covered the beginning of extensive contract carrying in the redeployment of troops across the United States.

The number of planes in daily use by domestic airlines reached a total of 414, as compared with the pre-Pearl Harbor peak of 359, with scores more in process of reconversion and other new models coming off production lines. The overseas fleet totaled 102 planes, giving a total of 516. Those aircraft were insufficient to handle the steadily increasing demand for seats, when in December the Army and Navy temporarily took over 70 per cent of the eastbound space for returning soldiers and sailors. The number of transport planes on order was large enough to bring the total fleet to more than 1,239 in 1946 and 1947, seating 49,757 passengers.

The domestic airlines in 1945 flew about three and a half billion revenue passenger miles and carried about six and a half million revenue passengers—an increase of more than 50 per cent in revenue passenger miles and more than 62 per cent increase in revenue passengers over 1944. Mail rose to about sixty-five million ton miles—an increase of about 27 per cent over 1944. Air express and cargo increased to a total of about twenty-three million ton miles, 31 per cent over 1944.

The average number of occupied seats per plane rose to 19.2 inside the United States. Fares had been reduced to 4½ cents a mile. A reduction of 13 per cent in basic express rates became effective January 1, 1946. Still with insufficient equipment, the airlines were able to handle the huge volume of traffic because they continued to maintain the exceptionally high utilization of aircraft achieved during the war. As compared with seven to nine hours before Pearl Harbor, planes in service during the later months of the war were flown 11 to 12 hours daily. That figure in 1945 dropped slightly on some lines, but actually improved on others, at least two lines recording a 12½ hour daily average use. Similarly, the wartime load factor, which hit a high average mark of 92 per cent, dropped somewhat, but three lines increased theirs. One line operated with nearly 95 per cent of available seats filled with paying passengers, and several held over the 90 mark. The international United States carriers were operating at better than an 80 per cent load factor, with average trips of nearly 1,000 miles.

After the war, the airlines commenced acquiring transport planes capable of 300 miles an hour speeds, as compared with pre-war 180 miles an hour models. Their capacity was rising to 50 or more seats. Increasing use of pressurized cabins raised comfortable "over the weather" cruising heights to 30,000 feet.

During the latter part of 1945, in addition to their regular civilian operations, the airlines, under contract and through seat allotments, helped speed the movement of about 126,000 troops. During the earlier part of 1945 the air carriers had completed their direct war job, which all told amounted to flying 8,000,000,000 passenger miles and 850,000,000 ton miles of cargo under contract for the Army and Navy and in war-tinged civilian operations. On Army and Navy missions alone the commercial carriers flew the equivalent of 26,000 times around the world at the Equator.

Eleven airlines continued to operate under contract for the Army and Navy, some of them for several months after the war. Those still continuing with work for the Army early in 1946 were American Airlines, American Export Airlines, Northwest Airlines, Pan American World Airways, Transcontinental & Western Air, and United Air Lines. The services of Consairway were terminated on December 15; Eastern Air Lines October 15; Pan American-Grace September 15; Western Air Lines August 31; Northeast Airlines April 1.

On contracts with the Army these carriers flew 100,544,961 transport miles between January 1 and December 1, 1945, the latest date for which figures were available. For that same period the ton miles flown were 399,928,428; and passenger miles, 1,751,763,336, of which 1,603,877,886 were on international routes and 147,885,450 on domestic. The contract carriers on the project for redeployment of returning soldiers and sailors carried 63,376 passengers from August 21 to December 31, 1945. That did not include seat allotments on regular eastbound civilian schedules.

In mid-September, 1945, wartime priority restrictions were greatly relaxed, leaving 85 to 90 per cent of airline seating capacity available for passengers without priorities on a "first come, first served" basis for regular reservations. On October 15 all priorities were abolished. The demand for air travel increased so heavily, however, that on practically all routes it was necessary to make reservations anywhere from several days to several weeks in advance.

BOEING C-97 FLIGHT CONTROL CABIN

The number of airline employees jumped to 55,000 by the end of 1945. This included a 20 per cent increase due to adoption of the 40-hour week by most of the carriers. Employment was expected to reach 120,000 by the end of 1947. In 1941 the total personnel of the airlines had been about 26,000. Skilled mechanics and their helpers led the roster. Pilots came second, stewards and stewardesses third and ground communications officers fourth. Jobs for veterans was the keynote of the airline hiring program. The carriers welcomed back their thousands of employees who had joined the armed forces and hired in even greater numbers veterans who were not previously in their employ. As the year closed, more than 10 per cent of all airline personnel were veterans.

The domestic scheduled carriers in 1945 had a remarkable record of only 2.2 passenger fatalities for each 100,000,000 passenger miles flown. In spite of wartime handicaps for a large part of the year this figure was the same as in 1944, when the corresponding rate for automobiles and taxis was 2.9. In 1930, the number of airline passenger deaths had been 28.37 per 100,000,000 passenger miles.

In 1945 there were 40 accidents—major or minor—on the domestic routes, as compared with 30 in 1944; and 76 passenger fatalities, as compared with 50 in 1944. But the number of passenger miles operated increased so heavily that the result was a record of 47,368,421 passenger miles flown per passenger fatality, as compared with 45,252,370 in 1944. There were eight fatal accidents as compared with five in 1944.

On the overseas routes in 1945 there were only five accidents all told, as compared with 11 in 1944, with two fatal accidents each year. The number of overseas passenger fatalities was 17, or a drop of three from 1944. The overseas passenger fatality rate per 100,000,000 passenger miles was 3.9. This means that the overseas lines operated 29,000,000 passenger miles for each passenger fatality.

The network of air routes available for the transportation of passengers, airmail, and cargo in the United States was increased by 4,042 miles in 1945. The total number of route miles reached the all-time high of 66,979.

The year was also a record breaker in international operations, with the Civil Aeronautics Board having granted three carriers of the United States certificates for routes across the North Atlantic through Europe to Russia and India. Examiners for the Board also made recommendations for service across the South Atlantic and the Pacific which were not finally decided on by the full Board, while determination of broad extensions in the Caribbean was still to come.

The international route miles certificated at the end of the year totaled 106,197 miles for the United States carriers. They were: American Export (now American Airlines Overseas) 9,208, Pan American transatlantic 28,718, Pan American Latin America 18,050, Pan American Pacific 18,297, Pan American Alaska 1,579, Pan American Grace 9,786, and TWA 20,539 route miles. The 106,197 overseas route miles compared with the 1940 figures of 57,804 miles divided among American Export with 6,817, Pan American 44,583, and Pan American Grace 6,404 route miles.

The principal awards of new mileage involved seven domestic carriers prior to September 30, 1945, while others related to comparatively minor terminal changes. The largest single new extension in the history of the Civil Aeronautics Board was made in July when Delta Airlines received a certificate to add 1,224 miles to its system, both to the north and south. From Cincinnati it was authorized to reach Chicago via Anderson, Muncie and Newcastle. From Knoxville it was authorized to fly to Asheville and Greenville-Spartanburg. From there one branch went to Columbia and Charleston, S. C., while another branch went to Augusta, Savannah, Brunswick, Jacksonville, and Miami.

American Airlines added a net of 653 miles to its system by reshuffling three routes in the Northeast. It also gained 43 miles by

LOADING FAIRCHILD C-82 PACKET

Designed to carry heavy war equipment, the Fairchild Army cargo plane is shown here taking on a 155 howitzer.

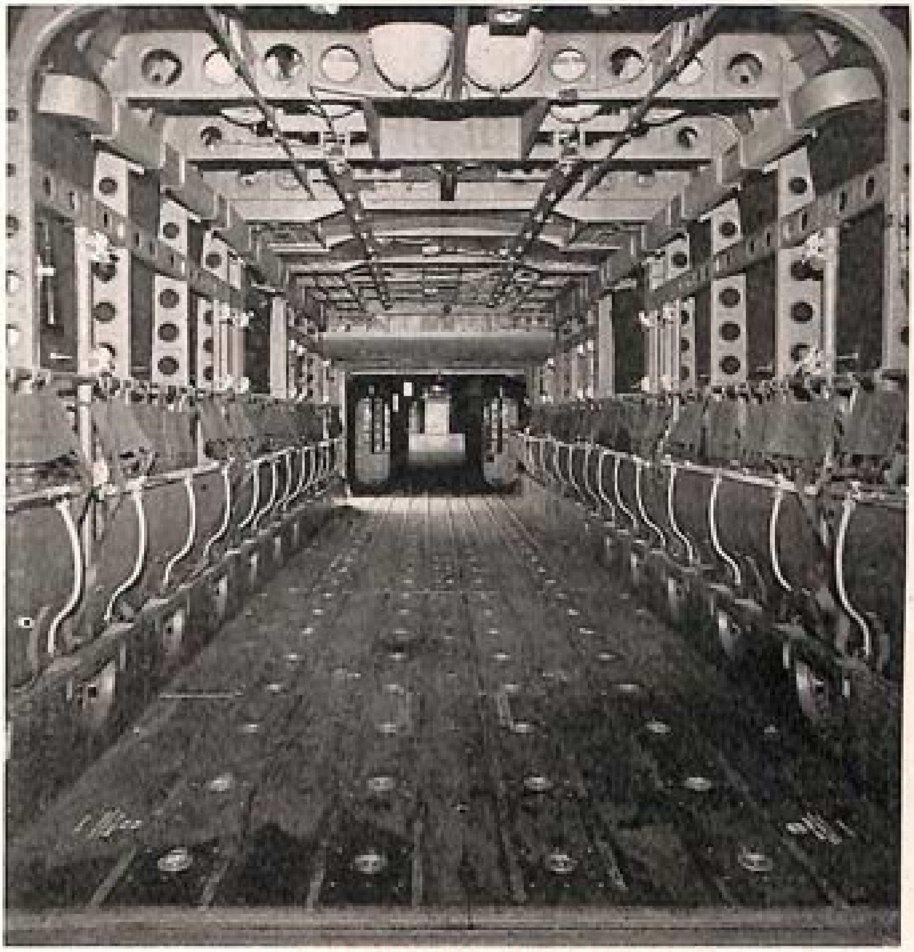
linking Syracuse, Elmira-Corning, Binghamton and Scranton-Wilkes-Barre. Mid Continent Airlines linked New Orleans with Tulsa, via Shreveport, Texarkana, Fort Smith and Muskegee with a gain of 584 miles. Continental was certificated for 519 new miles with a route between Hobbs and Tulsa via Lubbock, Wichita Falls and Oklahoma City. Eastern Air Lines gained 693 miles by an extension from Columbia, S. C., to Detroit via Charlotte-Winston-Salem, Greensboro-High Point, N. C., Roanoke, Va., Charleston, W. Va., Akron and Cleveland. Colonial Airlines was given 715 miles by route extensions linking Washington, New York, Ottawa and Montreal. From Washington the new set-up was to take Colonial through Baltimore, Reading, Scranton-Wilkes-Barre, Binghamton, Syracuse and Watertown to Messena, N. Y. Thence one branch was to go to Ottawa and the other to Montreal. Pennsylvania Central Airlines gained 46 miles and a link between Rochester, N. Y., and Washington, D. C., via Williamsport, Elmira-Corning, Rochester and Buffalo. Other changes were minor decreases or increases in the mileages of several routes owing to changes in terminal location.

There were 129 more applications for scheduled airline service pending before the Civil Aeronautics Board at the end of 1945 than at the end of 1944, this figure being the net result of cases disposed of and new applications filed. The total on December 31, 1945, was 755, as compared with 626. The domestic figure for 1945 was 581—conventional 479, pick-up or combination 41; helicopter or combination 61. The foreign total for 1945 was 87—conventional 79, helicopter five and lighter-than-air three. There also were 87 applications pending for service in Alaska. Non-scheduled applications pending at the end of 1945 were 107 as compared with 94 at the end of 1944. The domestic figures were 92 and 78, respectively, and foreign 15 and 16. All the foregoing applications were from American carriers. Applications pending from foreign carriers for service here were 20, as compared with nine in 1944.

The number of planes in the domestic and international fleets of airlines of the United States increased upwards of 43 per cent during 1945, most of the rise occurring in the few postwar months. This figure applied to aircraft actually in operation and did not include a considerable number which had been acquired by the carriers and were in process of reconversion. The fleets totaled 516 planes with about 11,500 seats at the end of 1945. Of these 414 were flying domestic routes and 102 outside the United States. Of the former, 375 were Douglas DC-3 and two were Douglas DST planes, three Lockheed Electras, and 18 Lockheed Lodestars, five Boeing Stratoliners, and 11 Stinsons. The transports in our overseas airline services included 13 Douglas C-54, two DC-2, 72 DC-3, three Sikorsky S-42, two S-43, three Boeing Stratoliners (307), and seven Boeing Clippers (314).

Most of the planes which the airlines acquired during 1945 were by allocation of military aircraft through the Surplus Property Administration. The total received was 364 (including a few transferred in the closing weeks of 1944). Of these, 180 were four-engine Douglas C-54 type; 169 two-engine Douglas DC-3; nine Lockheed Lodestars; and six miscellaneous smaller types. At the end of the year not all of these had been reconverted to commercial use, but work was being rushed and the delivery rate was increasing.

The allocations of the transport types to the various airlines was as follows: Alaska three, American 58, American Export (American Overseas) six, Braniff nine, Chicago & Southern eight, Continental six, Delta 13, Eastern 40, Hawaiian one, Mid-Continent three, National 10, Northeast seven, Northwest 17, Pan American 40, Pan



INTERIOR OF FAIRCHILD C-82 PACKET

View toward the front. It has 93 per cent of the cubic capacity of a railroad boxcar. Cargo is loaded into it from the rear.

American Grace four, Pennsylvania Central 28, Transcontinental & Western 48, United 43, and Western 14.

During 1945 international relations in the air were advanced by 41 Governments signing the interim agreement for the Provisional International Civil Aviation Organization. The permanent convention was signed by eight, the transit agreement by 25, and the transport agreement by 12. There were 36 countries which signed varying numbers of the five freedoms of the air (the transit and transport agreements), signed bilateral agreements with the United States, or interim agreements, or proceeded well along with negotiations. They were Afghanistan, Australia, Belgium, Canada, China, Czechoslovakia, El Salvador, Ethiopia, Greece, Honduras, India, Iraq, Liberia, Netherlands, New Zealand, Nicaragua, Norway, Paraguay, Poland, Spain, Sweden, Switzerland, Turkey, Union of South Africa, United Kingdom, United States, Denmark, Iceland, Ireland, Portugal, Colombia, France, Italy, Egypt, Iran, and Saudi Arabia. The situation in Germany and Japan, of course, was to depend for an indefinite time on military control, but it was believed that commercial lines would soon be able to operate into Germany. A study of the foregoing list shows that it opened the way to practically all the key places for routes throughout the world. The big blanks were Russia and the Balkan countries.

The Interim Agreement set up the Provisional International Civil Aviation Organization as a result of the Chicago Conference December 7, 1944. The "Convention" involved ratification of membership. The Transit Agreement included the first two freedoms: 1, Freedom for peaceful commercial aircraft to fly through the air of another country. 2, Freedom for such aircraft to land in other countries at agreed ports solely for the purpose of refueling and overhaul, but not to take on or discharge commerce. The Transport Agreement included the remaining three freedoms: 3, Freedom to carry traffic from the plane's country of origin to any other country. 4, Freedom to pick up in other countries traffic destined for the plane's homeland. 5, Freedom for a foreign plane to carry traffic between countries outside its own.

In addition to the foregoing were the series of bilateral agreements signed between various pairs of countries. Some countries signed bilateral agreements with the United States. Others signed interim bilateral agreements and others progressed with negotiations close to the point of signing. In the three foregoing categories were some countries which had not signed all or even any of the "freedoms," but the bilaterals were usually based on the five freedom form and were considered as opening the way to United States operations.

On the other hand, some countries which had not signed bilaterals did sign all five freedoms, which likewise virtually gave a green light to our traffic. Then there were cases like most of the South American countries where United States lines had been operating for years. New agreements might vary when the Civil Aeronautics Board rendered a decision opening up the area to additional lines.

In January, 1946, a conference between British and United States missions was held in Bermuda, seeking to arrive at an understanding on policy as to regulation of rates and limitation of frequencies and capacities. Great Britain, for self protection, wanted strict limitations while the United States wanted to be free to meet all traffic demands.

The part which the flag carriers of the United States were to play in air traffic across the North Atlantic was settled by the Civil Aeronautics Board. Decisions in other overseas areas were pending. The Civil Aeronautics Board's designation of North Atlantic terminal points within the United States was significant in that it reversed past policy that an international airline should end at the coastline and that an international route's airport need necessarily coincide with a seaport. The North Atlantic terminal points named were Chicago, Detroit, Washington, D. C., Philadelphia, New York and Boston.

Three lines won transatlantic certificates. American Overseas, formerly American Export, went to Glasgow or London either by way of Newfoundland and Ireland; or via Labrador, Greenland and Iceland. At Iceland, a branch went to Norway, Sweden, Finland, Leningrad and Moscow. From the United Kingdom, the line went to Amsterdam, where one branch proceeded through Denmark to Sweden and the other through Northern Germany to Estonia, Latvia, Lithuania, Poland and Russia, rejoining the first branch in Moscow.

Transcontinental & Western Air (TWA) was awarded a route which branched at Newfoundland, one going to Ireland, France (except Marseille), Switzerland, and Italy; the other going to Portugal and Spain (except Barcelona), where it split in two, one branch to join the first in Italy and the other going through Algeria, Tunisia and Libya to Egypt. The Italian route then joined it in Egypt, via Greece. The route proceeded through Palestine (Jerusalem), Trans-Jordan, Iraq (Basra), Saudi-Arabia (Dhahran), Yemen, Oman, to Bombay and the area of Southern India, including Ceylon.

Pan American World Airways was granted a certificate for arrival at London by two routes, one via Newfoundland and Eire, the other via Bermuda, the Azores and Portugal, where it operated a branch to Barcelona and Marseille. From London, the route went through Belgium, South Germany, Czechoslovakia, Austria, Hungary, Yugoslavia, Rumania, Bulgaria, Turkey, Lebanon, Iraq, Iran, Afghanistan, and North India to Calcutta.

A CAB examiners' report in a transpacific case, if followed by the board, would extend Pan American's authorized routes most significantly by creating a complete circle around the earth. This would be effected by extension from Hong Kong through Bangkok to Calcutta, the terminus of the eastbound transatlantic route. The proposed

THE DOUGLAS DC-6 TRANSPORT

route would go from either San Francisco or Los Angeles to Hawaii. From there one branch would go by way of Canton Island, Suva (Fiji Islands,) Noumea (New Caledonia) to either Auckland, New Zealand, or Sydney, Australia, the last named a new stop. From Hawaii, there would be a non-stop schedule to Wake Island, on through Guam to Manila, with one branch thence to Singapore and Batavia (new), the other to Bangkok and Calcutta. From Hawaii, there also would be a route to Midway, with a branch going to Wake (and thence through Guam to Hong Kong) and another branch extending to Tokyo and Shanghai and then joining the first in Hong Kong.

The CAB examiners recommended a route for Northwest Airlines starting from either New York or Chicago, then proceeding through Minneapolis-St. Paul, Edmonton (Canada), Anchorage (Alaska), the Kuriles, Tokyo, Shanghai, to Manila. Alternatives suggested, but not acted upon, would provide a parallel line somewhat to the west, beginning somewhere in the vicinity of the Kuriles and touching at several points in Russia and inland China.

United Air Lines was recommended for a route to Hawaii. Pan American had a link between Seattle and the principal points in Alaska, while various other lines also operated between Canada and Alaska, and within Alaska.

The South Atlantic situation would be handled by a single United States line, Pan American, according to the CAB examiners' recommendation, with a route from New York, through Lagens in the Azores, Dakar (Africa), Monrovia, Leopoldville and Johannesburg (Union of South Africa). However, there would be a route much farther to the south, from the bulge of Brazil to various alternate points on the opposite west coast bulge of Africa, some by way of the small island of Ascension. At the coastal points of both bulges, lines would go north to the United States and Europe, respectively, and south to Argentina, Chile and other South American countries; and South Africa.

Several European airlines planned to use this route and it was possible that the United States would do likewise, as it was one of the routes flown many times by our Army transport forces and associated airlines during the war.

At the beginning of 1946, American Airlines Overseas and Pan American were running 14 weekly round trip schedules to London via Botwood and Ireland, using four-engined Douglas DC-4 landplanes. Pan American was operating two additional routes to Lisbon via Ireland, daily trips from San Francisco to Hawaii plus two weekly with cargo and mail only, and from Seattle to Alaskan points on frequent daily schedules, as well as its Caribbean network. Terminals for the transatlantic trips were New York, Chicago, Boston, Washington, and Philadelphia. Pan American was operating two weekly trips to Bermuda, plus one on alternate weeks, continuing from there to Lisbon by way of the Azores. There also were weekly trips from Lisbon to Monrovia in Africa and from Monrovia to Natal in Brazil. The New York-London fare was $375, one way, with the round trip twice the one-way less 10 per cent.

TWA completed survey and preview flights on its North Atlantic

SECTION OF DOUGLAS DC-6 SLEEPER

BOEING STRATOCRUISER AT LA GUARDIA FIELD
It was powered by four Wright Cyclone engines.

route, planning to start service early in 1946 between the United States and Paris, using Lockheed Constellations. This line changed its unofficial name to Trans World Airline. Pan American also made survey flights in the Pacific beyond Honolulu with a view toward early re-establishment of service to Manila, the Orient and Australia. Plans were being made by all the transatlantic carriers for extending operations into Europe, Russia and over the Mediterranean as soon as conditions permitted.

A campaign for the removal of barriers in the shape of passports, visas, customs examinations, and other restrictions in order to make international air travel easier and more attractive was launched by the Air Traffic Assembly of the Air Traffic Conference of America. Removal of restrictions would be upon a reciprocal basis and would be founded primarily upon the issuance of cards which would make it possible for air travelers to move from country to country with almost as much ease and simplicity as they moved between the States of the Union.

As a first step it was proposed that uniform regulations be set up by the United States, Canada and Mexico. Later the system would be extended to the entire Western Hemisphere and thereafter to all members of the United Nations. Ultimately, nationals of other countries would be free to travel by air to the United States with a minimum of identifications and inspections, and Americans would be able to travel with greater ease throughout the world.

World-wide airline passenger travel without limitation became a standard risk in the issuance of new life insurance policies by about one-half of the 100 life insurance companies. The companies covered in a survey represent more than 80 per cent of the total life insurance in force in this country.

In addition, a limited amount of world travel, usually about 50,000 miles annually, is regarded as standard by 10 per cent of the companies surveyed, making nearly 60 per cent which now place no underwriting limitations on normal world-wide air travel. Only 10 per cent of the companies now decline applicants who contemplate such travel, or issue policies excluding this risk, the remainder giving individual consideration to each case.

In contrast with this, no companies accepted unlimited transoceanic travel as a totally standard risk prior to the war and only a little over 10 per cent accepted limited world travel on a standard basis, while almost a third of the companies then declined outright applicants who expected to make such flights or issued policies excluding this hazard.

Pilots and crew members of airliners in transoceanic service were able to secure life insurance protection for an extra premium with all but 15 per cent of the companies, the survey showed, the extra premium varying from $10 to $15 per $1,000 of insurance in most cases. Prior to the war, over one-third of the companies turned down such

KITCHEN OF THE BOEING STRATOCRUISER

LOUNGE ON THE BOEING STRATOCRUISER

applicants and those who secured insurance paid an extra premium which was usually from $15 to $25 per $1,000 of insurance.

Pilots and crew members on flights in the United States and Western Hemisphere alike were enabled to secure life insurance at an extra premium, usually $5 per $1,000 of insurance, with all but 15 per cent of the companies. Prior to the war, only about one-third of the companies insured such applicants and the extra premium was then usually $25 per $1,000.

Pan American World Airways reached new heights in its contract operations for the Army and Navy in the blazing months which marked the road back from the Battle of the Bulge to victory in Europe, from the beleaguered China-Burma-India theater and the island bastions of the Pacific to the unconditional surrender of Japan. The transition period after the war saw further stepped-up contract flying in the airborne redeployment of troops on an unprecedented scale as well as resumption of commercial transocean service so far as possible within the limitations of war-weary equipment and available ground facilities abroad. Before the end of 1945, however, the acquisition of four-engine land planes, declared surplus by the Services, permitted Pan American to reach two air transport objectives which would have been attained some four years ago had the war not intervened—the retirement of the last of the long line of pioneering flying boats, the 42 ton Boeing 314s, in favor of speedier, more efficient land planes on the transocean airways, and the offering of the lowest possible fares, a move made possible by improved equipment and in accordance with the company's long-range plan to bring worldwide mass air transport facilities within the reach of the average individual anywhere. At the beginning of 1946, Pan American was operating this interim flight equipment, the Douglas-built DC-4s which won fame the world over as the Army's C-54 and the Navy's R5D, on daily schedules to Great Britain and Europe and across the Pacific as far as Hawaii; and these four-engine transports were beginning to go into service on the Latin American trunk routes. Beyond Hawaii the DC-4s were serving Pan American's central Pacific airways to the Orient and the southern route to Australia. In the Atlantic area, reminiscent of the airline's earlier pioneering, a DC-4 was off on the longest survey flight in air transport history—a survey scheduled to cover 17 countries in Europe, the Middle East and India in preparation for extension of Pan American's transatlantic services to Calcutta.

During 1945, Pan American was granted extension of its transatlantic routes to Calcutta by decision of the Civil Aeronautics Board in the North Atlantic case. CAB decisions on international route ap-

BOEING 377 STRATOCRUISER
Showing the main passenger cabin.

plications in the other world areas, in the South Atlantic, in the Pacific and to Latin America, still were pending, as was decision on Pan American's application, filed in 1945, for permission to operate express routes within the United States connecting its international air gateways.

Meanwhile, the first of Pan American's fleet of Constellations were rolling off Lockheed's assembly lines and were being made ready for the inauguration of the first 300 miles an hour civil air transport service early in 1946. By the fall of 1946, the company expected delivery of the first of its fleet of Boeing Stratocruisers. In 1947, with Republic Rainbows, Pan American planned to increase operational speeds to 400 miles an hour plus.

In civil operations the company's Atlantic Division during 1945 carried a record number of 20,025 transatlantic passengers. To handle the increased demand for transatlantic travel, which was more than 50 per cent above 1944, the company replaced the flying boat Clippers with faster land planes late in the year, lowered passenger and express rates and increased schedules to London from twice a week to daily flights. In the 6½ years of operation since the Dixie Clipper's initial conquering of the Atlantic on June 28, 1939, the Clippers had transported a grand total of more than 88,000 passengers. In carrying the record 1945 traffic the flying boats and the DC-4 land planes flew the Atlantic a total of 419 times between the United States and Europe, not including twice-weekly trips to Bermuda. The four flying boats and later, the six land planes, flew approximately 1,750,000 miles on these flights, preliminary figures showed. Other than passengers, Pan American transported across the Atlantic 203,000 pounds of Clipper express, 339,000 pounds of U. S. mail and 183,000 pounds of foreign mail. Two major innovations for passenger service and comfort were made during the year—in March addition of stewardesses, and in November introduction of moving pictures while in flight.

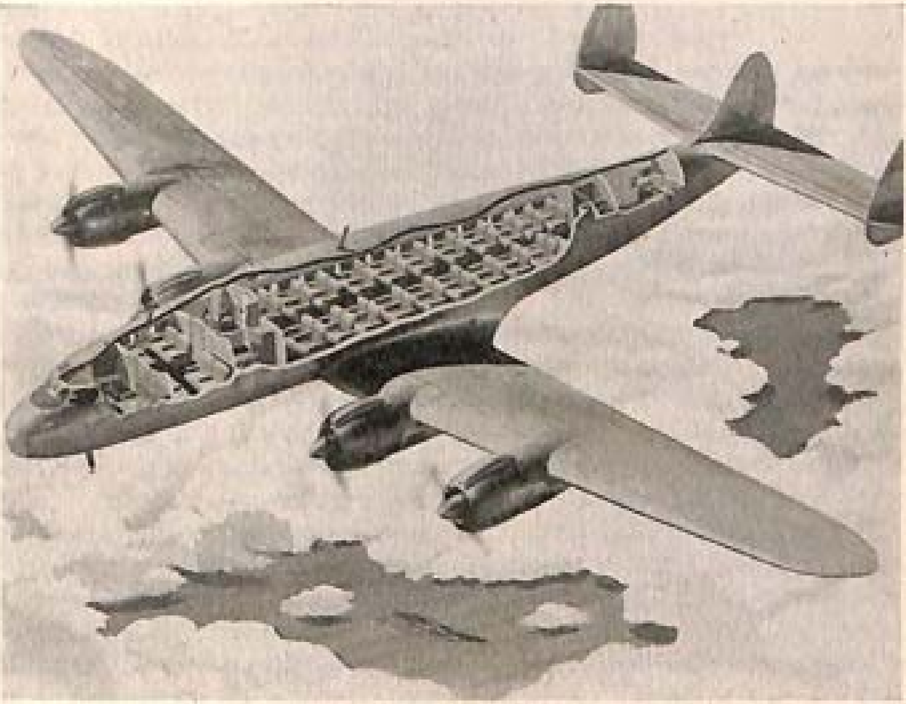
The Boeing-built Clippers established new records before they were retired. On the 2,000-mile run over the North Atlantic—the most direct and most used route to Europe—a record 34 passengers, plus 12 crew, were carried. On the 1,870 mile South Atlantic run, 56 passengers were flown from Africa to Brazil. A Bermuda Clipper leaving La Guardia Field carried the greatest number of commercial passengers ever lifted off the ground—64, plus a 13-man crew. For the fourth record, three different Clippers carried 191 passengers into and out of La Guardia Field's marine terminal in a 24-hour period.

At Pan American's suggestion, the first entry office at any airport was established at La Guardia Field by the U. S. Customs. As a result clearance time on incoming express was cut down from the previous two to seven days to one hour. At the start of 1945, the camouflage had been removed from the flying boats and regular commercial operations resumed. Two days after V-E Day schedules were made public and interviews of passengers by the press were permitted. Several days later, business men were allowed priorities to travel, and this later was extended to all but tourist travel. Late in June, visitors again were allowed to view the Clipper arrivals and departures from the terminal building at La Guardia Field. In September, following V-J Day, Bermuda was reopened to tourist travel and PAA's schedules to the islands increased.

One continuing part of the war job was flying and maintaining a fleet of C-54 transport planes, for the Army's Air Transport Command, on the run to Calcutta, India. This continued at year-end, but at a diminishing rate. The Flight Mechanics School run by PAA for training flight mechanics for the Naval Air Transport Service closed in August after having trained 1,400.

Pan American made its first transatlantic flight by commercial land plane on October 27, arriving in London on the 18th anniversary of its 1927 first 110-mile flight from Key West, Fla., to Havana.

The Latin American Division, largest in the Pan American System, with headquarters in Miami, Fla., established new records in the number of miles flown, number of passengers carried, and amount of mail and Clipper express shipments handled during 1945. In number of miles flown on all routes, the division had a total of 23,015,256,



LOCKHEED 649 CONSTELLATION INTERIOR

adding more than four million miles to the previous year's total of 19,003,995 miles. Total passengers in 1945 were 336,656, compared to 1944's total of 302,555. The year's total of express flown was 11,740,920 pounds, while American and foreign mail totalled 3,521,420 pounds. The 1944 mail and express shipments aggregated 13,000,000 pounds.

The year 1945 saw a steady increase in services throughout Pan American's Latin American Division. While its entire resources, equipment and personnel were available to the armed forces during the war, the Division nevertheless had made preparations for the tremendous expansion and improvement of its Latin American services immediately upon the end of hostilities. Under contract to the Air Transport Command of the Army, the Africa-Orient Division of the airline rushed vital supplies and high priority military personnel to India from Miami in three days on the famous cannonball run. Returning flights, participating in the Army's Green Project, brought wounded war veterans from Europe and Africa to the United States for expert medical treatment. Immediately after V-J Day, its services for the armed forces ended, the Latin American Division threw its entire energies into reconverting to peacetime operations and in putting into actuality its postwar expansion program. Availability of equipment and a program of training personnel permitted new schedules to be put into effect during the Fall, new routes to be opened, and a general increase in services. With 15 hours lopped off previous schedules, Rio de Janeiro was brought within 48 hours of Miami. New four-engine equipment was put into service between the United States and Latin American points. Soon after V-J Day a number of Latin American governments ceased requiring passports for international travelers. Priorities were dropped and tourist travel by air between the Americas increased appreciably.

PAA Clippers carried more Clipper express shipments during 1945 than ever before in the airline's history. This volume, coupled with additional planes and increased cargo capacity, made possible a 10 per cent reduction in express rates throughout the Latin American operations. During the war, Clippers carried millions of pounds of high priority cargo for Allied and American forces overseas. Toward the end of the year a fleet of 45 four-engine Douglas DC-4s was being prepared for use on routes of the Latin American system. The first went into operation on December 29, flying non-stop between Miami and San Juan, Puerto Rico. Others were to follow speeding schedules and offering greater and more luxurious accommodations.

The first of PAA's fleet of 20 four-engine Lockheed Constellations passed through Miami enroute to New York to go into transatlantic service early in 1946. Other Constellations were to go into service on the Latin American system, carrying 65 passengers and reducing travel time between the Americas still further.

During 1945 eight classes of stewardesses were graduated from the Division's flight stewardess school in Miami. Selected from applicants from all parts of the country, they underwent a comprehensive six weeks' course of training in radio, meteorology, handling of baggage and mail, caring for passengers, preparing meals, and learning customs and laws of the Latin American countries. All spoke Spanish fluently and attended brush-up courses in Spanish between flights. There were 89 flight stewardesses stationed in Miami, 14 in Brownsville and 14 in New Orleans. The Division also had 77 stewards based in Miami. On trips flown with four-engine equipment both a flight steward and a stewardess were carried. Flight stewardess service over the Atlantic was started.

With an aerial network covering more than 50,000 miles of routes in the southern hemisphere, Pan American's Latin American Division and its affiliate companies served more than 300 capitals and trade centers in the 37 countries and colonies of Latin America. From the five gateway cities—Miami, New Orleans, Brownsville, Laredo and Los Angeles, the company's routes extended to every corner of the Caribbean, and down the east coast of South America to Rio de Janeiro and Buenos Aires. At Panama, PAA connected with its affiliate, Pan American Grace, with routes down the west coast of South America to Santiago, Chile and across to Buenos Aires, thereby forming a complete circle around the South American continent. Connections with 10 other affiliated airline companies afforded local air services throughout all the countries to the south.

Complete integration of Pan American's Pacific Alaska Division was effected in the Fall of 1945, at the termination of the Navy contract. Pan American's combined Pacific-Alaska operations in 1945 totalled 9,213,788 plane miles flown between San Francisco and Honolulu and over the Seattle, Ketchikan, Juneau, Whitehorse, Fairbanks, Bethel and Nome routes. A total of 34,144 passengers, 9,798,053 pounds of U. S. mail, and 5,224,533 pounds of express was carried during the year.

In Alaska, Pan American's service to the territory was increased from seven to nine flights weekly. Resumption of service to Ketchikan on the basis of eight flights a week and increased service to Juneau, Whitehorse, and Fairbanks followed in early July to meet heavy traffic demands—making a total of over 2,400 seats a month available to air travellers between the United States and Alaska.

For the first time since the Japanese attack on Pearl Harbor, commercial air service between the United States and Hawaii was resumed on November 16, 1945, when Pan American began a schedule of daily round trips between San Francisco and Honolulu. Engineering studies, training programs and surveys were made for the shift from seaplane to land plane operations with DC-4 equipment. Anticipating the arrival of large, faster Constellations early in 1946, the division prepared to resume its prewar operations to Manila, China, the East Indies and New Zealand.

Pan American ordered a fleet of 23 Constellations in September, 1945, and two months later announced an order for 20 Boeing Stratocruisers, the first of the postwar air transports capable of flying between New York and London non-stop with a full complement of passengers, baggage, mail and express. Orders for a fleet of the revolutionary new Republic Rainbow Clippers also were announced.

In a year marked by amazing technical advances, one of the most important to air transport was a high octane safety fuel for use in aircraft engines demonstrated by experts of the Standard Oil Company of New Jersey and Pan American. The safety fuel packed all the power of 100 octane gasoline but was so resistant to accidental ignition that a lighted match could be dropped into it without causing a fire.

Panagra (Pan American Grace Airways), in its 17th year of uninterrupted scheduled commercial operations along the west coast of South America in 1945 far surpassed all its previously existing performance records. In this twelve month period Panagra flew 77,000,000 passenger miles over a distance of 5,540,000 miles, and carried 92,000 passengers, 2,540,000 pounds of express and freight, 640,000 pounds of excess baggage and 355,000 pounds of mail. In this last year of the war, Panagra intensified its services to handle increased demands for air transportation of passenger, express and mail caused by the continued curtailment of ocean shipping, thereby being instrumental in aiding the Latin American nations through a period of economic strain, while simultaneously transporting vital raw materials from these nations. In 1945, Panagra received the Inter-American Safety Award for its flawless operations without a single fatal accident to passengers or crew over its 8,800 mile route.

The Panagra route extending over eight Latin American countries—Panama, Colombia, Ecuador, Peru, Bolivia, Brazil, Chile, and Argentina, covered the most affluent region in natural resources in South America. This direct service along the west coast of South America reaching into the interior of the continent, and crossing the Andes to Buenos Aires was of great commercial importance. It linked the active industrial, agricultural and mineral-rich regions of South America with the key trading centers of North and South America. Connecting with Pan American World Airways' routes at several points, Panagra brought Buenos Aires within 3½ days of New York, and all the principal cities of Latin America within a few hours of each other.

Panagra concluded another year of transporting freight across the Caribbean out of Miami under military contract with the Air Transport Command, and at the same time operated the longest commercial all-cargo route in the world from Balboa to Buenos Aires. In October, 1945, Panagra announced that delivery of Lockheed Constellations and Douglas DC-6s capable of carrying more than 50 passengers in luxurious comfort was expected in 1946, when they would be placed in operation providing accommodations for the expected increase in tourist and commercial traffic to South America. In addition to providing added passenger accommodations the Constellations and DC-6s would enable Panagra to begin night flying operations over the Great Circle Routes for which the airline had applications pending before the Civil Aeronautics Board. This would provide much more rapid service to Buenos Aires, would reduce the elapsed time between Balboa and Buenos Aires to 13 hours, a 41-hour reduction over the present time required for the trip, and cut the elapsed time from the United States to Buenos Aires to less than 24 hours. Anticipating the utilization of these larger aircraft and night flying operations, Governments of countries served by Panagra accelerated their airport development program by lengthening runways, providing night landing apparatus and enlarging terminal facilities.

K.L.M., the Royal Dutch Airlines, the oldest airline in the world, was one of the several companies to set up North Atlantic service with American equipment. The K.L.M. route was between Amsterdam and New York, via Rineanna, Eire, and Gander, Newfoundland. Lockheed Constellations were used on that route.

Before the war the routes of K.L.M. were extended over a network including nearly all the capitals of Europe, with a main route from Amsterdam to Batavia, and a network in the West Indies. With the outbreak of hostilities in Europe, and as a result of the German occupation of Holland, K.L.M.'s European services were suspended with the exception of the London-Lisbon route, flown under charter of British Overseas Airways with a fleet of Douglas DC-3s which escaped the invasion in Holland. Headquarters of Royal Dutch Airlines were transferred first to the Dutch East Indies in 1940, later to London while the company's seat was in Curacao. The Amsterdam-Batavia route continued to operate until the occupation of the Dutch East Indies by Japan, with Naples as the western terminal which was shifted to Lydda (Palestine) after Italy entered the war. After that, airline activities of K.L.M. were confined to the Dutch West Indies section.

Immediately after the liberation of Holland, attempts were made to renew the domestic network within the shortest possible time. After some discussions, the Ministry of Transport and Power opened a service called Netherlands Government Air Transport for which K.L.M. Royal Dutch Airlines acted as civil contract carriers, and for which purpose De Havilland Dragon Rapide MK III aircraft were used. N.G.A.T. started operations on September 26, 1945, with the opening of the Amsterdam-Eindhoven service on a thrice daily schedule. The Amsterdam-Leeuwarden-Groningen line was opened on October 10, and Amsterdam-Enschede on October 27, both of which were operated three times daily. An agreement was made with the Netherlands postal authorities for transport of mail on condition that only half of the loading capacity should be used. On November 10, the routes were reduced to a twice daily service owing to bad radio-communications which made it impossible to fly between sunset and sunrise. K.L.M. planned to extend the services to a four times daily schedule during the Summer of 1946, while a fourth line to the province of Zeeland was to be added.

K.L.M. began postwar operations in Europe with the reopening on December 7, 1945, of one of the oldest routes in the company's history, the Amsterdam-Copenhagen-Malmo service. At first, Dakotas were used, but DC-3 transports were to be installed as soon as they were available. On April 1, 1946, a direct Amsterdam-Stockholm service was opened, using Douglas DC-4 transports on thrice a week schedules. An Amsterdam-Gothenburg-Stockholm service was operated with Dakotas thrice a week, and a fourth Scandinavian connection extended K.L.M. service to Oslo. As quickly as K.L.M. could procure a sufficient number of DC-4 planes, it planned to operate a direct service between Stockholm and Paris. A daily service between Amsterdam and Zurich made connections with all Swiss train services. At the same time, K.L.M. had a new line to Spain and Portugal, thrice a week, and projected another service between Amsterdam, Milan and Rome. K.L.M. also reopened its old Amsterdam-Prague route with three flights weekly, planning later to make daily flights.

In April, 1946, the military air transport service between Holland and England—the first K.L.M. route after the first world war—was taken over by K.L.M. in cooperation with British Overseas Airways, with eight round trips daily. K.L.M. also projected a service to the middle of England. Among K.L.M. projected services was one to Moscow. At the same time the company was planning night air mail schedules as far as London, Stockholm and Paris.

After the invasion of the Netherlands East Indies by Japan, the Amsterdam-Batavia route—last operated between Lydda, Palestine, and Batavia, Java—was discontinued, of course. As a speedy restoration of this all important airline was needed imperatively at the earliest possible date after the Japanese capitulation, negotiations were opened between the Dutch Government and the Allied military authorities. The latter gave their consent to a regular Government service from Holland to her overseas territories, and after trial flights, a regular thrice-weekly schedule was effected by the Netherlands Government Air Transport starting on December 18, 1945. For this service K.L.M. acted as civil contract carrier. The aircraft serving this line was the Douglas C-54A, with a crew of eight, and equipped for transport of 28 passengers.

The route followed in 1945 was Amsterdam-Naples-Cairo (nightstop)-Basrah (Sheiba)-Karachi (nightstop)-Colombo (nightstop)-Cocos Islands-Batavia. The Allied military authorities gave their consent to the use of the airfield on the more northern route from Karachi to Allahabad-Rangoon-Penang. K.L.M. planned to use the northern route in 1946, as soon as the airfields were put in condition for operations by the larger transports. At first only high priority passengers and freight, including medical personnel and relief supplies, were carried eastbound, while westbound passengers were mostly repatriates.

During the war years, K.L.M.'s main operations were in the Caribbean where traffic increased past the capacity limits of the equipment. Early in 1946, K.L.M. was using DC-3 transports between Miami, Fla., and the Netherlands West Indies, Cuba, Jamaica, Haiti, Colombia, Venezuela and Trinidad. Holland and her West Indies domain were to be linked together by air in 1946, according to K.L.M. plans which had been drafted before the outbreak of war in 1939.

Northwest Airlines was preparing to serve the Orient by commercial routes to Alaska, over the North Pacific to Tokyo, Shanghai, Hong Kong and Manila. Rehabilitation of the Far East required the swiftest possible communication lines. Oriental countries represented a great potential market for American goods. In its presentation before the Civil Aeronautics Board, Northwest foresaw a time in the near future, a year or two perhaps, when it would be possible to fly from certain parts of this country to the Orient in fewer hours than the days formerly required by surface carriers. It spotlighted the possibility of American industry finding new markets in the Orient which slow transportation had not been able to reach. It pointed out the necessity of air routes to the Far East as an integral part of the United States' national defense. It emphasized the strategic position of Alaska astride the top of the world, commanding the short air lanes from this country to Asia and Europe. Northwest engineers and operations experts also were studying the Boeing C-97, commercial counterpart of the B-29 bomber, and other 80-100 passenger planes for possible use on its transcontinental and projected Orient routes.

Eastern Air Lines, early in 1946, was flying at the rate of more than 1,000,000 passengers annually, as compared with a figure of 488,000 in 1944 and only 230,000 in the pre-war year of 1939. During the first 10 months of the year the company flew 22,130,000 revenue miles, utilizing an average fleet of slightly over 37 planes 13 hours and 26 minutes daily to set a new record for plane utilization and gain the nation's top award for maintenance and performance.

Strengthened by the return of Eastern's Military Transport Division, which in 3½ years of operations with the Army Air Transport Command flew more than 47,500,000 pounds of vital cargo and 130,000 passengers over the South Atlantic, Caribbean and Latin Amer-

THE REPUBLIC ARMY F-12 RAINBOW

ica, the Silver Fleet numbered 52 DC-3 transports at the end of 1945. Scheduled for delivery in the Spring of 1946 were 20 DC-4 Skymaster Silverliners, leased from the Government. In early Summer of 1946 Eastern was to take delivery on 20 high-speed, four-engine, 50- and 62-passenger Lockheed Constellations, an investment representing more than $16,000,000. Looking even farther ahead, the company had contracts for 50 newly designed, 36-passenger two-engine Martin 202 medium range transports, for delivery in April, 1947. Eastern reduced passenger fares to a point 24½ per cent below those of 1942.

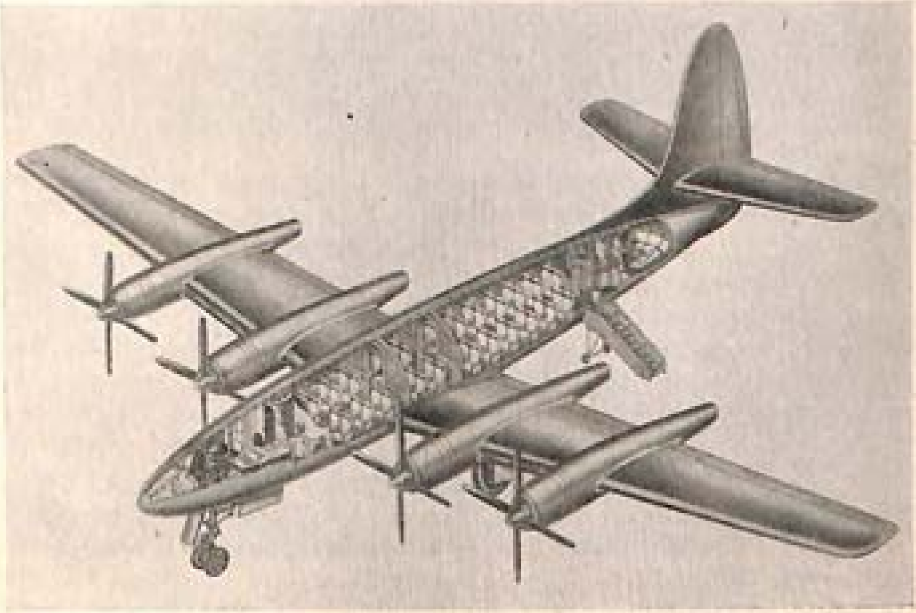
Pennsylvania-Central Airlines conducted parachute delivery tests at the Washington National Airport presaging the delivery of cargo to communities without sufficient facilities for landing passenger planes. Shortly thereafter PCA successfully flew a shipment of fresh Great Lakes whitefish from Detroit to Washington without necessity of refrigeration, pointing out the benefits of flying such commodities by air.

Transcontinental & Western Air launched its postwar expansion program in July, 1945, when the Civil Aeronautics Board awarded the company international routes to Europe, the Middle East, Africa, India and Ceylon. This added more than 17,000 miles to TWA's domestic network of 7,700 miles, and created an international air system some 25,000 miles long. TWA already had developed an airplane for its international and coast-to-coast routes in the big four-engine Lockheed Constellation. Howard Hughes, principal TWA stockholder, and Jack Frye, the airline's president, conceived the Constellation in 1939 but delivery was held up by the war. In September TWA had purchased 36 of these 300 miles an hour transports at a cost of $30,000,000, and by the end of the year, 10 of these 51,-passenger planes had been delivered to TWA, the first airline to acquire the super transports.

On December 3, TWA's Constellation, the "Paris Sky Chief," flew from Washington to Paris breaking all Atlantic speed records for non-military aircraft. The overall time, including stops at Gander, Newfoundland, and Shannon Airport, Ireland, was 14 hours and 48 minutes. TWA's plans for 1946 call for the inauguration of Constellation daily schedules over both its international and coast-to-coast routes.

TWA resumed its air freight service in July, 1945. Shipments were handled on a deferred basis, but still were faster than the fastest surface transportation. Charges were established on an airport-to-airport basis, with separate charges for pick-up and delivery, made at the shipper's option. Although its new air freight program was started on a limited basis, TWA had extended the service to 33 cities throughout its transcontinental system by January 1, 1946, when it was operating six transcontinental all-cargo flights daily. Plans called for an increased number of cargo flights as aircraft and trained personnel became available. TWA in 1945 acquired a 28 per cent stock interest in Philippine Air Lines and dispatched technical and administrative personnel to aid the carrier in resuming the inter-Island service suspended at the time of Pearl Harbor.

United Air Lines in 1945 conducted commercial operations over its 6,700-mile route, making new records and increasing scheduled service over its coast-to-coast and Pacific Coast airway to 136,500 miles daily; carried on military contract services, continuing the operation of Air Transport Command routes over the Pacific and troop redeployment flights within this country while winding up its bomber modification and training activities; and started expansion and future growth, with emphasis upon significant advances in flight equipment



REPUBLIC RAINBOW AIRLINER INTERIOR


EYES FOR THE BLIND

Human eyes, willed to the Eye Bank for Sight Restoration, New York, must be handled with great speed under rigid temperature conditions. This picture shows a pair of eyes in a special container arriving at La Guardia Field by Eastern Air-lines plane, to be rushed to the hospital where the eyes will be used to restore the sight of a blinded veteran.

and operating efficiency. United carried on its domestic commercial flights 22,507,000 ton-miles of mail in 1945 as compared with 18,888,704 in 1944. Express totaled 4,938,000 ton-miles as against 4,222,853 ton-miles the year previously. While much of this tonnage represented vital war materials, the flow of urgent war supplies was reduced sharply following V-J Day. Reconversion goods and machine parts, first postwar model radios, nylon hosiery and other manufactured articles took their place in the cargo pits of United's Mainliners and Cargoliners.

In their military tasks, United's flight and ground crews had many exploits which provided stirring accounts of the significant role played by the ATC in the Pacific. It was shortly after noon on August 16, 1945, when United's San Francisco headquarters in charge of the company's ATC flights across the Pacific, received an urgent Army telephone call. The company was ordered to make ready and service for immediate departure every available C-54 transport and to alert every available Pacific operations flight crew. Men and planes were ordered to depart before sundown for a certain spot in the Pacific. All movements were to be in the strictest secrecy. Planes enroute across the Pacific were ordered by radio to disregard scheduled destinations and head immediately for the rendezvous. Before nightfall, a total of 125 crewmen were dispatched from San Francisco in thoroughly serviced planes. Counting crews already enroute over the Pacific or stationed at intermediate points on the company's Pacific route, 250 United flight crew members and 20 planes were headed for the rendezvous, which was Okinawa. The route from San Francisco to Honolulu, to Johnson Island, to Kwajalein and into Guam followed one of United's regular transpacific runs. From Guam, United crews made their first entry into Manila and thence to Okinawa. There it was revealed that these men and planes were to participate in the initial occupation of Japan. Severe typhoons to the west held up operations at Okinawa for a time but on August 30 these crews and planes, transporting military personnel, were among the first to land at Tokyo for the official signing of the historic document of surrender.

Month by month, as twin-engine DC-3 planes were returned to the company from Army service, United speeded up its operations until at the start of 1946 they were at an all-time high of 136,500 miles of flying daily as compared with the best pre-war record of 84,000 miles

FAIRCHILD C-82 CARGO PLANE

This Army Air Forces freighter was named the Packet. It was powered by two 2,400 h.p. Pratt & Whitney Wasp engines and had 2,312 cu. ft. cargo capacity.

THE MARTIN 202 AIRLINER

Interior of the postwar two-engine transport produced by The Glenn L. Martin Company.

a day. As part of its large expansion program, United began taking delivery of a fleet of four-engine 220 miles an hour Douglas C-54 transports for passenger-cargo service following their conversion from military to commercial equipment. Simultaneously, United and Douglas engineers whipped into final form the details for the 300 miles an hour Douglas DC-6s on which the company prepared to take delivery beginning in the Summer of 1946. As still another development in new aircraft equipment, United announced plans for purchasing a fleet of new type, high speed, twin-engine transports to replace its present fleet of twin-engine Douglas DC-3s, beginning in 1947. United conducted numerous experiments with the shipment and merchandising of perishables—including a round trip coast-to-coast flight with the first fully refrigerated plane in history—and actively prepared for expansion of air shipping with the inauguration of a new air freight service with charges graduated according to volume and destinations shipped to give the lowest possible rates to volume shippers.

Reorganization of the Air Transport Association of America with expansion of functions and operations designed especially to expedite all-weather flying by the 24 airlines through the application of radar, electronics and other instruments developed during the war, was a major development of 1945. The Association had three new top officials, a president and two vice presidents. The new vice presidents were former Congressman Robert Ramspeck, and Gen. Milton W. Arnold, former Acting Chief of Staff of the Air Transport Command. The new president was Vice Adm. Emory S. Land, formerly chairman of the Maritime Commission. The three new officials, together with Stuart G. Tipton, who was acting president after the death of Col. Edgar S. Gorrell in March, 1945, were to map out a detailed program for intensification of the work of the Air Transport Association, especially in the fields of operations and engineering which involved improvements in all-weather flights and adaptation of larger and speedier planes to airline service. Under the reorganization, much of the technical work was to come under Gen. Arnold, aided by John Groves, director of operations, and A. W. Dallas, director of engineering. In the operations department it was planned to add at least four experts including specialists on air traffic control, regulations, lighting and "trouble shooting."

The new air traffic control unit engaged in research toward ex-

BEECHCRAFT MODEL D18S

A six to 10-place monoplane.

pediting the use of radar, all-weather instruments and gadgets developed during the war, and also toward solving the problem of better control of air traffic around airports in order to handle the larger number of planes already ordered for commercial service, especially during the winter months. In conjunction with the air traffic control unit, it was proposed that a laboratory on Long Island be employed to collaborate on all-weather operation plans with the Army and Navy, the CAA and other research organizations.

In engineering it was proposed that a conference of airline experts be set up to handle engineering and maintenance problems so the entire industry could take advantage of the best thought and experiences of each individual operator. Subcommittees were to study and make recommendations on such subjects as aircraft requirements, revision of domestic and international air regulations, standardization of equipment, cargo handling, servicing and fuels.

More than 50 bills dealing directly with important aspects of aviation were pending in the 79th Congress of the United States at the beginning of 1946.


PRESIDENT TRUMAN'S AIRPLANE

Looking "over the shoulder" of the President's Douglas C-54 "Sacred Cow" at United Aircraft Corporation's Rentschler Airport control tower, East Hartford, Conn. The C-54 and its DC-4 commercial version are powered with Pratt & Whitney R-2000 Twin Wasp engines.

## CHAPTER VI

### PRIVATE AND NON-SCHEDULED FLYING

The Rapid Increase in Numbers of Private Owners—Popularity of Personal Planes—Increase in Student Pilot Permits—Army and Navy Aviators Retain Their Interest in Flying After Leaving the Services—The United States Has About 200,000 Private and Commercial Pilots—More than 5,000 Women Have Civil Pilot Licenses—The CAA Simplifies Process of Obtaining a Private Pilot License—Many Organizations Work to Develop the Personal Plane for Private Owners—Communities Encouraged to Provide Airparks—Fixed Base Operators Asked to Provide Adequate Facilities for Itinerant Flyers.

EARLY in 1946, there were more than 30,000 registered civil aircraft in the United States, and a vast majority of them were personal planes used by private owners or fixed base operators carrying on aerial service activities. The manufacturers had orders on their books aggregating about 40,000 planes, approximately half of which were scheduled for delivery in 1946. A total of 70,000 student pilot certificates had been issued in 1945, and by July 1, of that year, the Civil Aeronautics Administration had a total of 141,280 on its list of licensed pilots, many of the new names belonging to veterans of the war. By March, 1946, the list had grown so fast that CAA personnel could not keep an accurate day by day check on the totals. CAA had issued 20,012 private pilot licenses in 1945. At the same time, it had granted commercial pilot licenses to 97,193, an estimated 90 per cent of them being Army and Navy pilots who were given special help in gaining civil flying status. Anticipating an unmanageable flood of applications immediately after V-J Day, the CAA made a head start on this human reconversion program. Through a simplified procedure, pilots were given CAA certificates even before leaving the Service, at a rate of more than a thousand a week. They presented credentials to prove flight status and passed a simple written examination on Civil Air Regulations, conducted at military bases by CAA flight inspectors. The authorities estimated that there were about 200,000 licensed pilots in the United States in March, 1946.

The Aircraft Owners and Pilots Association, its roster limited to pilots, reported a membership of more than 22,000, with the number

INTERIOR OF NORTH AMERICAN NAVION

increasing rapidly, especially among salesmen or farmers, who were using their planes in business.

An increasing number of the pilots were women. In the course of her survey on women in aviation for the Air Transport Association of America, Marian Park Davis made these comments: "In the field of private flying, activities of most women were somewhat retarded during the war years. As soon as the United States was at war, women were banned from the CAA pilot training course, although the program had been credited with increasing the number of licensed women from 675 in 1939 to more than 3,000 by 1941. But with the cessation of hostilities, it was expected that young women again would flock to take advantage of any Government pilot training program. Despite the war, however, the number of women holding pilot licenses is increasing steadily. In January, 1945, women having private licenses totalled 4,829; and commercial, 618. By January, 1946, this had grown to 5,164 women holding private licenses, and 969 with commercial licenses. Women always have carried off the honors as teachers, and aviation is no exception to this rule. January 1, 1945, found 230 women engaged in flight instruction, and 915 in ground instruction. This number was expected to increase. With the influx of small planes into the market, women are bound to figure more prominently as instructors. Several members of the WASPS, following deactivation of their branch of the Service, turned to flight instruction outside the country. Typical of these were Hazel Raines and Irene Crum, now ground school instructors at Sao Paulo, Brazil.

"In January, 1945, 267 women were still at their posts as parachute technicians, and 1,595 as traffic control operators. By January, 1946, traffic jobs were beginning to fall to veterans as they came back from war duty to old jobs or with new skills acquired in the Service. In private flying women seemed destined to play an important part as buyers and users of planes, as well as in instructing new fliers. An indication of this is the fact that there are approximately 300,000 more adult women in the United States than men, plus the fact that before the war 60 per cent of all automobiles were purchased by women. It follows naturally that in airplane sales, too, women will control the purse strings. So strong is the feeling that women will prove the key in private flying and in the private plane market—as well as in commercial transportation—that one expert on the subject


THE NORTH AMERICAN NAVION

THE PIPER J-5C SUPER CRUISER

recently declared: 'Women have always been the key to any market for consumer goods. The airplane cannot become an everyday-machine without them. Right now there appears to be a big demand, but after a year or two of production to meet this demand, manufacturers will find that women and their influence will be absolutely necessary, if private planes are to continue to be sold.'

"Interest in aviation begins at an early age these days. The Girl Scouts of America in 1942 established the Wing Scouts, and today there are approximately 5,000 members in 38 States. Wing Scouts range in age from 15 to 18 years, and many already have earned their private pilot licenses. Women have become a vital cog in Government supervision of aviation. The CAA employs approximately 11,000 persons of which about one third are women. Some of these have risen to positions of real responsibility. For example, Katherine Stinson tests aircraft designs for safety, and during the war helped to figure out a method of converting light planes into gliders. Another CAA employee, Doris Clinton Grautoff, is an expert on rotary wing control. Two women with wide experience in aviation who hold positions of authority with the Government are Phoebe Oemlie and Blanche Noyes. Mrs. Oemlie is associated with the CAA training program while Mrs. Noyes is an expert on airport marking. Skyways magazine is edited by Doris Ahnstrom. Alice Rogers Hager published a book giving a graphic first-hand description of the air war in Burma, after flying many thousands of miles to round up material, for this and other volumes she has written on aviation subjects. Women are not really new to aviation, or aviation to women. Napoleon had a woman minister of air, and a woman went aloft in a balloon seven months before the Wright brothers first airplane flight in 1903. But now that the age of flight has really arrived, women are taking prominent parts in the aviation drama."

Addressing a large gathering of flying farmers in convention at the Oklahoma Agricultural and Mechanical College in Stillwater in August, 1945, Joseph T. Geuting, Jr., manager of the Personal Aircraft Council, Aircraft Industries Association of America, reported that a recent poll of country newspaper editors had indicated that a total of 500,000 personal planes would be in operation in rural areas within five years after the war. "The country people," said Mr. Geuting, "according to the editors, plan to use planes for a wide variety of purposes—crop and orchard dusting, transport of chickens and eggs, locating cattle, patrolling and surveying storm damage, emergency transport, elimination of farm and ranch pests, and limitless other activities." One of the Personal Planes Council's major activities was assisting communities in planning airparks as an incentive to private flying. The CAA repeatedly urged fixed base operators and others in charge of small fields to clean up their airports and provide proper facilities for itinerant flyers, on the principle that private flying could not develop in any community without adequate facilities, just as motoring required adequate service stations as well as good roads before it amounted to anything.

Manufacturers of personal aircraft were doing everything possible

THE REPUBLIC SEABEE AMPHIBIAN

ERCOUPE WITH BEECH PROPELLER

to develop confidence among private owners. Piper Aircraft distributed a very comprehensive booklet on "What Your Town Needs for the Coming Air Age," and all the companies coached their distributors in the many and varied ways to win friends and customers from the moment the prospect looked at a plane and after he bought it, until he was ready to turn it in for a new model. Based on years of experience in the motor car field, the oil companies were helping the fixed base operators in every possible way, with improved service stations, repair shops and salesrooms for parts, besides creature comforts for the visitors—from good lunch rooms to powder rooms, shady parking places and route information, and most important of all, cleanliness, neatness and politeness as part of service with a capital S. On that subject, Mr. Geuting spoke pointedly before many gatherings of airport managers. "We all have seen the change that has come about in our automobile service stations. Certainly, years ago any roadside stand having barrels of gasoline and a hand pump was a service station. But compare that outmoded service unit to the modern super-stations of today. The modern airpark should become the social and recreational center of a community. Its landing facilities, the runways, will be but one phase of its value. It will offer tennis courts, swimming pool, fine dining facilities, beautifully landscaped grounds. And when, as in Florida a few weeks ago, we see thousands—yes, literally thousands—of men, women and children dressed in summer finery—white flannels, pretty slacks, the ordinary dress of holiday-bound American citizens—step from the more than 1,500 personal planes which flew to Miami during the Christmas holidays,—then, I say, these patrons of personal flight must be given the very best service wherever they fly."

Material issued to guide the thousands of discharged Army and Navy men seeking aviation jobs, included a CAA booklet "Employment Outlook in Civil Aviation", containing information on how to start such aviation businesses as small airports, flying schools and aircraft or engine repair shops. The importance of private flying for pleasure and convenience was emphasized by setting up a new Washington office of CAA for the development of personal flying, under the direction of John H. Geisse. An assistant in each of the seven regions was appointed to help in this job of suggesting policies and planning for the advancement of all branches of private flying.

Additional recognition was given non-scheduled flying by the appointment of a special 12-man advisory committee to speak for the aviation industry and private fliers. The committee, with members representing the State aviation organizations, airlines, manufacturers, aviation consumers, airport service operators and the private fliers in each of the seven regions, was active in presenting practical suggestions for encouraging this phase of civil aviation. Included in non-scheduled flying were operations for hire such as crop dusting, forest patrol, insect control, photography and charter flying; use of planes by individual firms to transport representatives and products; and flights for pleasure.

To simplify the process of becoming a private pilot, new condensed requirements were issued by the Civil Aeronautics Board, working in close cooperation with the CAA. Detailed navigation and meteorology questions were dropped from private pilot written examination and limited to air traffic and general operation rules. Any registered doctor could give the physical examination, previously restricted to designated examiners. In preparation for a heavier work load in flight testing private pilots and inspecting aircraft, the CAA provided for the appointment from industry of a large number of pilot examiners and aircraft inspectors to supplement the regular CAA staffs. Under the expanded flight test system, qualified in-


THE BEECHCRAFT MODEL G17S
A five-place biplane.

NEW BELLANCA CRUISAIR SENIOR

dividuals outside the CAA were authorized to give flight tests to applicants for private pilot certificates, and were permitted to charge a $5 fee for that service. They also could give and grade the written examinations. Over 1,200 pilot examiners were designated in 1945. The goal was 2,000, with at least one at each fixed base operation.

Appointment of designated aircraft maintenance inspectors and manufacturing inspection representatives at airports and factories was authorized to insure speedier inspection service to plane owners and manufacturers. Prompt service in giving even the present 30,000 civil aircraft the required annual inspections and inspections after major repairs was out of the question for CAA's staff of 124 aircraft inspectors, and more than 100,000 planes were expected by 1950. Owners of private or non-scheduled commercial aircraft were able to get this service from any designated aircraft maintenance inspector. Early in 1946, 251 had been appointed.

With only about 50 factory inspectors employed by the CAA, delegation of their authority to designated manufacturing inspection representatives was an essential step to prevent bottlenecks in the big civilian aircraft production under way. Employees of aircraft manufacturers holding CAA production certificates were authorized by the CAA to issue NC airworthiness certificates, which indicated that the plane coming off the production line complied with plans and specifications previously approved by CAA engineers.

The 108 surplus planes acquired by the CAA for use by inspectors and other field men added to the efficiency of field operations. Four training planes, two DC-4's and two DC-3's, were allocated to the Standardization Center at Houston to familiarize inspectors with these types, and three other DC-3's were used for routine work and freighting in Alaska. With a better and safer personal plane in mind for the lower level of skill expected from the high percentage of beginners, the CAA drew up new airworthiness standards for non-transport planes (normal, utility, acrobatic and restricted types). These standards were adopted by the CAB as Part 03. The helicopter entered the official picture when CAA engineers, using machines loaned by the Army, started study on requirements for certificating helicopters and their pilots, and research on helicopter design problems.

The elementary and high school aviation courses, introduced with CAA help into thousands of schools during the war, were established on a piecetime basis. To supplement these courses, several States added "flight experience" programs under which high school students received about four hours of instruction in the air.

Encouraged by the manufacturers who made many recommendations, the CAA issued a new list of simplified rules to help the private owner in 16 different ways, as follows:

1. Revised flight test for private rating to provide that spins need not be accomplished solo. This was in response to numerous complaints that some people were allergic to solo spins.
2. Revised written examination for private pilot, eliminating all except questions on Parts 43 and 60.
3. Revised Form ACA 342A, Pilot Flight Test Report, and incorporated therein a short application to eliminate the necessity of filling out a lengthy form when applying for any pilot certificate or a rating above the grade of student.
4. Appointed over 1,200 private pilot examiners privileged to conduct private pilot flight tests.

THE COMMONWEALTH TRIMMER AMPHIBIAN

THE NEW LUSCOMBE SILVAIRE
A two-place plane for the private owner.

THE NEW STINSON VOYAGER
A four-place plane for the private owner.

5. Authorized all certificated flight instructors to conduct the cross-country written examination for private pilots which was the only written test required for a private pilot rating.
6. Revised pilot certificates so that any grade of pilot other than student or airline transport received a basic pilot certificate. He then was rated as a private or commercial pilot on the accompanying rating record. This eliminated the necessity of holding additional certificates in the event of obtaining ratings on different types of aircraft. For example, a pilot holding a basic pilot certificate could be rated as private pilot on airplane single and multi-engine land and, on the same rating record, as a commercial pilot-glider, or private pilot-helicopter, or any other similar combination of ratings.
7. Eliminated horsepower ratings, which ended the necessity for a rated pilot above the grade of student to take the horsepower test if he wished to carry passengers in an airplane of higher horsepower than that for which he was rated.
8. Eliminated duration period for Form 578A, which was the report of written examination received from the Washington office indicating grades obtained on the various written examinations other than private or military competence. The latter two were graded in the field.
9. Revised Form 309, Aircraft Operation Record, which formerly consisted of five full-sized pages. The new one consisted of but two small pages containing all data essential to the safe operation of the aircraft. The new form reduced the time of execution to about fifteen minutes, as compared to an hour for the earlier form.

THE RANGER-POWERED FAIRCHILD F-24

A four-place plane for the private owner.

10. Revised Form 307, Aircraft Inspection Report, to eliminate nearly all written insertions but still give the required information.
11. Revised and simplified Form 305, Application for Airworthiness.
12. Revised Form 363, Application for Mechanic Certificate, and Form 364, Inspector's Examination Report, by combining them into one form.
13. Revised procedure for designation of aircraft maintenance inspectors so that these designees could charge for their services and have enough jurisdiction to afford a real service to the public.
14. Greatly simplified annual aircraft inspection procedure so that it would be basically similar to taking a motor car to an inspection station for its annual safety sticker.
15. Simplified procedures for designation of landing areas. (The CAA wanted to remove entirely this hold-over from wartime emergency regulations, but early in 1946, had been unsuccessful in obtaining military concurrence.)
16. Eliminated necessity for obtaining waivers for crop dusting, coyote hunting or aerial photography.

THE TAYLORCRAFT BC12D DELUXE

## CHAPTER VII

### AVIATION TRAINING AND EDUCATION

The Need for Trained Personnel in All Branches of Aviation—Work of the Private Schools—Aviation Courses in the Colleges—Gen. Arnold Asks for Constant Program—The Navy's Plan for Aviation Officers—Remarkable Educational Work of the Civil Aeronautics Administration—Aviation in the Public Schools, a Survey of Progress in the Different States.

WITHIN six months after the end of the war, those who gave the problem any serious thought knew that conflicting political ideologies and international trade rivalries made increased aviation training imperative if the United States could hope to maintain its position among the powers which had vast and expanding programs designed to give them supremacy in the air. Here in the United States there was every incentive for educating millions of young Americans in the various fields of aeronautics. The United States had emerged from the war with more operating aviation than all other nations combined. The Army and Navy planned to maintain adequate air forces which could be expanded to meet any emergency. The air transport industry, as great as it was early in 1946, had only started the developments which soon would be required to foster our economic and cultural—and possibly political—progress both at home and abroad. Air transportation soon would need trained men and women by the tens of thousands. Private and non-scheduled flying activities, combined with State and municipal aviation development, probably offered more young people opportunities for careers than the other fields. Millions already were taking advantage of the educational and training facilities already available. Hundreds of colleges were giving aviation courses. The public school systems in many States were preparing their students for the "air age," as will be explained in detail further on in this chapter. More than 15,000 instructors were licensed by the CAA to teach ground courses. There were 560 CAA-approved flying schools and 35 approved aircraft and engine mechanic schools. Many schools were expanding their prewar facilities in order to take care of a greater number of students.

After V-J Day, Parks Air College, East St. Louis, Ill., one of the oldest aviation schools, again was on a full civilian student basis, and was moving toward a capacity enrollment of 400 students in 1946. Early in the year, 151 new aeronautical trainees, two-thirds of them

FUTURE DESIGNERS AT PARKS AIR COLLEGE

war veterans from all parts of the country, brought the enrollment to 286. Applications on file, a majority of them from other veterans already returned or scheduled to return in 1946, totalled several hundred, and made certain that the school will reach its enrollment goal probably by the time summer term classes opened on July 8. No more than 400 students could be admitted because of lack of classroom space. While the college continued its program of aeronautical training with its two-and-a-half year courses in aviation operations engineering, aviation maintenance engineering and aeronautical engineering leading to bachelor of science degrees, its expanding program of civilian and postwar activities through affiliate enterprises forged ahead. Already in major operation at the beginning of 1946 was Parks Aircraft Sales & Service, a five base chain covering six and two-thirds mid-western States. Parks Air Transport was organized to provide feeder line service over 15 States. As the development of the affiliate organizations proceeded, the college maintained a constant interest and lent a helping hand where one was needed. Instructors employed to train students gave technical and professional advice. More and more the experiences recorded by the new operations made themselves felt in the training philosophies and techniques of the school. This served as a "field laboratory" for the college and provided the students with "on the job" training.

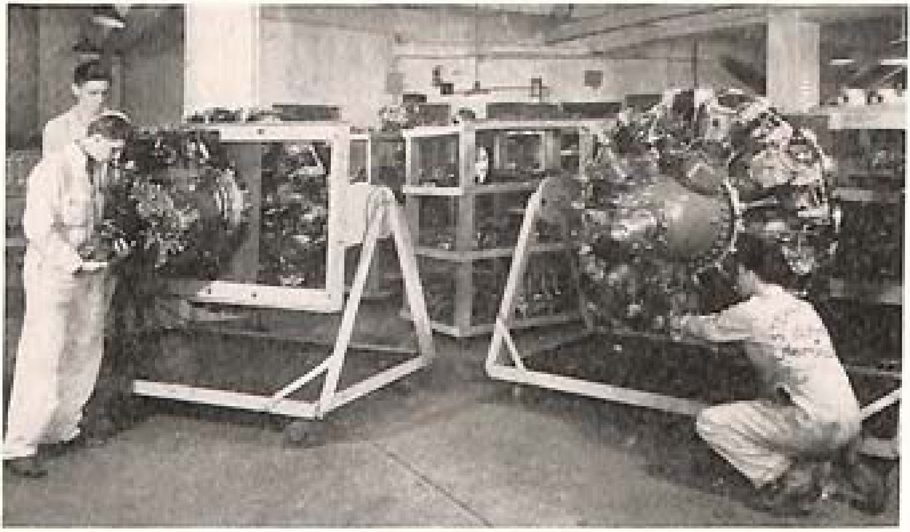
A second main purpose of the affiliate operations was to provide jobs not only for the employees of the college and of the training schools operated for the Army, but for as many graduates of the college as possible. Numerous graduates of the school, not already located elsewhere in the aviation industry, were filtering into the sales and service firm. When Parks Air Transport reached the operational stage, with the great variety of positions it would have to offer, many more graduates would be brought back to jobs.

Cal-Aero Technical Institute (formerly Curtiss-Wright Tech) at Grand Central Airport, Glendale, Calif., was under the personal direction of Major C. C. Moseley, and it offered complete courses in aeronautical engineering and civilian aviation mechanics. Students were enrolled from nearly all States and from an increasing number of other countries. Graduates were employed by the manufacturers, airlines and other aviation enterprises. At Grand Central Airport, a wide variety of aviation businesses, from airplane modification center and repair shops to sales distributors and charter services, offered Cal-Aero students opportunities for study and experience.

The Northrop Aeronautical Institute at Hawthorne, Calif., was a new organization set up by Northrop Aircraft to train engineers and mechanics.

AT CAL-AERO TECHNICAL INSTITUTE

Personalized instruction is the policy at Cal-Aero. Student, left, is shown working on airplane under guidance of instructor, right.

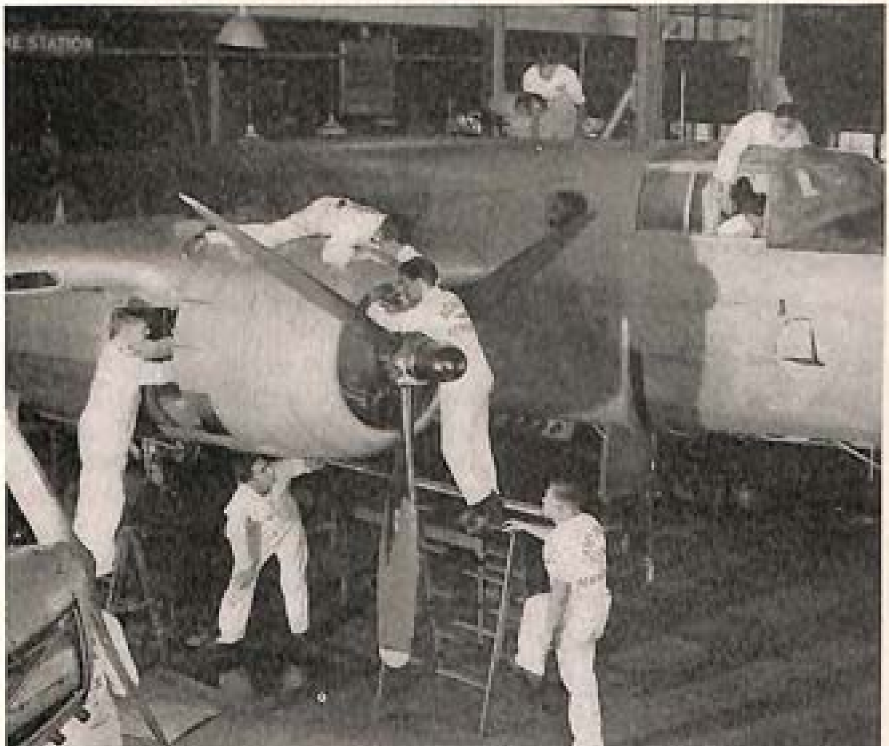


STUDENTS AT STEWART TECHNICAL SCHOOL

The Casey Jones School of Aeronautics, with 14 years experience, after V-J Day consolidated its student body and facilities with its more recently established affiliate, Academy of Aeronautics, La Guardia Field, New York. During the war months of 1945, these schools had given short courses to civilians for employment in Air Corps depots, under contract with the Army Air Services Command and the Army Air Transport Command. After the war, the schools reverted entirely to their long term courses, in the day session, of two years for aircraft mechanics and maintenance, and two and a half years for aircraft design and construction, with similar courses in the evening session. Courses became available to veterans under the G.I. Bill, and a large number of veterans were enrolled. During the war, the two institutions had trained more than 20,000 students for the military services and the war training program.

Stewart Technical School, New York, with 14 years experience in specialized training of technicians for the aircraft industry, was one of the first schools approved by CAA as an aircraft and aircraft engine mechanic school. Stewart offered two courses, a master mechanic course and a drafting course. Many veterans were in attendance under the G.I. Bill. The requirements for admission and the standard of training were maintained at a high level.

Universities and colleges were being encouraged to provide professional aeronautics courses; and there was much room for expansion in that field of higher education. The last comprehensive survey of the situation was made by The American Council on Education and published in October, 1944. Its foreword was self-explanatory. It read in part: "There has been a considerable interest in the opportunities for advanced study of aviation and related subjects at the college level. Returning veterans, college students, and high school graduates are all inquiring about facilities which will prepare them for careers in aviation. In an effort to determine the extent of such opportunities, the American Council on Education on July 1, 1944, asked 1,500 colleges and universities what aviation courses were offered in 1943-44 and would be offered during the coming school year 1944-45, and also what types of aeronautical research were being conducted. Twelve hundred and forty-three replies were received, indicating that 399 institutions had offered or were offering academic work in aviation or related fields, while 844 schools reported no aviation courses. No response was received from 257 schools. Courses offered ranged from four and five year courses in aeronautical engineering to summer school offerings in aviation for elementary teachers, while a large number of schools offered aviation ground school courses, which ordinarily included units in air navigation, meteorology, general service and operation of aircraft and civil air regulations. Most of the courses carried academic credit. Schools, colleges and numerous Government agencies expressed keen interest in knowing



STUDENTS AT ACADEMY OF AERONAUTICS

the facts about opportunities for aviation education in the years immediately ahead."

Gen. H. H. Arnold, in his final report as wartime commander of the Army Air Forces, the largest and most effective air force ever organized, asked for a continuing training program, even among civilians, in order to have the country prepared for an emergency. He said:

"Results of World War II have shown that AAF training methods are sound. Training of personnel in time of war can be done on a large scale only by utilizing all the nation's facilities and experience. Full use must be made of civilian agencies. The armed forces will never have all the facilities required to meet war programs. Civilian agencies must in some way be kept aware of their responsibilities especially during peace when planning and preparation for war are so distasteful to Americans. The AAF had to go to all walks of life to secure square pegs for square holes and round pegs for round holes when we built our world-wide organization. The ever increasing complexity of modern war machines will make this procedure much more important in the future than in the past, and we shall not attain our goal by traditional methods of personnel selection and training. This is an age of specialization. No rational man can hope to know everything about his profession. Encouragement should therefore be given to specialization, and proper use must be made of special talent.

"The time has passed when the Air Staff can be composed exclusively of command pilots. It must have officers who have mastered the production skills of scheduling materials and synchronizing the flow of industrial components. A modern air staff without industrial technicians is as obsolete as a Model T Ford. There must be established for the air force, perhaps as a part of a general program of training for the armed services, schools devoted to industrial, business, economic and scientific training. The faculties of these schools should be drawn from competent representatives of industry, business, finance, engineering economics and science. Experienced officers who are inactivated should be used in industrial and economic planning, and in other activities which bear upon the military preparedness of our country.

"The qualifications of the combat commander determine to a larger extent than any other single element the effectiveness of a unit in combat. The science of screening and classifying personnel must accordingly be utilized in such selections to the greatest extent possible. From our experiences in wartime procurement of aircrew personnel we know that in future recruiting we must go beyond the time of actual entry of individuals into the Service and must start by promoting educational systems which will fit more of our youth for aviation training. By utilizing all available educational means, both civilian and AAF, considerable improvement can be made in the type of personnel available for future AAF training and service. One of the major problems of peacetime military forces will always be the maintenance of high personnel standards in the regular establishment. Since this establishment must be the nucleus around which emergency forces are organized, and since the regular personnel must bear the major responsibility for training and leading the total force as well as for planning the strategy, operations and techniques, it follows that quality in volunteer regular personnel is a primary requisite. Every incentive must therefore be given to encourage select individuals to volunteer for careers in the air force, in commissioned as well as enlisted grades."

The Navy had plans for training aviation personnel, both active and reserve, to meet the requirements of the postwar naval establishment.

In his annual report issued on February 7, 1946, Secretary of the Navy James Forrestal presented the official postwar plan for maintaining sufficient officer personnel with adequate training. Of Naval aviation officers, besides those trained at Annapolis, he said: "Naval aviation officer candidates would be selected on a merit basis from high school graduates and college freshmen, and would be given a subsidy of tuition, textbooks, laboratory fees and $50 a month to attend any accredited college of their choice. Upon completion of two academic years they then would be ordered to flight training for one year, upon completion of which they would be ordered to flight duty as midshipmen, U.S.N. At the end of one year of such duty, they would be commissioned ensigns in the Navy with probationary commissions. Upon completion of another year of duty in the fleet, they would elect and the Navy would select those to be career officers in the Navy. Upon selection they would be ordered to duty under instruction at the Naval Academy, as officers, for two additional years. Those who did not elect a Navy career or were not selected for such would be offered commissions in the Naval Reserve, and, provided they continued with reserve aviation training, would be eligible to receive for two years an educational subsidy of tuition, textbooks, laboratory fees and $100 per month at any accredited college of their choice, provided that they remained in good academic standing. This benefit would be offered in consideration of the interruption of their college work to undergo flight training and to give them the opportunity of qualifying themselves for a civilian career."

Our march to victory in Europe and the Pacific in 1945 made the Civil Aeronautics Administration's military training no longer necessary, so the Air Education Division of the CAA devoted its main efforts toward a permanent aviation education program in American schools. The program, stimulated by war needs, had been started in 1942, but it was not until 1945 that it could be broadened and redirected to emphasize the significance of air commerce in a world at peace. The CAA education representatives found a majority of persons in such agencies as the State departments of education, the American Council on Education, State aviation commissions and the Civil Air Patrol eager to contribute in every possible way toward a permanent education program. The question most frequently asked was, "What can we do?" Providing the answers to this question—through seminars, conferences and speeches—was the main job of the CAA Air Education Division in 1945.

An urgent and continuing need was proper textbooks. Since 1942 the Education Division had sponsored 28 books on aviation, suitable for use in all grades from elementary to college level. The most comprehensive of the texts, Aviation Education Source Book, prepared at the Sanford University School of Education, was completed during 1945. Intended as a guide for teachers and authors, it had 1,400 pages and more than 1,000 maps, charts and diagrams. A project was established at Syracuse University in 1945 for preparation of a new high school text on aviation in the modern world. To be available about the middle of 1946, it was designed to help redirect established courses and also lead to the introduction of new aviation courses in many secondary schools.

Teachers in the elementary schools found that pupils were easily stimulated to learn about aviation, and that aviation information supplied with the regular subjects made those subjects more interesting. Airplanes were almost as wonderful to a child as to an adult who grew up before flying was common, but children accepted airplanes as a regular part of their environment and not as a recently added marvel. In the secondary schools, many good teachers ceased to speculate about the social and economic implications of aviation, and started specific study of just how the airplane does affect us. The better high school aviation courses included factual information on such subjects as air safety, commercial air transportation, private flying, community aviation facilities and international aviation agreements. Thousands of school teachers attended CAA Operational Institutes conducted at major airports to show the operation of airways facilities, and to add to their knowledge of general airline and airport operations.

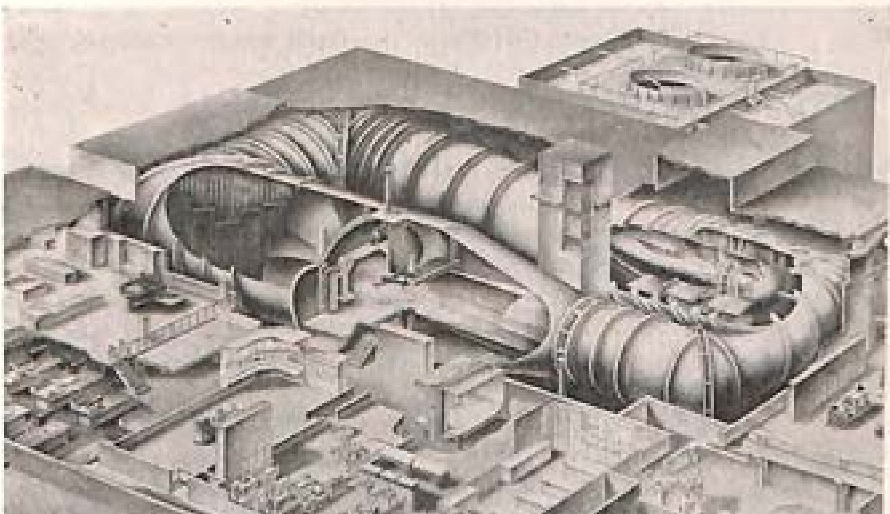
Much of the Education Division's work centered around comprehensive State plans of aviation education. The Division recommended flight experience as laboratory work in connection with high school aviation courses. The most extensive flight experience program was in Tennessee, where more than 600 high school students were receiving actual flight experience. Each student flew four hours in connection with his academic study of aviation. The cost was borne jointly by the Tennessee Bureau of Aeronautics and the individual students.

Small high schools with meager facilities and little money to spend for apparatus faced a difficult problem in trying to set up useful laboratory equipment for aviation teaching. To meet that situation, a laboratory manual entitled "Demonstrations and Laboratory Experiences in the Science of Aeronautics" was published by the Division, giving suggestions for inexpensive construction of such equipment. The Division also operated an aeronautical library in Washington, together with a complete collection of films for use in teaching aviation. Many bibliographies, lists of films, sources of free or inexpensive materials, as well as syllabi and outlines for teachers were published.

A special survey of what the schools were doing with aviation education was made by the editor of The Aircraft Year Book, and highlights of that survey follow.

New York State had an extremely comprehensive and fruitful system of aviation education under the direction of Lewis A. Wilson, Deputy Commissioner of Education, and Oakley Furney, Assistant Commissioner for Vocational Education. The junior aviation schedules were for pupils in the general elementary and secondary schools. The vocational aviation program was for pupils planning to enter some field of aviation.

Elementary schools were provided with junior aviation sugges-



FOR AERONAUTICAL RESEARCH

The Curtiss-Wright Airplane Research Laboratory which was presented to Cornell University.

tions for construction of non-flying model aircraft, together with some information regarding the nature of aircraft and flight. The junior high school grades were furnished suggestions and assistance in making and flying model aircraft. Teachers of industrial arts were encouraged to assist pupils in the construction of model planes and the study of aviation. In the senior high schools pupils and teachers were urged to work with and study full-sized aircraft which would give youth the opportunity to familiarize themselves with the equipment and apparatus of aviation. They also worked with aircraft engines and the various instruments and apparatus of the airplane and the airport.

Pupils in the vocational high schools were offered two types of courses, technical and trade, both of which prepared them for gainful employment in some form of aviation work. In those schools pupils spent about three hours a day studying aviation and working on aircraft. Their work, unlike that of the pupils in the general high schools, called for considerable repetition, so that they could develop technical skills. The same vocational schools also met the needs of adults who required special training for employment purposes. Such courses usually were offered during the evening in order that students would not have to leave their regular employment. Veterans also were being served in the vocational schools in some communities and in others, such as Elmira, special schools were organized for them. The vocational schools were adapted easily to meet the needs of adults who desired special training.

Early in 1946, vocational schools in five areas of New York State offered aviation courses. Aviation training programs were to be developed in other areas as the needs became apparent. The Burgard Vocational School at Buffalo had 26 CAA-certified shops devoted to aircraft engine repair, and aircraft repair courses. The school also had a mechanic school rating. Equipment, supplies and materials were approved types available to the aviation industry. The aviation training was departmentalized in these instructional units: Aircraft maintenance and airport operation; aircraft engine maintenance and overhaul; aircraft electrical work; aircraft hydraulic and propeller work; aircraft instrument, maintenance, calibration and installation; and aircraft sheetmetal, structure and repair.

The day school vocational program required four years and led to a mechanic school certificate. A fifth year was being added to enable the students to acquire additional experience necessary for the CAA examinations in airplane and airplane engine repair. In February, 1926, 508 day school students were enrolled. Additional courses were conducted in CAA regulations, meteorology, air navigation, Link trainer, and machine shop work. Twelve regularly licensed teachers gave instruction.

Rochester, N. Y., had two schools operating four-year aviation mechanic courses for high school students. In Lackawanna, a two-year course was available. In Barker a two-year course was offered, and pupils had access to operating planes on the airport in the rear of the school. In Elmira, the Board of Education organized a school for veterans and other vocational students, giving a mechanics course 1,950 hours long for CAA rating. The Schenectady vocational school offered a three years course for high school students. Floral Park had a three-years course, Mineola a two-years course.

New York City had three public schools giving instruction in aviation trades. The Manhattan High School of Aviation Trades, devoted exclusively to aviation, had 50 instructors and about 3,000 students taking three-years courses. The Woodrow Wilson Vocational High School had six instructors giving four-years courses, while the East New York Vocational High School had 14 instructors giving four-years courses.

For more than 20 years technical high school courses had been given in New York State to prepare pupils for employment as draftsmen, testers, technicians, laboratory assistants and assistants to production supervisors in manufacturing and construction. In these courses the emphasis was in mathematics, drawing, science and technology of technical occupations. Instruction in shop work was included so that pupils might have an understanding of the processes of production and the operation and maintenance of modern complicated machinery and equipment.

Although the vocational-technical course in mechanical design as given in several schools of the State did not include specific instruction in airplane manufacturing, it did contain drafting and strength of materials and shop work useful to boys who went to work in airplane manufacturing plants. Because some graduates accepted jobs in airplane manufacturing, Dr. A. L. Colston, principal of Brooklyn Technical High School, in 1936 decided to establish a vocational-technical course in aeronautics. The school already had machine shops, a foundry, sheet metal shops, woodworking shops as well as well-equipped laboratories in physics, chemistry and strength of materials. For use in the course in aeronautics there were provided two airplane shops, an airplane drafting room and a navigation and meteorology laboratory. Since the major objective of this course was to prepare pupils for positions as draftsmen, computers, inspectors, testers and potential foremen in airplane manufacturing companies, it was necessary to add to the staff teachers who had appropriate training and experience. Accordingly, an aeronautical engineer with design experience and another who had been in charge of production in an airplane manufacturing plant were secured.

The Brooklyn Technical High School in 1926 offered four-year courses beginning with the ninth grade. The work of the first two years was the same for the course in aeronautics as for the technical mechanical course. It included mathematics, science, drawing, machine shop, foundry and pattern shop. If the pupil elected at the end of the 10th grade to take the course in aeronautics, he was given specialized instruction in that field. In order for a pupil to graduate from the curriculum, he had to pass a Regents examination in English four years, American History and a comprehensive technical examination in all of the work in aeronautics. The State college entrance diploma required only 16 units, and the curriculum in aeronautics included 21 units. Obviously, the course was not an easy one. While the curriculum was established to prepare boys for employment in the aviation industry, pupils who completed it were well prepared for entrance to an engineering college. Graduates were accepted for entrance to engineering colleges except to those requiring a foreign language for entrance. Many of those waived that requirement for applicants who held a Regents diploma in technical subjects because it was found that, if a boy could maintain the high standards required to complete a State-approved technical course, he had the ability and aptitude to carry on an engineering college course.

The best evidence of the value of the curriculum was the record of the first graduating class. There were 41 boys who graduated in 1940. Records are available for 37 of those boys two years after graduation. All of these obtained jobs at graduation in airplane manufacturing, and all advanced during the two years. At the end of two years, the positions held were as follows: nine inspectors, six draftsmen, five stress analysts, three foremen, seven lead men, three tool designers, and one research worker in plastics. Three had gone to engineering colleges.

When the attack on Pearl Harbor shocked the country into a realization of its military weakness, the 1942 New York State Legislature, acting upon the advice of the State Education Department and several influential persons, appropriated $150,000 for aviation education in the State. During succeeding years, each Legislature made additional appropriations to a grand total of $265,000. About $200,000 of those funds were given directly to local school boards for use in providing facilities for aviation education. The remainder of the appropriation was used by the State Education Department to provide administrative, supervisory and curriculum service.

Aviation courses organized during the war period naturally featured objectives and values for pupils facing induction into military service. With the conclusion of the war, objectives in aviation education changed to meet the needs and responsibilities of the pupil in peacetime.

In 1940, there were few if any pupils enrolled in aviation courses in the general secondary schools of New York State. Since that date courses were organized in many communities, 98 of which offered aviation courses in 1946. Flying model airplane construction courses were being given to more than 4,736 pupils in 46 communities. Junior aviation maintenance and repair courses were offered early in 1945 in 69 schools to about 3,000 high school pupils. Glider construction courses organized in 11 communities enrolled about 150 pupils. The flight instruction courses enrolled, and were successfully completed by, 273 secondary school pupils. The total number of pupils enrolled in junior aviation courses early in 1946 totalled well over 7,000 pupils in all types of aviation courses. Undoubtedly, many other pupils were studying aviation courses in both a formal and informal way under the leadership of industrial arts, vocational, technical, and science teachers.

The appropriations of funds by the legislature made possible the development of an extensive program of aviation education in the public elementary and secondary schools. Four types of courses were organized in public schools of the State to meet the needs of boys and girls at the various school levels. These courses were: Flying model aircraft construction—elementary, junior and senior high schools; junior aviation maintenance and repair course—senior high school; glider construction course—senior high school; and flight instruction —senior high school.

Flying model aircraft construction work was carried on extensively as an informal activity in elementary and junior high school grades. In the elementary schools the work usually was directed by the classroom teacher who had little preparation for this type of work and consequently the projects were of a very simple character.

In the junior high school grades (seventh, eighth and ninth) the industrial arts teachers and some science teachers aided boys and girls in the construction of flyable model aircraft as part of the regular shop courses or the regular science courses. Few schools offered 40-week courses in flying model aircraft construction in these school years. In these courses, boys and girls were led to construct small, model cardboard and wood gliders and airplanes. In the most successful classes, frequent contests were held in which pupils were encouraged to fly their models. Approximately 25 per cent of the regular class time was devoted to a discussion of aerodynamics, meteorology, aircraft structures and other phases of model aircraft work, which familiarized pupils with some of the elements of the aviation industry and airlines.

Forty-week courses in flying model aircraft construction work were organized in many senior high schools of New York State. Pupils in these classes usually met for one or two periods a day throughout the entire year, to build model gliders and planes which were purchased in kit form from local hobby shops. Some classes built planes from stock material according to plans and instructions printed in the State course of study. After a few months of work in a course of this type, pupils reached the point where they desired to experiment with new models and designs. Considerable experimental

THE COMMONWEALTH SKYRANGER

work was done, particularly in the schools where wind tunnels had been constructed. This type of course undoubtedly will be maintained as a part of the regular school curriculum in many schools for years to come. There was a tremendous interest in flying model aircraft work, and it provided school pupils with an excellent approach to the study of aviation and its problems.

Junior aviation maintenance and repair courses first were established in 50 demonstration centers to each of which the State appropriated $1,700. The organization of this course was predicated upon the assumption that pupils would learn more about aviation through becoming familiar with aircraft, aircraft structures, engines, instruments and landing gears together with a study of related theory of aviation, than they would through the study of aviation from a textbook. Shops and laboratories were organized for this course. The equipment installed in the shops was used for several purposes. Some of it was not in good condition and so was used for repair work. A few of the items were new and could be used immediately. In either case pupils were assigned repair, adjustment, assembly, dismantling jobs or experimental jobs. Others were given apparatus such as that used in meteorology, communication, aerodynamics and navigation, and asked to perform experiments or to acquire some skill in the use of the apparatus. About 25 per cent of the total time given to the shop work was set aside for organized class discussion and teaching. In these class periods the instructor presented the theory of aviation and aeronautics. Subjects included airplane identification, airplane structures, aircraft engines, instruments, communication, meteorology, aerodynamics, theory of flight, airport organization and operation, and Civil Aeronautics Regulations. Ground trainer and glider construction courses were offered in 11 different schools, in 10 communities in the State.

The Bethlehem Central School was particularly successful with those courses. Pupils trained in them were able to find employment in the woodworking aircraft factories in the State. Because of the shortage of aircraft woodworkers, the pupils who graduated from the classes in that school were in great demand in the factories.

During the 1945 school year, State funds were used to reimburse local boards of education for one-half of the expenditures incurred in connection with flight instruction for high school pupils. Two hundred and seventy-three boys and girls in 21 high schools in the State received exploratory flight instruction courses without mishap. The courses were organized by the local boards of education with the approval of the State Education Department. It was a logical conclusion for pupils who had studied aviation throughout the grades and high school. Pupils were given from eight to 10 hours of dual flight instruction, together with a minimum of 40 hours of class work, including a study of theory of flight, aerodynamics and meteorology. Class work usually was offered parallel with the flight instruction. The combination of theoretical work and flight instruction qualified for solo flight all pupils successful in passing the courses. The related instruction prepared them to take the CAA ground school examination.

Pupils enrolled in flight instruction courses were selected by the local school authorities for scholarship and coordination. Those pupils who did not show the required ability were eliminated from the course during the beginning state. To be eligible for flight education in a power plane, a pupil was required to be 16 years of age or over. Each school required the pupil to present a statement from the parents granting permission to enroll in flight instruction courses. They also were required to present a medical certificate from a flight surgeon. Local school authorities made all arrangements for actual flight with the operator of a local airport or flying school. In some cases one of the teachers was appointed as coordinator and given the responsibility for making the necessary arrangements. Pilots providing the flight instruction were required to hold a flight instructor's license granted by the CAA. Actual flight was given only at airports designated by the CAA and in aircraft properly licensed. All school boards offering these courses were required to carry liability insurance to protect the pupils, teachers, superintendent, principal, board of education, Commissioner of Education and the State Education Department against liability. Only a few of the pupils carried personal accident insurance. The reasonable cost of the liability insurance was one dollar an hour of flight for each pupil.

The York Central School at Retsof, N. Y., offered flight instruction to pupils in a glider which was owned by the school board.

THE PIPER CUB J-3 SPECIAL

Pupils were transported to and from the airport. The glider was launched with a tow car. Eleven pupils were taught to fly the glider successfully.

When junior aviation was first initiated in 1942, practically all individuals who were acquainted with aviation were employed by the military forces. In order to organize aviation courses in public schools it was necessary to offer a special two-week course in aviation for teachers selected to give instruction in the demonstration centers. State funds were used to provide a two-week course at New York University under the guidance of Dr. Roland Spaulding. During the succeeding summers, courses in glider construction and junior aviation maintenance and repair work and flying model aircraft construction were offered in various sections of the State under slightly different conditions. It was only through the organization of these special teacher training courses that the State Education Department was able to prepare instructors who were qualified to teach aviation courses.

During succeeding summers additional courses were offered to teachers of industrial arts work who expected to organize junior aviation courses. Early in 1946, seven courses were conducted for teachers in flying model aircraft work.

Tennessee, this survey indicated, had a first class program of aviation education, and probably ranked second only to New York State in the practical application of the various courses. The State-wide program was under the supervision of C. H. Gilmore, director of the Division of Aeronautics Education of the education department; and he had numerous committees of aviation experts and educators helping to develop the program which was designed to make aviation knowledge in one form or another available to every school and college student in the State. The State Department of Education and the Tennessee Bureau of Aeronautics developed programs for training aviation teachers in the various State colleges. More than 300 individuals were trained through this program. The teacher training course consisted of approximately 200 hours of classroom work and 10 hours of flight experience. The major objective of this program was to prepare teachers to handle aviation in the high schools. The scholarships for the training were provided by the Tennessee Bureau of Aeronautics. Early in 1946, the emphasis on the college program was directed toward development of aviation programs at the higher education level for all students interested. Teacher training was only one phase of this program. Six of the State colleges participated in the teacher training program.

During the school year 1945-46, 65 high schools throughout the State had 1,350 students enrolled in aviation. Most of the teachers handling these programs were trained through the college teacher training programs. During the year the Bureau of Aeronautics provided 685 scholarships to high school students. Under the adopted plan, four hours of flight experience could be taken, half of the cost of which was paid by the Bureau and half by the student. The flight training was done by air service operators who contracted with the Bureau of Aeronautics. A safety program also was adopted.

Alabama's aeronautics and education departments expected to have ready in 1946 a joint plan for teaching aviation subjects at all levels. Arizona's high schools in several instances were giving courses in pre-flight and ground instruction, as well as vocational courses in mechanics. The Arkansas program lagged because very few public schools were equipped with facilities and personnel to offer any adequate instruction in aviation. California reported in February, 1946, that of 320 four-year and senior high schools in a survey, 119 offered courses in general aeronautics, with an enrollment of 2,650 early in 1946; 13 gave aircraft maintenance courses, with 517 students; and 33 gave aviation mechanics courses, with 1,126 students. Here again, the Federal Government figured in promoting aviation education; because the CAA officials worked with the secondary education division of the State department of education, which had no staff members particularly assigned to that work—this in a State with large and vitally important aviation manufacturing plants, and equally important air transport operations radiating to all parts of the world. However, the really great private schools such as Major C. C. Moseley's

THE TAYLORCRAFT BC12D STANDARD

Cal-Aero Technical Institute at Glendale and Northrop Aeronautical Institute at Hawthorne combined with the splendid engineering courses at some of the colleges to lift the youth of the State out of the dark ages of aviation education.

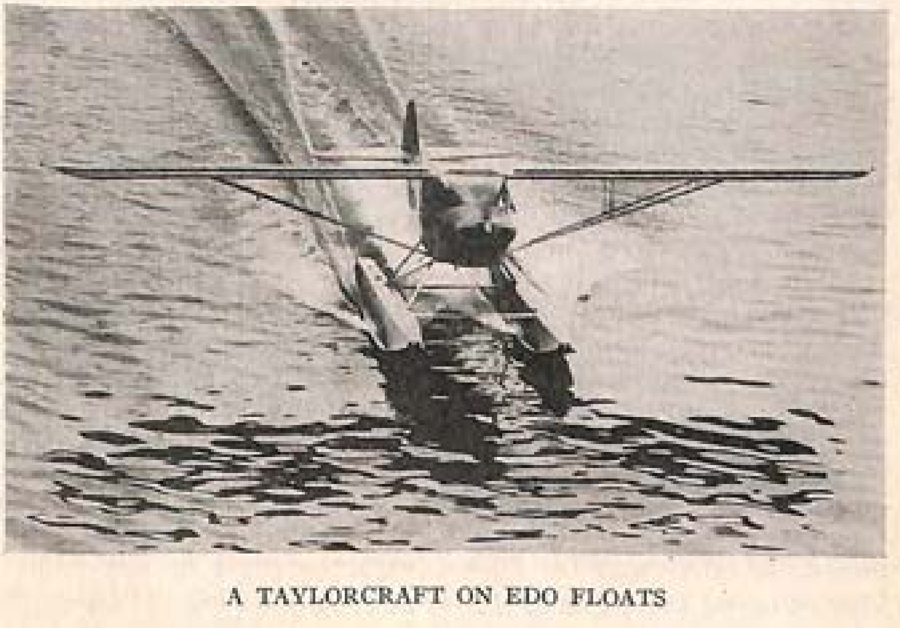
In striking contrast was Connecticut's modern system. There was the Connecticut Aeronautics Teachers Association with a comprehensive program, and its efforts to secure flight scholarships of four hours for teachers and students of aeronautics courses promised to be successful in 1946. About 45 of the secondary schools offered special courses, mostly taught by teachers of science, mathematics or the industrial arts. The State educational department produced a 100-page booklet on aviation courses as a teacher's guide in all levels of aeronautical education.

Delaware, which during the war had some promising aviation activity in many of its principal schools, found that interest among the boys and girls tended to subside after V-J Day because they felt that they would not be wanted in the air forces or the industry. In fact, throughout the various reports of this survey it became apparent that something must be created to take the place of the war effort as a means of inspiring the great body of public school pupils to study aviation, not only with a view to flying but through ambition to enter one of the scores of special professions and trades incident to the operation of aircraft. Genuine inspiration was needed, along with textbooks.

Florida, which saw considerable Army and Navy flying during the war, reported steadily increasing interest. In 1945, 32 high schools offered aeronautics courses; and there also were 14 communities in which aircraft and engine maintenance courses were taught. In 1946, the State department of education shifted emphasis from highly technical instruction to that showing the practical effects of aviation on everyday life, its influence on modern living and international relations. Teachers were given a guide for elementary and secondary courses and an outline for an elective course in senior high schools.

Indiana gave science credits for aviation courses in all high schools. Clement T. Malan, superintendent of public instruction, had a committee of 12, with five sub-committees working to adjust the postwar educational program to the "whole air age." The five parts of the program were to include elementary, secondary, technical-vocational and teacher-training schools and institutions of higher education. Iowa had a few schools giving various kinds of aviation courses; but the State apparently had no definite program. Illinois had a State bulletin as a guide to teachers of aviation subjects in all branches; and a large number of the public schools had extensive courses.

Kansas followed the CAA formula, which had been adopted by at least 20 States early in 1926. Aviation instruction was being encouraged in all grades and through college. A bulletin containing all the various levels of study was being prepared by Kansas colleges. Some high schools continued their courses in mechanics, blue-printing and other trades. In one year during the war, the Wichita High School East had trained 30,000 adults and students for work in local airplane factories. The school operated 24 hours a day in three shifts.



A TAYLORCRAFT ON EDO FLOATS

Early in 1946, Kansas had more than 600 students enrolled in regular aviation courses in 78 high schools, and 35 of the schools had instructors with flying experience. Some of the schools had planes used either for flying instruction or ground studies. The new State commission on aviation education advocated teaching aeronautics by use of material in the regular courses of mathematics, general science, social studies and shop practice.

Louisiana had well-developed courses in her colleges and at the same time encouraged pre-flight courses in the high schools. At one period of the war 65 schools were giving pre-flight instruction to boys who planned to enter the air forces, but after V-J Day, the number dropped to seven, with a total enrollment of 139 students. Mississippi had no aviation program for its secondary schools, but education authorities admitted the desirability of having one.

Michigan left aviation to the local school districts, but in cooperation with the CAA and the Army Air Forces was planning a fairly comprehensive program as an aid to local teachers. Maine had 25 secondary schools teaching aviation subjects. Massachusetts, which had 204 high schools teaching pre-flight courses at one time during the war, had a committee working on a regular postwar program. Maryland included aviation in its science courses. Early in the war, 18 high schools gave aviation courses but the teachers were drafted, and that ended the program. Missouri had 71 schools teaching aeronautics, with 1,848 pupils enrolled. A fine brochure on air age education served as a general guide to the courses. Minnesota reported a substantial amount of aviation instruction offered in the public schools, much of it stimulated by the CAA. A State committee on aviation education was being planned to develop a comprehensive program for all public schools. In a public poll by the Minneapolis Tribune 78 per cent voted that the schools should teach subjects on the importance of aviation, and 77 per cent voted that public schools should teach the mechanics of aircraft.

New Hampshire had 35 high schools and academies teaching the principles of aeronautics, with a total of 44 aviation instructors. The courses were carefully prepared and most comprehensive, with the result that students graduated in aviation subjects with excellent preparation for further and specialized study in the aviation professions and trades. North Carolina had three schools giving basic courses, but planned to develop a comprehensive program for all schools. The problem there was to provide teachers capable of handling aviation courses. New Mexico had about 50 high schools teaching aviation during the war, but after V-J Day interest in the subjects decreased. The end of the war also reduced the number of special courses taught in the schools of Oregon where most of the larger institutions had large aviation classes during the years of the conflict. Oklahoma had 144 schools with 144 teachers handling 145 classes in pre-flight aeronautics, with 2,100 pupils. Some schools had airplanes and were preparing to give flight instruction.

Ohio's Department of Education in 1942 set up 58 aviation conferences attended by over a thousand school administrators. A college conference also was held. As a result, seven universities set up teacher's courses in pre-flight aviation, and 17 universities opened to teachers their courses in the Civil Pilot Training program of the CAA. During 1942-43, 227 high schools gave pre-flight courses to 4,529 pupils. In 1943-44, 228 high schools had an enrollment of 4,690. In 1944-45, 143 schools enrolled 2,382. The figures were believed to be about the same for 1945-46. There was considerable sentiment among Ohio high school teachers that flight courses should be started.

Pennsylvania had an aviation educational system which in 1945 embraced 259 high schools with 6,276 pupils. The State-wide program was under the direction of the education department. In Rhode Island there was no State program, the courses being optional with local boards. Providence and Pawtucket had pre-flight aeronautics courses in the high schools.

Texas had 400 high schools giving aeronautics courses aggregating about 10,000 students. Teachers conferences were being held at intervals in efforts to develop a comprehensive State-wide program of aeronautical education.

Utah had an excellent aviation educational system under the direction of E. Allen Bateman, State superintendent of public instruction. High schools and colleges were teaching theory through the

PIPER CUB FINAL ASSEMBLY

facilities of their science departments, while some high schools also taught shop work in the aeronautics trades.

Vermont had some form of aviation education in practically all high schools, and several provided definite classes. The Haas Project, set up by the family of Lt. Robert K. Haas, Jr., Navy pilot and a hero of World War II who was killed in service, provided for creating aviation education facilities in all Vermont schools. Virginia in the 1944-45 school year had 76 schools teaching pre-flight aviation, with 202 other schools teaching subjects related to aviation. The State of Washington reported that it had no aviation program in the public schools. West Virginia had 20 public schools teaching aviation. Wisconsin had 75 teachers giving aviation instruction in the public schools. In 1945 a law was passed authorizing local school boards to make contracts with flying schools for flight instruction approved by the State superintendent, the cost to be paid out of school district funds. Wyoming was working on a school program.

U. S. Navy photo

ONE OF OUR BASES ON GUAM

Showing Orote Field, one of the flying fields the Navy built on Guam.

## CHAPTER VIII

### AIRPORTS AND AIRWAYS

Description of Existing Airports—Status of the National Airport Plan—More Fields for Private Flying—Uniform State Regulation of Aviation Activities—Airport Zoning Acts—Aids to Airport Planning and Construction—Airparks for Private Flying—Advantages of Accessibility—Extent of the Federal Airways System—New Developments Along the Airways.

DETERMINED that American aviation should have all the facilities essential to its logical postwar development, many official, and semi-official and other organizations were hard at work in 1946 providing airports and other airway aids for private owners and other non-scheduled operators, at the same time expanding the already vast system of terminals and way stations for the airlines and other scheduled services, such as the hundreds of projected feeder lines designed to establish a complete network of air transportation. On January 1, 1946, the United States had 4,026 airports, including 1,509 commercial, 1,220 municipal, 216 CAA intermediate and 1,081 Army, Navy, private and other miscellaneous fields. More than 1,000 airports were lighted for night flying operations. Linking together the major airports were more than 35,500 miles of the Federal Airways System, with 3,839 additional miles under construction. These airways were equipped with 304 radio range stations, including 293 with scheduled broadcasts, one with non-scheduled broadcasts and 10 without voice. There also were 83 radio marker beacons, 533 Weather Bureau and CAA long line teletypewriter-equipped weather and airway stations, 373 traffic control stations equipped with teletype service. At the same time, airmen were given flight information provided by 62,835 miles of weather-reporting teletype and 32,807 miles of traffic control teletype service. They used data assembled at 164 Weather Bureau stations, and they also had under them throughout the country 2,025 revolving beacons, 121 flashing beacons and 207 lighted intermediate fields—all maintained by the Civil Aeronautics Administration—and besides, a total of 1,454 privately owned beacons.

A majority of the airports created or under construction after V-J Day were smaller fields primarily for private flying and fixed base operations; although 23 airlines station stops had been added to the system in 1945, requiring either new airports, or improvements in existing facilities. Also during the year, 19 stops, which had been suspended either by wartime restrictions or inadequacy of facilities, were restored to service. On January 1, 1946, 319 airline station stops were in operation, and 87 still were under suspension, with many, however, due to be restored early in the year. Of the total of 4,026 airports, 599 were added in 1945.

The Civil Aeronautics Administration was the Federal agency charged by law with the development of interstate aviation, and its activities, therefore, covered more than the Federal Airways System. The CAA National Airport Plan, presented in full in the Aircraft Year Book for 1945, had been stalled in Congress for more than a year, and early in March, 1946, still was before a conference committee of the House and Senate. There seemed to be general agreement on the overall plan for about 3,050 new airports and improvements to 1,625, involving one billion dollars, plus a quarter billion for land and buildings, with the Federal Government paying 50 per cent of the cost, the rest to be provided locally. The differences between the two branches of Congress were over the amount of Federal financing per year and the channeling of the funds, as between States and municipalities.

No action developed on the Lea bill for reorganizing the Civil Aeronautics Administration as an independent agency and setting up a separate office of a director of safety. Nothing crystallized in respect to proposals for a general investigation of transportation with a view toward the so-called "integration" of various forms of transportation, to which the airlines were vigorously opposed.

States and municipalities rushed to avail themselves of airports released for civilian use by the Army and Navy. Previous difficulties were ironed out by freezing operating equipment so that the new occupants could depend on having all facilities ready for immediate use. Forty-four airports which cost the Government more than $5,000,000 were listed as, or likely to be declared, surplus, according to the Surplus Property Administration's report. The total reported cost of those airports was $343,331,000. There were about 200 more airports, each with a reported cost of less than $5,000,000, which probably would be declared surplus. The list of 44 big airports declared surplus, or likely to be, did not contain necessarily all the airports of that category going back to local units. Where the Government took over an airport entirely by lease, it was permitted to return the airport to the local unit without the formality of declaring it surplus.

With communities filling in the details of the CAA national airport plan by drawing up local airport building and improvement plans, the CAA was "on call" to assist in their problems. Through the Washington staff and field officers, comprising airport supervisors in seven regions and 22 district airport engineers, help was given in selecting airport sites; preparing projects for airport improvement and solving airport management problems. More general information was furnished through a number of new publications, including "Small Airports" and "Airport Planning for Urban Areas." The CAA's proposed goal was 6,300, with smaller fields in a majority.

Lifting of security restrictions permitted the CAA to resume its air marking program to aid private flying. Communities were stimulated and guided in applying uniform methods of marking which could be recognized from the air.

The CAA continued to encourage enactment of State and local airport legislation beneficial to civil aeronautics interests. Particular attention was given to State legislation which was required for municipalities and counties to establish airports and to prevent, by the zoning method, the presence of hazards within the aerial approaches of airports. These efforts met with considerable success, resulting in the enactment by 15 States of airport zoning Acts similar to a model Act prepared by the CAA.

Further harmony in Federal and State regulation of aviation activities was achieved through State adoption of two other model Acts proposed by CAA. Twenty-five States designated an official body to represent the State in aviation matters, as suggested by the CAA Aeronautical Department Act, and 35 States passed airport enabling Acts setting up machinery for accepting Federal funds in building airports under the proposed national airport plan. Eight States revised their gasoline taxation bills.

Assistant Secretary of Commerce William A. M. Burden, addressing a national convention of the American Road Builders Association in January, 1946, said that "aviation in the United States is entering a critical transition period, very much like that which the automobile industry passed through a quarter of a century ago."

"The engineering and construction skills of many firms represented here today," he told the road builders, "played a great part in bringing the automobile industry successfully through its adolescent period. Your 'know-how' transformed the face of America from a sprawling continent, linked together very loosely by narrow inadequate dirt roads, to a nation unified by ribbons of concrete and asphalt. You provided the million and a half miles of hard-surfaced highways which made possible a tenfold increase in motor vehicles to the prewar total of thirty-four million. Today aviation stands ready to emerge from the dirt road era. We have some 35,000 civil aircraft in the United States, roughly the same as the number of registered motor vehicles in 1903. We have more than six times that number of pilots registered with CAA. We have about 3,000 airports for more than 16,000 communities.

"There is a wide and growing public interest in aviation which, if given the opportunity, can be translated into the purchase of aircraft until 400,000 planes are in use by 1955. When I say 'if given the opportunity', I mean, if these potential buyers are offered a product with real utility. Greater utility for the airplane will come from two sources. One is the aircraft industry, which has the important task of building safer, easier-to-operate planes. The other source is made up of all the private and public interests concerned with building airports, in which group the road builders are numbered. No matter how fine a plane the aircraft industry builds, it will be of little value unless our present airport system is improved drastically. Indeed, it is hardly accurate to use the word 'system' in talking about our present haphazard scattering of landing areas. One county may have three excellent airports, while a comparable county will have none. To be exact, 1,441 counties, or 47 per cent of all counties in the United States, are without airports today.

"In the 140 metropolitan districts of the nation, which cover only 1.5 per cent of our land area, there is an airport every 80 square miles, while the remainder of the country averages only one airport for every 1,230 square miles. We have improved our airport situation somewhat during the war years, but not in the direction most needed for peacetime aviation. Necessarily we have built large fields for military planes; more than 500 have been completed in the CAA defense landing area program, at a total cost of $400,000,000. As a result, we have today more than 800 of the largest categories of airports; what the CAA calls Class 4 and 5—in sharp contrast to no large airports of those classes in 1939. On the other hand, there has been a decline in the number of small airports, the so-called Class 1 and 2 fields. From 2,117 in 1939, the total dropped to 1,791 in 1944. Since V-J Day there has been a growth in the number of small fields, but the total has climbed only a little beyond the 1939 level, despite tremendous increases in the number of airport users.

"These deficiencies in our airport system harm not only the towns without airports; they hurt the towns which do have fields. If you were considering buying an airplane, you would of course want to know what kind of a base for operations there was in your home town. But more than that, you would weigh the number of places to which you could fly your plane. You would ask yourself: 'Is there a landing field near Smithville, where my folks live? Would I be able to run up to Bear Lake on summer weekends? Are there airports in most of the towns where I do business?' If the answer to these questions is 'No,' the chances are you will drop the idea of buying a plane, and the airport in your town will lose a paying customer simply because there are no airports in other towns. If you buy a plane without considering these important factors, it is very likely that you will give it up in a year or two, when you realize how little use you are getting out of it. This is exactly what more than 60 per cent of plane purchasers did in the years 1931 to 1939. That is why every town has a vital interest in the development of airports everywhere, and that is why we call our proposal for airport construction the National Airport Plan. It has been framed with the idea of achieving a uniformly adequate distribution of airports—for town and country; for thickly populated industrial regions; and States with large areas between population centers. Even after necessary Federal legislation is enacted, many months must elapse before construction can start. States must complete their legislative and administrative machinery for participation in a Federal-aid airport program. Metropolitan areas which have not already done so must set up community plans which fit airports into their proper place. Sites must be selected, detailed surveys made, plans and specifications drawn up, contracts let. If everything goes smoothly, it may be possible to get some construction under way this Summer, but delays will mean that work will not begin until the 1947 construction season.

"Meanwhile, the aircraft factories are going full speed on orders for 40,000 civil planes. Thousands of men are coming out of the armed services eager to take up civil flying either as a pastime or as a business. During 1945, the CAA issued more than 50,000 commercial pilot certificates to men in the armed services. In addition, we certificated 70,000 student pilots, which compares with less than 30,000 in 1939.

"It is plain that we have here the makings of a real civil flying boom. The question is, will it be a brief bubble that bursts, or a sound and lasting growth? Fundamentally, the answer depends on the two elements I mentioned earlier—better aircraft and a better airport system. We in Government are doing everything we can to help. Pending legislation for a Federal-aid construction program and the implementation of that legislation by appropriations, we are advising both Governmental and private interests how to proceed with their plans. Our airport engineers are swamped with requests for advice on site selection, airport design, and the like. Many veterans are asking for guidance in establishing small fields.

"Let me make plain that the CAA plan for a national system of 6,300 airports in no way is intended to set a maximum. Beyond this there is plenty of room for private enterprise or local government to develop fields at locations where there is not sufficient national interest to justify Federal expenditure.

"As private flying expands, we will need many thousands of additional landing areas, which will constitute the secondary or dirt-road system needed to fill out our pattern of ground facilities for civil aviation. The financial responsibility for such landing areas will be a local one—State, county, and municipal—just as is the financial responsibility for our subsidiary roads system and our streets. If, as is likely, 20,000 such landing areas are ultimately required to serve the 15,000 incorporated communities of the United States, the cost at the very modest average figure of $25,000 per unit would be five hundred million dollars."

Among the organizations helping State and municipal governments plan their airports was the Personal Aircraft Council of the Aircraft Industries Association of America, the manager of which, Joseph T. Geuting, Jr., told a national airport conference that one of the best ways to serve the private owner and industrial users of aircraft is to establish airparks inside the main business districts or as close to them as possible. "One of the fine purposes to which airpark construction may be put," said Mr. Geuting, "is in the clearance, development and beautification of former slum areas. Modern municipal planning, which should give every consideration to the establishment of airparks in such areas, would increase vastly the value of such property by replacing an economic and physical eyesore with a place of beauty and utility.

"An objection to airport building is the sound which the airplane makes. But this is really beside the point, because noise is only a relative matter anyway, and we become accustomed to it from association. Moreover, engineering improvements will make airplanes quieter than they now are, for the very same reasons that automobiles are quieter through the introduction of mufflers and soundproofing. The public demand will insist that aircraft follow the same pattern.

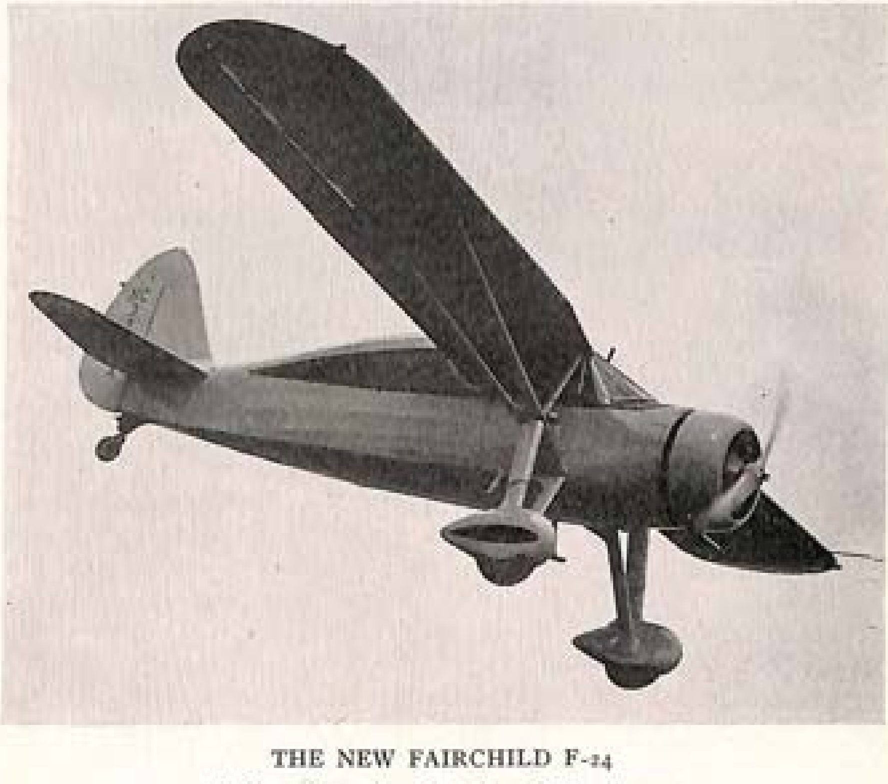
"A very unreasonable but difficult objection of those who oppose the location of an airpark in their neighborhood is a fear, real or fancied, that airplanes will come crashing through their roofs, destroying their property and endangering their life and limb. Over a period of years we have come to have a nation of people who have been conditioned to adjust their lives around transportation provided by automobiles. We also have developed very practical solutions to highway safety, and have developed traffic rules and regulations and penalties for reckless driving. Despite this, automobiles still crash into one another and, moreover, sometimes go through store windows or run into porches. The establishment of an airpark is actually a safety measure rather than the creation of a risk, for it provides an adequate, strategically located emergency landing field where it is most needed —in the heart of population centers. However, despite objections, America's future is in the air. The average person, whatever his blood, his education, his pocketbook, is going into the air because he is an American, because he is part of the future of this great land and because he wants to be in the vanguard of our triumphal march into the future.

"And now let us appraise the impact of the airport in a little different manner. Air travel must be wholly and nationally available before we can say it has real utility. Yet less than 20 per cent of our American communities are prepared to avail themselves of the many advantages of air travel or airborne commerce. All these communities which do not now have an available landing facility will eventually build one. This is inevitable because it is a part of modern progress. Nothing will stop progress—all we can do is delay it. What does this mean? It means thousands of employment opportunities. And it means thousands of new businesses to service the airport users. Just as the automobile had an impact on the community and the lives of all of us, so, too, will the airplane."

The AIA Personal Aircraft Council's book "Put Your Town on the Air Map" was widely used by airport planning committees.

The first model airpark was created at Eldon, Mo., under the guidance of the Missouri State Resources and Development Department. It had two turf landing strips, one 300 by 2,000 feet and the other 300 by 2,300 feet, a small combination service building, aircraft and motor car parking facilities and space for exhibits and sales. The area was landscaped.

Unlike airports, the Federal Airways System was being developed smoothly because it was under the direction of one organization, the CAA. The end of the war permitted action on the CAA plan for a changeover from low frequency to very high frequency radio ranges on the entire system. Installation of 25 VHF range stations had been



THE NEW FAIRCHILD F-24

A four-place plane for the private owner.

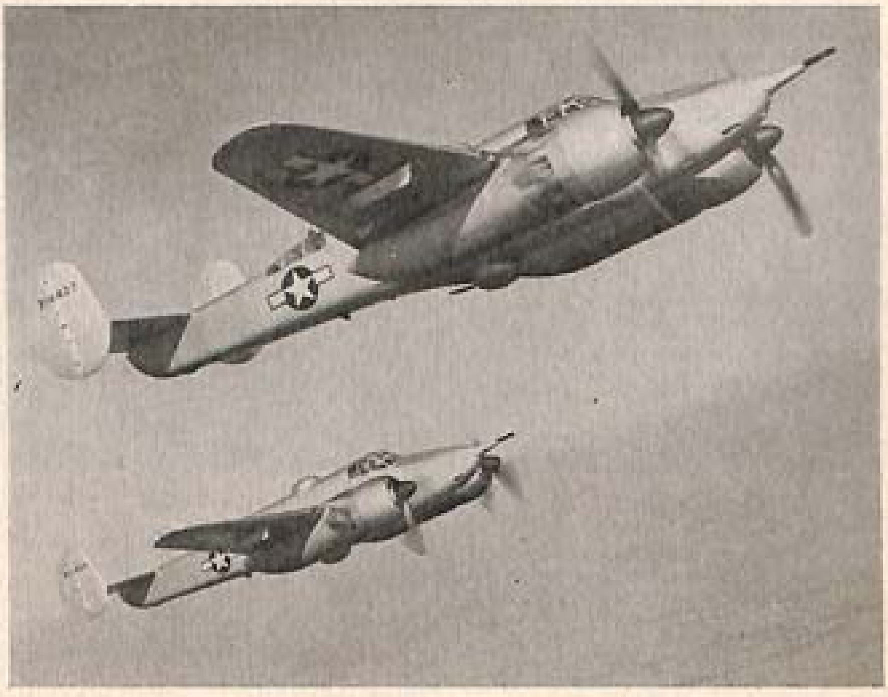
BELL KINGCOBRA OVER NIAGARA FALLS

completed at the close of 1945. Six were under construction. Surveys were completed for 24 stations and 28 more were being surveyed. Work was to continue until the entire system had been converted to VHF ranges. However, the CAA planned to continue operation of the low frequency ranges for about two years to permit gradual changeovers in airplane receiving equipment. VHF ranges were expected to speed up and simplify navigation by eliminating static and interference.

Progress was made on the installation of instrument landing systems designed to help airliners to land under blind flying conditions. Developed by the CAA, this system consisted of a localizer to guide the approaching pilot to the center line of the runway; a glide path to lead him down to the surface at a safe angle and one or more marker beacons to tell him how close he was to the end of the runway. Signals were transmitted on very high frequencies. Installation of 36 instrument landing systems was completed in 1945. Nine of these were at civilian airports and 27 at Army airports. Construction was under way on 14 more for civilian use. About 125 airports were scheduled for blind landing equipment. A new airport "approach control system" permitting landings every three minutes in bad weather was developed by the CAA and put into practice at 46 airports.

The system was described by the CAA officially, as follows: "The instrument landing equipment being installed is the three-element system developed by the CAA, consisting of the localizer, glide path and marker beacon, and is the system acceptable to the CAA, the industry and the Services. Although the Army and Navy did remarkable things with radar in instrument landing during the war, the pilots of the airlines, the technical men of the airlines, and CAA radio engineers all agree that considerable development work will be required before radar is safely applicable to commercial use, and still further development is proceeding on the CAA's VHF system. During the war the Army standardized on the CAA's instrument landing system.

"Of the three elements, the marker beacon is considered fully developed. The localizer, heretofore operated on a basis of amplitude comparison, with 90 cycles transmitted on one side of the line and 150 cycles on the other to define the course along the runway, has been improved by using phase comparison instead of amplitude comparison. Now the course is defined by comparing the phase of two 60-cycle signals. This change has resulted in a considerable simplification of



BEECHCRAFT XA-38 DESTROYERS

the equipment required in the transmitter on the ground, and a lightening and simplification of the airborne receiver.

"A straight line glide path has been developed as an improvement of the landing system. This has come from early work of the CAA and the Bureau of Standards, and the straight line path has been in operation at Indianapolis, Ind., for observation by airline pilots and engineers. It is the consensus that the straight line path is definitely superior to the curved path based on hundreds of landings at Indianapolis by scores of pilots of the CAA, the airlines, Army and Navy. The CAA is cooperating with the Army in service testing of its automatic instrument landing system. In this, the indications of the cross-pointer instrument by which the system is flown are connected to a standard automatic pilot, and the station's airline-type airplane is flown repeatedly to the point of contact with the ground without human hands on the controls."

To avert shutdown of 105 airport traffic control towers operated by the CAA during the war, with Army support, the CAA renewed its request for appropriations to staff airport traffic control towers as a regular part of its Federal Airways System.

U. S. Army photo

WE USE IWO JIMA

North American P-51 Mustang fighters taking off from the bloodily won air fields of Iwo Jima for the first strike against Tokyo by land-based fighter planes.

## CHAPTER IX

## FEDERAL AGENCIES IN AVIATION

Work of the National Advisory Committee for Aeronautics—The Civil Aeronautics Administration—The U. S. Weather Bureau—The U. S. Forest Service—The U. S. Public Health Service—Federal Communications Commission—The Aviation Division, Department of State.

MANY of the non-military agencies of the Federal Government made important contributions to the war effort. Each of the agencies discussed in the following pages were engaged in aviation activities as important to our postwar air power as they were of value in contributing to the defeat of our enemies.

### National Advisory Committee for Aeronautics

The National Advisory Committee for Aeronautics, developed its original research station, Langley Laboratory, at Hampton, Va., until at the end of the war it was the largest and best equipped laboratory of its kind in the world. To meet the extraordinary demand for technological superiority in the war emergency, and to insure the maintenance of our superior position in both military and civil aviation in the years to come, the Government expanded its NACA research facilities to include another aerodynamics laboratory at Moffett Field, Calif., and an aircraft engine research laboratory at Cleveland, O. From those laboratories came the basic scientific data which were applied by the Army and Navy in evaluating and specifying its aviation equipment; and by the aviation industry's engineers in designing and producing America's unmatched aircraft. The high-speed NACA cowling was used on all radial engine aircraft, and the low-drag NACA wing was used on high-speed aircraft. Other NACA data for American designers included basic aerodynamic data on wing forms, aerodynamic data on propeller blade forms for high-speed aircraft; optimum location of engines on multi-engine airplanes; load factors in design based on gust intensity; pressure distribution information on both wings and control surfaces, permitting safe designs; flight research on handling and flying qualities permitting satisfactory specifications to be drawn; structural methods and data; means for heat de-icing wings, control surfaces and windshields; flutter prediction; and drag elimination studies.

Development of new propulsion methods indicated revolutionary changes in aviation techniques. Vast research regions had to be explored, such as high-temperature alloys for gas turbines and jet-propulsion engines, more efficient compressors and combustion chambers, jet, gas turbines, and rocket power plants. The new propulsion systems offered extraordinary high-speed possibilities and created the need for data on characteristics of flight in the transonic and supersonic speed ranges. NACA scientists thought it possible that entirely new aircraft forms would have to be evolved to sustain safe flight in those speed ranges, and they were working on the various problems in efforts to determine just what new aircraft forms, if any, would be required.

### Civil Aeronautics Administration

The Civil Aeronautics Administration under Theodore P. Wright, administrator, made substantial progress in measures designed to accommodate a large-scale peacetime increase in civil flying at home and abroad. Evidence of aviation growth was shown by the 1945 spurt in civil plane production and pilot certification. Manufacturers of personal planes indicated they had orders totaling 40,000. The best production of civil aircraft during any earlier year was 6,844 in 1941. With the release of surplus military planes, the number of certificated civil aircraft increased from 22,000 to 30,000 in 1945. Airlines placed orders for about 500 new transport planes, which would more than double the existing fleet. Need for the equipment was demonstrated by a rise to 7,700,000 in the number of passengers carried in domestic operations during 1945, from 4,668,000 in 1944, and 1,876,000 in 1939.

Using 10 carloads of radar equipment loaned by the Army, adaptation of military radar to civil use was started at the CAA Indianapolis Experimental Station, the development center of the new VHF ranges and instrument landing system. Among the radar experiments under way was a screening device to permit tower controllers to visualize actual positions of all aircraft within a 25-mile radius, and a collision warning device on the instrument panel of the plane.

While radio and radar occupied much of the time of CAA's engineers at the Experimental Station, they were only two of dozens of projects under way to make flying safer. Under the direction of Henry I. Metz, 14 engineers and 88 other workers continued development or testing work on such projects as aircraft fire protection, impact-resistant windshields, stall warning indicators and a photographic flight path recorder. Six types of airport lighting systems, including approach, runway and boundary lights, and high intensity flashing beacon, were installed for testing. Aircraft lighting devices also were under development.

The CAA's Research Division, working primarily through colleges under contract with the National Research Council, continued its unique work in the fields of pilot selection and training. A major development during the year was the initiation, at the request of the Civil Aeronautics Board, of a study of the relationship between visual standards and flight performance with respect to certification of civil pilots.

On-the-job training of 43 mechanic graduates wound up the third Inter-American Aviation Training program, and training courses in the fourth program were commenced in April, 1945, for the 138 young men selected from the American Republics by the State Department to receive U. S. aviation training under CAA supervision.

In the international phase of CAA commercial activities, the Office of Field Operations, created shortly before 1945, maintained foreign offices in Rio de Janeiro, Brazil; Lima, Peru; and Balboa, Canal Zone; to aid in the safety of U. S. flag carriers operating in foreign countries and foreign carriers operating in the United States. Plans were made for a total of 16 foreign offices in anticipation of a large increase in intercontinental traffic.

Supplying technical aviation assistance to other countries was a further service of this office. During 1945, it handled requests for information from 33 foreign countries. In addition this office carried on with its coordination work at the Montreal meeting of the Provisional International Civil Aviation Organization (PICAO), offspring of the November, 1944, Chicago International Civil Aviation Conference.

Starting point for a system of world-wide airways was the PICAO

BOEING B-29 FINAL ASSEMBLY

The end of the war found unlimited numbers of Superfortresses to be made available if needed. This is the Boeing Renton, Wash., plant, one of several B-29 arsenals.

meeting, where CAA technicians, because of their experience in building and operating airways, had important assignments. Meeting with technicians from other countries, they discussed international standards for landing areas and ground aids, communications, meteorological services, rules of the air and traffic control practices. Study of six technical documents, accepted at the 1944 Chicago Conference, was completed at the first session. The remaining documents were to be discussed in 1946.

Missions making trips abroad to study problems incident to peacetime air commerce included a round-the-world inspection tour of the Army Air Forces Air Transport Command activities by three veteran airways and engineering officials. Headed by Fred M. Lanter, Assistant Administrator for Safety Regulation, this group surveyed airways—many of them installed under CAA technical supervision—extending from Washington to Burma, and from Manila and Australia to San Francisco, with a view of adapting them to peacetime commerce. C. I. Stanton, CAA deputy administrator, headed another group attending the Commonwealth and Empire Conference on Radio for Civil Aviation, in London. Charles F. Dycer and Paul Spiess, flight and aircraft engineering officials, conferred in London with British technicians on airworthiness requirements for aircraft used in international operations, and went on to Paris for the airworthiness sessions of the International Commission for Air Navigation. CAA's other representative at the ICAN meeting in Paris was Eugene Sibley, head of CAA Communications. Other foreign assignments took CAA officials to Spain to negotiate with the Spanish Government for improvement of the Madrid airport in the interests of U. S. military and civil air operations; to Costa Rica to advise on airport construction; to Uruguay to lend assistance in air transport needs of that country, and to the Caribbean area.

Assisting in restoration of civil aviation in Germany and Austria were Fred H. Grieme, airport specialist, and John E. Sommers, who were assigned to this work on Gen. Dwight D. Eisenhower's request for CAA representatives qualified to advise on all matters pertaining to aviation.

The CAA completed testing surplus military transports for use on overseas hops by civil airlines, and conducted numerous "proving runs" to assure safety on the newly authorized transoceanic routes of Pan American Airways, American Overseas Airlines and Transcontinental & Western Air.

One phase of CAA's contribution to the operations of the armed air forces included establishment for the Army of air traffic control centers at Guam, Kwajalein and Johnston Islands, and a center for the Navy at Bermuda. The CAA already had centers in operation at Honolulu and San Francisco. Transoceanic communications stations were completed during the year at Balboa, C. Z., San Juan, P. R., and

Miami, while other stations in the globe-girdling CAA network were expanded.

Continuation of aircraft production data was assured the aviation industry and interested Government agencies when this work was transferred to the CAA from the Aircraft Resources Control Office. In addition to compiling production data for military aircraft, ARCO's wartime job, the CAA collected statistics for civil and export aircraft, thus providing a centralized source of information on all aircraft production.

For guidance of those interested in the future of aviation, the CAA prepared and published Civil Aviation and the National Economy, a book-length study of civil aviation's position today and its possibilities within the next ten years. It brought together the salient facts on aviation development to date, forecasting growth trends and setting forth a program of Government and industry cooperation for achieving the projected increases.

Other CAA publications were the CAA Statistical Handbook; Airport Buildings, a comprehensive treatment of the subject, including buildings for all sizes of fields; Path of Flight, practical information about navigation of private aircraft; Air Traffic Rules, a simplified manual dealing with air traffic sections of the Civil Air Regulations; Realm of Flight, giving simplified weather information for the private pilot; Employment Outlook in Civil Aviation, a discussion of the procedure for veterans to find aviation jobs and to start small aviation businesses.

**U. S. Weather Bureau**

The Aviation Weather Service of the U. S. Weather Bureau continued during 1945 with such extensions as appropriations and the influences of wartime operation (and subsequently of reconversion) allowed. In the latter part of the year, 14 reporting stations established for military purposes and operated on War or Navy Department funds, were closed, and at seven others portions of the service were discontinued. Most of these stations were in the far West or South. Two stations in the Southeast were closed and one in the central States opened. Limited service was started at five others. Radiosonde observations were initiated at seven stations and discontinued at one, and rawinsonde observations were started at eight stations. These rawinsonde observations, designated as RASONS, consisted of an upper-air observation of wind, temperature, pressure, and humidity made by use of a balloon-borne radiosonde—the ground equipment comprising a radio direction-finder (RDF) and an audio frequency recorder. The wind data obtained by rasons extend to levels within and above cloud layers, an impossibility with pilot balloon observations. Equipment for making these observations was supplied by the Army Air Forces. It was anticipated that the number of stations ultimately would be above 30 in the United States and 12 in Alaska.

As an aid to Pan American operations, radiosonde observations were started at Ciudad Victoria, Mexico. It was the fourth Mexican radiosonde observation station in the cooperative meteorological program of the Weather Bureau with the Mexican Meteorological Service. Under a similar arrangement with the Cuban Meteorological Service, the raob program at Havana was increased from one to two observations daily during December, 1945. Both Mexican and Cuban observations were distributed over teletype networks in the United States, and were available to all aviation interests. Reports from the Atlantic Weather Patrol, conducted for several years to furnish weather reports for transocean aviation, were released from secrecy toward the close of 1945. Early in 1946, there were eight stations in this service in the North Atlantic and one off the coast of Brazil. These ships conducted a full program of two radiosonde observations, four pilot balloon observations, and three-hourly synoptic observations daily. The observers, enrolled in the Coast Guard during the war, were returned to civilian status on October 1, 1945.

Ceilometers, the electrical device for measuring ceilings at all hours of the day or night, were put in operation at 18 stations during 1945. Additional installations were scheduled for 95 stations in 1946. The Weather Bureau adopted the method of constant-pressure analysis of upper air maps. This system of standard pressure surfaces included the contour or shape of the surface together with wind, temperature and humidity. To the analyst and forecaster, the system offered numerous advantages over the constant-level system which was discontinued.

Under a specific supplemental appropriation, a new International Aviation Section was established in the Synoptic Reports and Forecasts Division of the Weather Bureau at Washington, to direct forecasting activities for long-range overseas flights. Field units for the performance of this service were organized at La Guardia Field, New York, (an expansion of the International Forecasting Service already there); at the Washington National Airport; at the 36th Street Airport in Miami; and at the Baltimore Municipal Airport at Dundalk, Md. Plans also were practically completed for a similar unit at Chicago. The basic purpose of these forecasting groups was to provide forecasts prior to take-off and amended forecasts or other weather information as might be required during flight. In recognition of the high importance of weather service in international aviation, Weather Bureau representatives spent extended periods in liaison with the meteorological services of foreign governments, and took active part in the meetings of the Provisional International Civil Aviation Organization in Montreal, of the meteorological subcommittees of the International Commission of Air Navigation in Paris, in the Western

Hemisphere Telecommunications Conference in Rio de Janeiro, and at a conference to discuss meteorological service and facilities in the Pacific area, at Melbourne, Australia.

Under special authorization of Congress and with the cooperation of the Army Air Forces and the Navy, the Weather Bureau in 1946 started a detailed study of the structure and dynamics of the individual thunderstorm. The project, using airplanes, sailplanes, balloons and radar operated aloft simultaneously with a micro-network of autographic recording surface stations (including radar), was aimed at finding methods of circumventing thunderstorm hazards. Primary attention was given to excessive gusts or drafts, although hail and lightning also were important in the investigation. The Army Air Forces was establishing an airplane and radar program, and the Navy planned to operate "drone" (pilotless) aircraft as parts of the project. The thunderstorm flight observations were to be carried out in Florida and in the Middle West with coordinated balloon, radar and ground observations.

The Weather Bureau observers at the Mount Washington Observatory in New Hampshire had been making regular icing observations using new equipment designed by the Massachusetts Institute of Technology and the General Electric Company. The Mount Washington observers also cooperated with the Army Air Forces, Northwest Airlines, and the Goodrich Rubber Company in testing aircraft de-icing equipment under natural icing conditions. Close cooperation with the National Advisory Committee for Aeronautics was accomplished by the assignment of a full-time meteorologist to the ice research staff at Ames Aeronautical Laboratory at Moffett Field, Calif.

### U. S. Forest Service

Near Kalispell, Mont., on December 14, 1944, two wood-choppers discovered a Japanese balloon. Examination by the Federal Bureau of Investigation showed that the balloon was made of high grade processed paper; diameter of the bag was 33½ feet, gas capacity about 18,000 cubic feet, and a lift of at least 800 pounds. The balloon bore Japanese characters showing construction in October, 1944. It carried one incendiary bomb at the time of discovery.

Early in January, 1945, foresters reported that another balloon had been found in Oregon. Over the Japanese radio about this time came an announcement that they were setting forest fires in the United States. Actually weather conditions at this time were not favorable to the start of forest fires, but the U. S. Forest Service and the Army began immediate plans to cope with this new menace, which could become a serious threat to the Western States when the forests became dry later in the year.

The Forest Service increased its "smokejumper" corps to 215 (there were 87 in 1944). As in the previous year, most of the smokejumpers were conscientious objectors who volunteered for this parachute fire-fighting work. The men were given intensive physical training to toughen them for jumping, and this was also a big factor in their fire-fighting ability. They were then taught parachute jumping and fire-fighting techniques. As the fire season progressed, the jumpers were assigned to their fire suppression stations in Oregon, Washington, Idaho and Montana.

The Army placed at the disposal of the Forest Service a squadron (32 planes) of L-5 Vultee reconnaissance planes, with necessary pilots and mechanics, to be used for patrol, detection and report of balloons and for other missions requested by the Forest Service. Ground troops were assigned for forest fire-fighting at several western bases, and two companies of Army paratroopers were made available—100 men stationed at Pendleton, Ore., and 50 at Chico, Calif. The Army paratroopers were trained by the Forest Service in smokejumping and fire-fighting techniques. In May, the number of paratroopers at each base was doubled. Their operations became known as the "Fire Fly Project."

During the early months of 1945, large numbers of Japanese balloons came over. By the end of September more than 200 had been recovered. Other hundreds were seen. On several occasions the planet Venus was reported as a balloon by amateur observers. It was believed that the launching of the balloons was made an occasion for "pep" rallies of Japanese workers. The balloons were designed to drift with the prevailing westerly stratosphere winds to the American continent. They were equipped with ingenious devices to release sandbags when they drifted too low. They carried incendiary and antipersonnel bombs. The balloon barrage ended before the season of greatest fire danger in the Western States occurred, and there was no authenticated report of a forest fire starting from this cause. On May 5, 1945, however, in the Fremont National Forest near Bly, Ore., a woman and five children were killed as a result of handling the unexploded bombs of a grounded Jap balloon which they discovered while out on a picnic.

Bad outbreaks of fire from lightning and other causes occurred during the Summer of 1945 in the West Coast and Northern Rocky Mountain States; and the Forest Service smokejumpers and Army Fire Fly groups did important service in combating fires in isolated regions. Smokejumper crews fought 313 fires in the most inaccessible areas. They made the first attack on 288 of these fires, reinforced ground crews from the air on 15, and attacked 10 fires from the ground. Total number of fire jumps was over 1,500, not including 51 jumps made to render aid to injured persons. From July 11 to September 7, there were only three days when jumps were not made to fires.

Of all the fires the smokejumpers attacked initially, only one reached Class E proportions (over 300 acres), and this undoubtedly could have been held to a much smaller acreage had more jumpers been available. Without the smokejumpers, the record of burned area would have been far greater. The Clearwater National Forest had three fires on the same day under quite similar conditions. One handled by ground forces cost $75,000 to suppress. The other two were quickly extinguished by smokejumpers. The Forest Service estimated that for the season as a whole, smokejumper control resulted in savings of at least $300,000 over what suppression costs would probably have amounted to without the help of aerial forces.

Control of back-country fires by use of smokejumpers had proved economical for some years, but detection of fires by airplane patrol did not prove so successful in earlier tests. This had made it necessary to retain a ground lookout system in every area, even where it was possible to get better and faster suppression action from the air. During 1945, however, the Forest Service conducted an experiment to combine airplane detection with smokejumping patrol on an area embracing about 2,054,000 acres of remote inaccessible forest land in Montana. The area covered parts of four National Forests along the Continental Divide, with elevations ranging from 4,000 to 9,000 feet. The inaccessibility of this area, with the heavy manning required to give adequate ground crew protection, made it an ideal unit to test fire control by aerial methods. Within the area, 43 lookout-fireman positions were discontinued and the funds ordinarily allotted for this purpose were set aside for flying patrols and jumper training. Nine ground lookouts were retained to give detection coverage to some of the most dangerous areas, and to record lightning storms and furnish weather data used by the Weather Bureau. Through a profile system, regular airplane patrols were planned, with additional patrols to cover areas where lightning storms had passed. During the season, 29 fires occurred in the area. Of these 14 were first discovered by aerial observers. Eighteen of the fires were held to Class A size (less than ¼ acre) and only one reached large size, 2,270 acres. On that fire air action was not possible until the afternoon of the next day, because of strong winds, which spread the fire very rapidly. Another fire burning at the same time was controlled by smokejumpers in ground action, with a loss of 120 acres, mostly in grass. No other fire burned more than 10 acres, although four were outstanding as potentially dangerous. For one fire, fanned by a 15-mile wind on an extremely dry day, discovery, report and first action took only 47 minutes. It would have taken ground forces at least six hours for first attack. The experiment was successful enough for the Forest Service to plan another and larger such experimental unit for 1946.

For years, foresters dreamed of the revolutionary effects a hovering type of flying machine could have on methods of doing their job. Due to its ability to land and take off in very restricted space, a helicopter could land men and supplies in thousands of spots throughout forested areas. The Forest Service early in 1946 maintained approximately 90 airplane landing fields in National Forests, and if sufficient funds were provided, could extend the number in use; but topography would soon limit the number of available sites. Furthermore, the clearing and leveling of such sites in forested or mountainous country was a costly process. On the other hand, if perfected rotary wing aircraft were available, there would be almost no limit to the number of small landing spots already provided by nature or which could be prepared inexpensively. With such an air-ground transit system, small, well-trained and well-equipped crews could be transported to spots at or near fires very shortly after their discovery. On large fires reinforcements could be landed quickly and fire-fighting crews easily supplied. Helicopters would be ideal for search and rescue work, livestock and game counts, for survey and administrative travel in the back country, and for many other forest jobs. Much of the Federally administered forest is in rough and relatively inaccessible areas. Millions of dollars have been invested in roads and trails constructed primarily for, and in some cases wholly for, fire protection. Annual maintenance of these ground transportation systems represents a substantial financial outlay. A well-planned and effective helicopter operation conceivably could provide a degree of protection justifying material reduction in the road program. Under an appropriation from Congress in 1938, the Army Air Forces, acting for the military branches and certain civil agencies including the Forest Service, invited bids for design competition. Later, out of this action came the Sikorsky helicopter. In 1942, the XR-4 made its first flight and was the forerunner of the many war-inspired helicopters. From the foresters' standpoint, however, there still were several problems to be solved in adapting rotary wing aircraft to their needs.

During 1946, the Forest Service, with the cooperation of the Army Air Forces, planned an experimental project to include tests and demonstration of the suitability of helicopter operation as a part of the fire control system. March Field was selected as the center of operations, and the Angeles National Forest in Southern California as the proving ground. If the tests were even fairly successful, the Forest Service was confident that in a reasonably short time improvements in the mechanical elements would create a vehicle marking a turning point in the progress of forest protection and administration.

Wood utilization research conducted during 1945 by the Forest Products Laboratory, maintained by the Forest Service at Madison, Wisc., included much work in the aircraft field. A manual presenting maintenance and repair procedures to be used on wood and "compreg" propellers was prepared for the Army and Navy air forces. Three sessions of a course of instruction for inspectors of aircraft wood, sponsored by the Army Air Forces, were attended by 51 persons.

Since April, 1942, a total of 1,358 had attended aircraft wood inspection and related courses given by the Laboratory technicians. Representatives of the Army Air Forces, the Navy, and industry were among the 13,839 who attended courses in packaging and shipping container techniques given by the Laboratory.

A new type of free-fall container was developed by the Forest Products Laboratory as a means of delivering supplies to beleaguered forces from the air without the use of parachutes. The container was collapsible, easily assembled and adapted to production-line fabrication. The fiberboard container was equipped with fiberboard airfoil wings, which caused the box to rotate on its vertical axis in descent, reducing both the rate of fall and the landing impact. Some of its advantages over parachute delivery were: In war the container was less easily spotted by the enemy; the container and "lifting" apparatus were one unit; the load could not be caught in trees or dragged over the ground by wind after landing; the cost per pound of supplies delivered was reduced. In peacetime it should prove useful for supplying isolated groups, and for emergency delivery of foods and medical supplies to victims of floods and other disasters. As a means of regular delivery of mail, express, perishable foods and other items to outlying communities it would fit in well with the recently developed airplane pick-up system.

Design data developed at the Laboratory for "wood sandwich" constructions (soft, light-weight core material with thin, high strength facings) used as skins for airplane wings and fuselages, were used by the armed forces in the development of new high-speed aircraft. Structural veneers and plywoods overlaid with resin-treated paper—an outgrowth of the Laboratory's research in plastic paper laminates—withstood rigorous wartime use for cargo aircraft and glider flooring, and a variety of other products.

#### U. S. Public Health Service

During 1945 the Foreign Quarantine Division of the Public Health Service increased its activities in safeguarding the nation from introduction of quarantinable diseases through air transportation. Inspections of planes arriving at airports of entry from foreign countries increased 77 per cent over 1944. The number of air passengers examined upon arrival into the United States and insular possessions was 83 per cent higher than in the preceding year.

Activities in aviation medicine conducted at the Industrial Hygiene Research Laboratory of the U. S. Public Health Service's National Institute of Health were concentrated upon military research from 1941 through 1945. Work was carried on in close cooperation with the Bureau of Aeronautics and the Bureau of Medicine and Surgery, U. S. Navy. Equipment for aviation medicine studies at the Institute included low pressure chambers, cold rooms and a psychometric room.

These facilities permitted reproduction of the pressure and temperature changes to which aviators are subjected. Atmospheric conditions occurring in actual parachute descents from 40,000 feet also could be simulated. A large portion of research in 1945 involved investigation of respiratory apparatus to prevent oxygen deficiency. Developments included a breathing device capable of sustaining life for significant lengths of time at altitude and ground level in atmospheres made non-respirable by toxic gases, smoke or depletion of oxygen. A modification was made in regularly issued oxygen masks which facilitated resuscitation from asphyxia under adverse flying conditions and cramped positions in bombers.

Research also included a study of hazards resulting from combustion products of agents introduced to increase potency of aviation gasoline. Xylidine, one of the most effective, through animal experiments was found to produce striking toxic effects from both inhalation and cutaneous exposures. Based on the results of this work, proper precautionary measures were formulated, and the producers and processors of Xylidine were informed of the potential dangers of this material.

The laboratory developed a midget photometer for use in the field to determine the concentration of carbon monoxide in blood—an important problem in maintaining the efficiency of tank and airplane crews in armed service operations. One of the determining factors in an aviator's ceiling is the ratio of water vapor to oxygen in his lungs during ascent to high altitudes. Studies were under way to make precise determination of the water output from the lungs. Evaluation was being made of the effect of altitude on breathing patterns with particular regard to the factors influencing design of respiratory equipment. Studies were continuing on the intimate mechanisms of decompression sickness relating to high altitude flight as well as diving and caisson work.

With the jet propulsion engine and the rocket motor ushering in a new era of aircraft design, the future program of research should furnish physiological data to be used as fundamental source material. Human tolerance to the abnormal stresses and strains imposed by the greater speeds and higher altitudes attainable were to be studied. The rapid expansion of commercial air flights and private ownership of planes highlighted the medical aspects of basic problems such as determination of flight fitness for operating personnel and passengers, pressure change effects, air sickness and pilot fatigue.

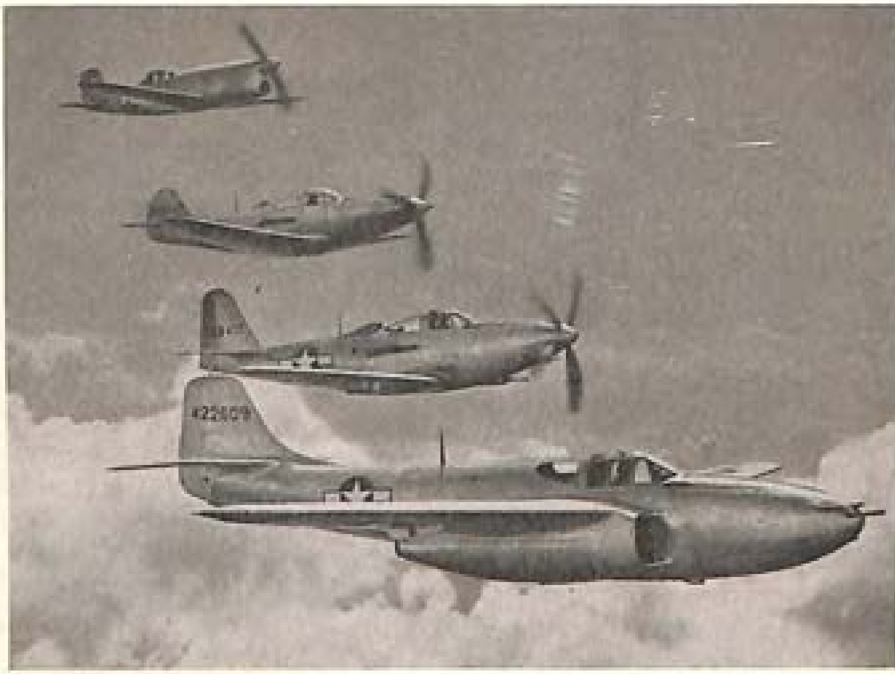
Protection and improvement of the health of aircraft workers was an important phase of the Public Health Service's Industrial Hygiene Division activities directed toward an effective national health program for industry. Through consultation service and direct assistance to State and local industrial hygiene organizations, the Public Health Service kept a finger on the health pulse of the employees in the aircraft industry, helping to develop adequate facilities for control of occupational hazards and prevention of disease. Public Health Service representatives visited aircraft plants upon request to aid in eliminating hazards to health. Poisoning from spray painting, degreasing and chromic acid created problems. The use of exhaust ventilation hoods was recommended for those engaged in spray painting, and lateral hoods were adopted as protection from degreasing and chromic acid. Ill effects suffered from airplane testing blocks were cleared by installation of exhaust ventilation for fumes and soundproofing to eliminate as much noise as possible. Principal skin hazards, the Dermatoses Section found, resulted from cutting oils, thinners and solvents used in paints and "dopes", plating and rustproofing of metals, fluxes used in welding and solvents used for cleaning and degreasing. Occasional cases of sensitivity to preservatives in dural sheets and to chrome yellow "fillers" also occurred. Preventive measures were advised as follows: Impervious clothing, the use of protective ointments and the use of non-irritating skin cleansers in addition to proper general and local ventilation. The Industrial Hygiene Division anticipated an expansion of industrial health facilities on a State level during 1946. Increased consultation service on industrial hygiene was to be available for the rapidly growing aircraft industry.

### Federal Communications Commission

At the end of 1945, the Federal Communications Commission was preparing for a sharp upward swing in the use of radio in all classes of non-Government radio services, both for communication and navigation.

The number of licensed aircraft stations which stood at 3,090 at the end of the fiscal year 1945, was expected to climb to more than 26,000 by the end of the fiscal year, 1947. This was based on the fact that as air traffic became more congested, safety would require a greater use of radio. Licensed aviation ground stations were expected to increase from 700 on July 1, 1945, to 2,500 in July, 1947.

The expansion of the use of radio in flying operations was provided for in the Commission's frequency allocation report above 25,000 kilocycles of May 25, 1945. As the result of these allocations, there was to be a gradual transfer of aviation facilities wherever technically practicable from their present position in the spectrum to the very high frequency range, primarily in the band between 108 and 132 megacycles. In its proposed frequency allocation report below 25,000 kilocycles, issued May 21, 1945, which had not been made final at the close of the fiscal year, various bands of frequencies were allocated to aeronautical mobile services between 1,605 kc and 17,100 kc and to aeronautical fixed aviation services between 160 kc and 24,985 kc; and to navigation aids between 200 and 2,000 kc. The Commission issued authorizations in the various classes of aviation service as fol-



BELL AIRCRAFT'S FOUR FIGHTERS

They are, top to bottom, the XP-77, all wood fighter for the Army Air Forces, the P-39 Airacobra, the P-63 Kingcobra and the P-59 Airacomet.

lows: aeronautical radio stations 665; aeronautical fixed radio stations 130; airport control radio stations 45; flight test radio stations 82; flying school radio stations eight; and aircraft radio stations 4,043. During the year, the Commission handled 592 official notices covering violations of treaties, Federal statutes or Commission rules and regulations.

Representatives of the Commission were technical advisers to United States delegations at the Chicago International Civil Aviation Conference and subsequent international conferences implementing this conference's actions. They participated in committee work and in the preparation of documents relating to aviation radio communication and air radio navigation.

Further indications of the expansion that had occurred recently in commercial airline activities were evidenced at two aviation hearings held by the Commission in June, 1945, and January, 1946. The applications heard at the first hearing were those filed by Pan American Airways for additional frequencies, proposing a general expansion of the existing radio communications facilities then operated by the applicant in the Caribbean area. Aeronautical Radio, the communications subsidiary of the domestic airlines, was obliged to intervene in the hearing because the Pan American applications requested authority to share frequencies already in use in the domestic aviation service operated by Aeronautical Radio. The Commission granted several temporary authorizations to use certain of the frequencies requested so that the experience gained through their use might be studied by the Commission in its determination of the case. The matter was still pending decision.

The applications which were the subject of the Commission's second hearing in January, 1946, were those filed by Aeronautical Radio for radio facilities at New York serving aircraft flying the Europe-North America route. The filing of these applications for international radio facilities by Aeronautical Radio followed the authorization given to some of the domestic airlines to engage in international flights. The service proposed by the applicant would duplicate certain of the aviation radio services then rendered at New York by the Civil Aeronautics Administration, and for that reason, that agency intervened in the hearing. Pan American Airways also participated in the hearing.

### 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 (PICAO) 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.

BUILDING LOCKHEED CONSTELLATIONS

The C-69 Constellation transport assembly line at the Lockheed Aircraft Corporation's main plant in Burbank, Calif.

## CHAPTER X

### AMERICAN AIRCRAFT—WAR AND POSTWAR

New Things in the Air—The Record War Production of American Aircraft Manufacturers—Development of the World's Most Powerful Air Force Equipment—Weapons Which Were War Secrets —Guided Missiles—New Giant Bombers and World Transports—Helicopters—Aircraft for the Private Owner.

DURING the war, the aircraft manufacturing industry in the United States became the largest single industry in the world. Starting from a prewar payroll of fewer than 50,000 employees producing less than 3,000 aircraft a year, it expanded its facilities, personnel and production until in 1944 it produced nearly a hundred thousand aircraft. The Aircraft Industries Association of America reported that the effort devoted to production of superbombers was the largest single industrial enterprise in history, and continued: "American production increased rapidly from the outbreak of war to March, 1944, to a total of 9,117 military aircraft in that month, and to a total of 96,369 aircraft for the year. Reductions in the aircraft production program began early in 1944, and continued throughout the year and during 1945. Three separate reductions totalled 75,700 airplanes at a saving of more than 13 billion dollars.

"These cutbacks resulted in the separation of more than 1,000,000 employees, a reduction in the production rate from nearly 10,000 units a month to only 6,000 a month. The industry was characterized in 1945 by a constant shrinkage due to these cutbacks, to employees leaving their jobs caused by a relaxation of 'victory pressure' and a foreboding of coming cuts by management resulting in gradual realignment of facilities and a 'drawing in' of the enormously outstretched operations. Personnel continued to drop through the first half of 1945, with about 250,000 employees leaving their jobs. As a result, the industry entered August, 1945, with a production rate of less than 5,000 planes a month, lowest in the preceding 33 months since November, 1942.

"On August 14, 1945, contracts for nine billion dollars worth of aeronautical equipment, including 31,000 military aircraft, were cancelled. This was 90 per cent based on the 1946 program. The net saving was approximately seven billions. Within the following two weeks approximately 450,000 employees were separated from the industry. Production came to a near halt, and only half-a-dozen specified types continued in production at the end of 1945, with about 150,-000 employees left in the entire industry.

"The application of war-developed scientific advances to commercial air transport is well underway. (Early in 1946.) All the new type transport airplanes now available are direct developments of war-spawned types redesigned for peacetime use. The millions of dollars of research and development and the hundreds of thousands of war-developed production techniques now are incorporated on the new models, with the result that the postwar air transport is faster, more powerful, more comfortable and more reliable than its prewar counterpart. In performance alone the increase approaches 100 per cent with 300 m.p.h. models now available to replace the 180 m.p.h. designs of 1939. Capacity has leaped from 21 passengers to 50 and more and the pressure cabin has increased comfortable cruising altitudes from 12,000 to 30,000 feet. The reliability of these new types, proved in the uncompromising trial of war, has made scheduled transoceanic flight a fact and regular 2,000 mile flights a daily occurrence. These technical advances produce real benefits for the airlines and the air traveling public. Higher cruising speeds mean less traveling time, reduced fuel consumption per trip, longer airplane life, reduced maintenance and, therefore, reduced air fares. Development of new metals and materials has resulted in lighter structure weight, thereby providing more luxurious passenger accommodations and comfort refinements."

Aeronca Aircraft Corporation, Middletown, O., was in production on a postwar version of a two-place plane, the Champion, and was preparing for production of a two-place side by side plane to be known as the Chief.

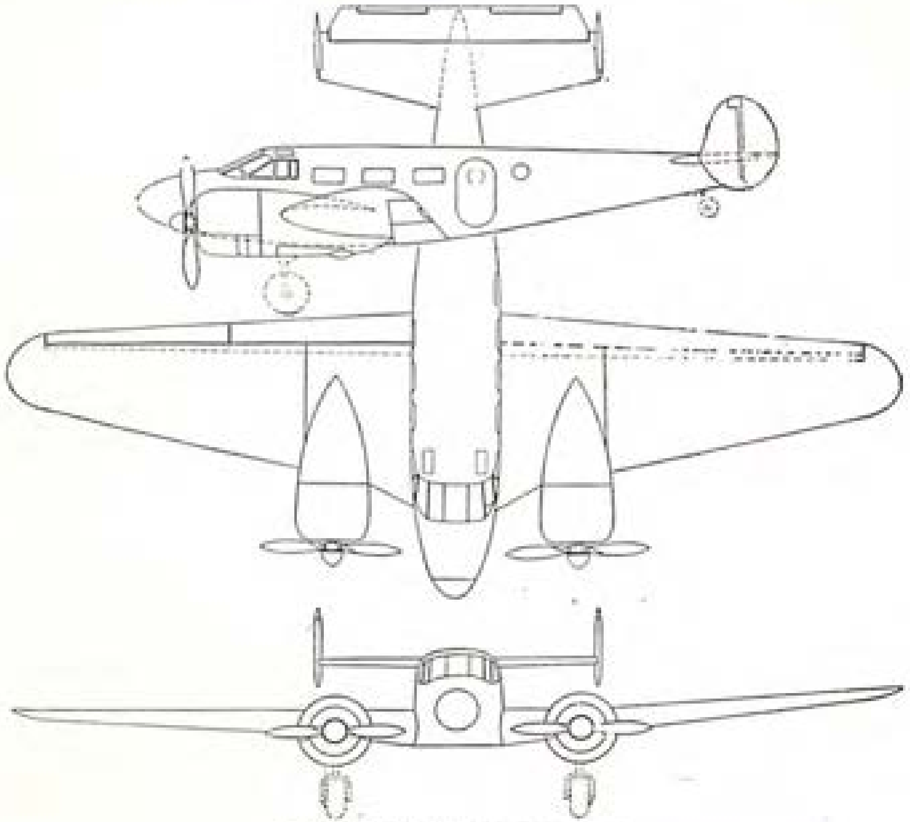
Beech Aircraft Corporation, Wichita, Kans., in 1945 maintained its scheduled deliveries to the armed services up to V-J Day, and then became one of the first major aircraft builders to resume commercial production in substantial volume. At the time of the Japanese surrender, Beech was still building quantities of its UC-45 personnel transport, one of the very few non-tactical aircraft in demand by the Army Air Forces after hostilities ended in Europe. The Beechcraft UC-45 won world-wide favor as a command transport for high-ranking officers because of its speed, comfort, and ability to utilize small, rough, unprepared landing areas safely. Beech also maintained a high scheduled rate of output of complete A-26 attack bomber wings and nacelles, which were complex assemblies making up more than 40 per cent of the complete A-26 airframe.

Beech also completed deliveries of prototypes of an entirely new type of Beech-designed combat plane, the XA-38 Beechcraft Grizzly attack bomber. Built around a rapid-firing automatic loading 75-mm. cannon mounted in the nose at the exact center of the thrust line, and carrying six .50-cal. machine guns covering a 360-degrees sphere of fire from nose mounts and remotely controlled upper and lower turrets, in addition to heavy bombs, smoke tanks, long-range fuel tanks, or full sized torpedoes, the Beechcraft Grizzly was described as a formidable weapon. Thick armor plate and bulletproof glass protected the crew of two, pilot and bombardier-gunner, from enemy fire. In its acceptance tests, the Grizzly handily kept pace with one of the fastest propeller-driven fighter planes. Its design gross weight was 29,900 lbs. and its alternate gross weight was 36,332 lbs. In outline the Grizzly bore a distinct family resemblance to the Model 18 Beechcraft, with its twin rudders and conventional type retractable landing gear and tail wheel. Like other Beechcrafts, the Grizzly's ratio of top speed to stalling speed was approximately four to one, and it could operate from fields closed to aircraft with higher take-off and landing speeds. Scarcity of suitable engines after the design was ready for production prevented its use in combat before the end of the war, but the Grizzly fully proved its abilities in rigorous tests under simulated tactical conditions.

Volume production was continued on Beechcraft continuously variable-pitch propellers for wartime use on Army liaison light planes, and afterward for commercial use in 65 to 250 h.p. power ranges. So useful were these propellers in boosting performance of military artillery spotting and utility planes that all units produced were shipped by air direct to the battlefronts for immediate installation.

As a result of their design and production achievements, the men and women of Beech Aircraft were awarded a fourth renewal star

BEECH POSTWAR AIRCRAFT ASSEMBLY
Showing D18S twin-engine executive transports nearing completion.



BEECHCRAFT MODEL D18S

for their Army-Navy E flag in 1945, making theirs one of the few organizations to qualify for this award five times in succession. During the war they had produced more than 400 million dollars worth of aircraft and components. They built 5,204 Model 18 twin-engine all-metal Beechcrafts, in five distinct versions of the basic commercial design, making this one of the most versatile aircraft used by the armed services. Those versions were the F-2 photographic plane; the JRB-1 aerial gunnery target control plane; the UC-45 (JRB-2) personnel transport; the AT-7 (SNB-2) navigation trainer; and the AT-11 (SNB-1) bombing trainer. More than 90 per cent of the Army's navigators and bombardiers were trained in AT-7 and AT-11 Beechcrafts; and probably 50 per cent or more of Army multi-engine pilots gained experience in the AT-10 Beechcraft. This was a plywood, twin-engine, two-place advanced trainer developed by Beech in 1941 at the AAF's request, using a minimum of then critically scarce materials in its construction. The record shows that the AT-10 Beechcraft was the only all plywood airplane used in large quantities by the armed services during the war. Beech delivered 1,771 of these AT-10 advanced trainers, and 600 additional AT-10s were built by another contractor using Beech drawings and engineering, production and tooling assistance.

Beech delivered to the armed services 425 single-engine biplane UC-43 and GB-2 five-place utility transports, almost identical with the commercial Model 17 Beechcraft biplane. As one of three Wichita aircraft manufacturers participating in an emergency glider production program for the Army Air Forces, Beech fulfilled on schedule its assigned duties in connection with a contract for 1,500 CG-4 troop-carrying gliders, the first gliders of this type built in quantity.

At one time five distinct types of Beechcrafts were simultaneously in volume production: AT-7, UC-45, and AT-11 all metal monoplanes; AT-10 plywood advanced trainers; and UC-43 composite wood and metal biplanes. In addition to the basic types, there were variants for specialized purposes, such as seaplane versions of the AT-7. This was the largest number of different types of airplanes constructed by one manufacturer in a single facility during the war.

At all times throughout the war production program, Beech kept to an absolute minimum the size and the cost of its manufacturing plant and the number of its personnel. Total Beech facilities built especially for war production did not exceed 700,000 square feet of space, with a total employment of approximately 14,110 persons at the peak. One of America's foremost production authorities bluntly stated that he thought it impossible for Beech to meet delivery schedules, at the outset of the expansion. On a later visit to the Beech factory, he revised his opinion, and complimented the Beechcrafters on their record.

Important to its production record was the Beech subcontracting program. Started experimentally in 1939, it grew in size until, at the end of the war, more than $133,000,000 in contracts had been placed for outside production with many hundreds of subcontractors, large and small, located throughout the Middle West from the Canadian border south to the Gulf of Mexico, and from the Rockies to the Mississippi River. At the program's peak, Beech subcontractors employed 9,725 persons on Beech work, utilizing 1,479,871 square feet of floor space. More than 85 per cent of the subcontractible parts of the AT-10 Beechcraft, including complete finished wing panels, and more than 40 per cent of subcontractible parts of other Beech models and of A-26 wings and nacelles, were built by subcontractors, using Beech-furnished tooling and operating under Beech inspectors. Subcontracts were placed chiefly in non-industrial areas, with shops and factories which otherwise might have had to suspend work for the duration of the war. Thus Beech kept fixed costs at a minimum and accomplished results attainable otherwise only by much larger expansion of its own facilities and personnel.

The willing spirit and constant cooperation of its employees were notable. With patriotic zeal, and spurred by the Beech efficiency incentive plan which rewarded their efforts financially in direct proportion to the magnitude of their production, Beechcrafters formed a labor-management team to which no tasks were impossible. With War Department approval, incentive payment plans patterned after that originated by Beech were adopted by other aircraft producers, with excellent results. Beech employees, who comprised about five per cent of Wichita's wartime population, bought more than 49 per cent of the "E" War Bonds sold in Wichita, their purchases as individuals totalling over $25,500,000 maturity value.

From December, 1943, Beech helped to ease shortages of critical materials and components, and aided many war contractors to dispose of surpluses and meet their emergency and normal needs for supplies, through its only corporate subsidiary, Material Distributors, Inc. An outgrowth of the highly active Beech conservation and salvage department, Material Distributors specialized in the redistribution of surplus inventories, bringing holders and buyers together. Materials valued at many millions of dollars were promptly channeled into use in that way. In at least one instance, a shutdown was prevented on a critical war production line. Long delays were averted many times.

After V-J Day, Beech accomplished its plant clearance and reconversion for commercial production quickly. Because of the urgency of the company's war production schedules, an absolute minimum of manpower and engineering talent was utilized in postwar planning prior to the Japanese surrender. Nevertheless, from almost a standing start, the first postwar commercial Model 18 Beechcraft, incorporating many basic improvements in payload, design features and aerodynamic qualities over the wartime types, went to flight test from manufacturing only 60 days after V-J Day. By December, 1945, production of the postwar Model 18 reached a rate of one airplane a day. Beech was the first aircraft manufacturer to qualify for an Approved Type Certificate on a postwar commercial design under Section 03 of the Revised Civil Air Regulations, receiving on December 5, 1945, temporary Type Certificate No. 756 on its D18S executive twin-engine transport. At the beginning of 1946, deliveries were completed or pending on more than $3,000,000 worth of finished D18S Beechcrafts. A 10-place air carrier version, the D18C, using two 525 h.p. Continental engines, was undergoing flight tests. Tooling was nearing completion for production of the G17S Beechcraft biplane, an improved version of Beech's widely known 5-place, single-engine, negative wing stagger, high-performance, deluxe cabin biplane, using a 450 h.p. Pratt & Whitney Wasp Junior engine.

An entirely new design, the Model 35 Beechcraft 4-place, low-wing, all-metal, retractable-gear cabin monoplane, passed its initial flight tests successfully in December, 1945. This airplane was designed to offer Beechcraft standards of performance and luxury to buyers in the medium price range. Another new design, a 20-passenger feeder airline unit with unique design and performance attributes, reached the mockup stage. The Beechcraft controllable pitch propeller was in production for commercial use on several types of popular planes in the 65 to 250 h.p. class, and engineering and testing were well advanced toward C.A.A. certification of additional models of this propeller.

Beech also continued cooperation with Dymaxion Dwelling Machines (later renamed Fuller Houses, Inc.) and produced a full-sized prototype of the Fuller house. A new and unique kind of housing unit constructed largely from aircraft materials, and using aircraft design and construction techniques and methods, the Fuller house was an extremely interesting development, both for its possibilities as a large-scale production item and a means of helping meet the critical world-wide postwar housing shortage.

Beech's subsidiary, Material Distributors, expanded its peacetime activities, serving manufacturers located all over the United States, not only in aircraft but in all lines of manufacture. Its materials-finding and surplus disposal services proved valuable in hundreds of instances to industries seeking scarce materials needed for feeding reconverted production lines. In addition to its operations as an intermediary between buyers and sellers, Material Distributors engaged in buying and warehousing substantial quantities of materials for resale to meet emergency and normal requirements of manufacturers.

Bell Aircraft Corporation, Wheatfield, N. Y., produced and delivered a grand total of 13,594 military airplanes as one of its many contributions to the war effort. They included 9,588 P-39 Airacobra fighters, 2,971 P-63 Kingcobra fighters and 663 B-29 Superfortresses, these last in the Marietta, Ga., bomber plant. Bell's Niagara frontier division produced 64,956,833 pounds of fighter airframes. The Georgia division turned out 36,799,051 pounds of bomber airframe, more than two-thirds of it in 1945. The Russian air forces received 7,229 Bell fighters, including 4,773 Airacobras and 2,456 Kingcobras. Of the total, 5,180 fighters were delivered all the way by air from Niagara Falls to Russia. The British RAF also received more than a thousand Airacobras to augment its own fighter strength. After the war, Bell Aircraft expanded its helicopter program and the development of advanced airplanes.

Contract terminations after V-J Day concluded the production of P-63 Kingcobras in the Bell facilities in Buffalo and Wheatfield, near Niagara Falls, but did not affect materially other Bell contracts which included manufacture of RP-63s, the armored fighter plane; the processing of Bell's second jet propelled plane, the XP-83; and the development of full-scaled aircraft remotely controlled by radio, as well as several secret military projects.

In Marietta, Ga., B-29 Superfortresses had been produced at the rate of 60 a month when the Japs surrendered. In Burlington, Vt., the Bell Ordnance Division changed from specialized gun installation equipment, when requirements were filled, to the production of parts for the B-29 and special types of equipment and shells for the Chemical Warfare Service. Within a week after V-J Day, Bell commenced tooling for production of a number of helicopters suitable for military, commercial and industrial uses and the helicopter experimental plant was transferred from Gardenville, N. Y., to the plant adjoining the Niagara Falls airport at Wheatfield.

The end of the war brought a cessation of activities in the Bell bomber plant in Georgia. Bell had produced 663 B-29 Superfortresses, an average of over one a day from the time production began in December, 1943. On V-J Day, Bell's heavy bomber production was running 50 per cent greater than the 40 Superforts a month originally contemplated for the Georgia facility. This plant had a remarkable safety record. All 663 Superforts from the Marietta plant were flight tested by Bell crews, flight tested by Army crews and delivered by ferry pilots to their destinations without a single accident. The fact that improvements to the B-29 were being made constantly required a substantial amount of modification work. Bell was the first of the three prime contractors to institute a program under which all its Superfortresses were fully modified and made ready for combat when delivered from the Marietta plant to the Army Air Forces.

In Bell's Western New York plants, in addition to the mass production of fighter planes, the company also carried on modification work on many aircraft, some of its own design and some designed by other manufacturers. The total cost of this work amounted to almost five million dollars, and included modification of transports, single- and twin-engine fighters, flying boats and bombers.

The Bell Kingcobra, which supplanted the P-39 Airacobra, was produced in quantity in 1945, and like the P-39, many of them were delivered to Russia. The Kingcobra also was selected by the Army Air Forces Training Command for adaptation as the RP-63, the armored fighter plane which was used on "frangible bullet" air-to-air firing missions in AAF flexible gunnery schools.

The RP-63 was covered by more than a ton of specially treated armor plate, and this provided a special engineering match between the armor and the frangible bullet which caused the bullet to disintegrate on contact with the armor at high velocities. In the original contract, which employed RP-63A-11s, RP-63A-12s and RP-63C-2s, the armored skin ranged from one-eighth to one-quarter inch in thickness; whereas later models, RP-63Gs, had dural of one-quarter to five-sixteenths inches in thickness. Gunners were restricted to shooting at the original models from within a 30-degree angle each side of head-on, but the RP-63G could be fired at from any angle. The earlier armored planes also had one spotlight in the nose (where the

37-mm. cannon normally fitted in the Kingcobra) connected with an electrically operated hit mechanism which transmitted the impact of the frangible bullets to an amplifying device which caused the light to flash and at the same time recorded the hits on a counting device in the cockpit.

Despite the extra ton added to the normal weight of the P-63, the armored plane retained the high performance characteristics of the Kingcobra. Complete protection for the pilot was assured by 1.5-inch laminated bullet-resisting glass in the windshield and one inch glass on the side shields, cabin top and cabin doors. In addition, a coating of plexiglas lined the inside surface of the glass in case the armor glass shattered. AAF officers reported that the target plane-frangible bullet combination had numerous advantages for training bombardment gunners under conditions closely approximating combat aerial warfare. The bullets, which could pierce the thickness of 12 inches of pine were harmless against the skin of the RP-63. Delicate radiosonic instruments under the plane's armor picked up the bullet's contact and registered hits on the cockpit meter.

A long-range jet-propelled plane, the XP-83, also was developed by Bell. Like the Bell P-59, the nation's first jet-propelled plane, the XP-83 also was a twin-engine fighter and early demonstrated a high speed well in excess of 500 miles an hour. One of the larger planes of the day, the XP-83 was a medium wing monoplane of semi-monocoque construction with a wing span of 53 ft. The fuselage was 44 ft. 10 in. long and of all metal construction. The tail, upswept to clear the powerful jet blasts of its General Electric I-40 engines, was approximately 15 ft. 3 in. at the top of the fin. It had a tricycle landing gear, and weighed 15,500 lbs. empty and nearly 14 tons with full fuel load. The cockpit was unusually large for a fighter, and was equipped with a bubble canopy and a minimum of controls, compared with a conventional plane. According to the Air Technical Service Command, the XP-83 was one of the longest range fighters in the world.

While Bell was developing that new jet fighter, its original propellerless model, the Airacomet, was used in a project which produced radio remotely controlled operational-sized test aircraft and permitted the simultaneous transmission of flight data from the robot test plane to automatic recording instruments. The new method of transmitting flight data, both by television and telemetering, was of special significance in the continuous quest for aircraft operating in the sonic range where hazards to aircraft and pilots are greatly increased. Transmission of flight data was considered a major contribution to flight research because it insured collection of important data even in the event of an accident. If an experimental plane crashed, for example, the new equipment developed by engineers of Bell and the ATSC still would make it possible to possess a record of all flight data including stresses and strains which might have influenced the destruction of the plane. In the past, loss of an experimental plane invariably destroyed the flight data and retarded progress of important aeronautical programs. Development of the radio remotely controlled Airacomet also eliminated many of the risks to pilots conducting hazardous tests on experimental aircraft, and it permitted research into phases of flight testing previously considered too dangerous for pilots to attempt; for example, high speed dive tests in which aircraft would approach or surpass the speed of sound.

From the theories and ideas of Robert M. Stanley, chief engineer of Bell Aircraft, was developed a new type of autopilot, called a "rate" pilot, which permitted effective control of the robot airplane at diving attitudes or in sharp maneuvers. This "rate" pilot was the most widely influential single factor in the success of the Bell robot plane. Three physical components were used in the project—two P-59s and a truck or ground station. One of the P-59s was the controlled or robot plane while the other was the controlling or flight station and was referred to as the "mother" plane. The truck also could serve as a control or ground station for the robot. Unlike the flight station, however, the truck was equipped with telemetering and television instrumentation, and at all times could determine what the robot was doing and its position. The flight station depended on the pilot's visual contact for the location of the robot. Turbo jet powered planes were selected for the initial development for several practical reasons—their characteristic lack of torque and vibration; their speed, stability, high altitude efficiency and the ground stability afforded by the tricycle landing gear. The project employed both the "rate" pilot and the "displacement" pilot which were coupled together in an electrical bridge so that their functions were interchangeable. The "displacement" pilot was used for maneuvers involving less than plus-or-minus 30-degrees change in pitch or plus-or-minus 45-degrees change in roll while the "rate" pilot, with its tumbling-proof gyroscopes, was employed for all other maneuvers. Both the flight and ground stations had a switch which permitted selectivity of the autopilots. At the same time, either or both autopilots could be controlled from both stations. A miniature stick, very similar in operation to the stick in a normal plane, was mounted on the regular stick in the mother ship, and another miniature stick on the ground operator's chair was secured to a platform built on top of the truck.

As further insurance of the successful operation of the robot, the ground operator's controls were duplicated in the interior of the truck, so that the robot could be controlled by observation of its televised flight instruments when out of sight of either the flight station operator or the ground operator. The motions of the miniature stick closely paralleled those of a normal stick. Moved forward, the miniature stick initiated the impulse that lowered the elevators, causing the robot to dive; moved backward, the miniature stick produced a climb, and to the right or left, a turn in either direction. Such parts of the robot as throttle, flaps, landing gear and brakes were actuated by servo motors which derived electrical power from circuits controlled by the radio receiver. Thus, by proper coordination of these controls, ground or flight station operators could direct the robot through warm-up, taxiing, take-off, climb, level flight, banks or turns, dives, loops, and all the other maneuvers involved in flight testing of aircraft.

Credited to the Bell Airacomet was a new unofficial American altitude record, set a year previously, but not announced until 1945. The No. 1 YP-59, first production model of the Airacomet series, performed the feat, and as a matter of fact, accounted for new record heights twice within four months. Jack Woolams, chief test pilot for Bell Aircraft, took the jet plane up to 47,600 feet in a flight from Muroc, December 15, 1943, and four months later, the late Major E. W. Leach, test pilot for the ATSC, reached 47,700 feet in the same plane, 100 feet beyond the altitude attained by Woolams. The official U. S. altitude record for heavier-than-air aircraft was 43,166 feet, set in June, 1930, by Lt. Apollo Soucek, in a Wright Apache.

The Bell helicopter program, begun modestly in 1941, continued along experimental lines and received new impetus after V-J Day which directed the course of the rotary aircraft into commercial peacetime production. Bell Aircraft carried on the program entirely with its own funds and had expended approximately $1,500,000 on helicopter work. On January 5, 1945, Chief Helicopter Test Pilot Floyd W. Carlson, picked up a physician, blocked by snow-clogged roads, and flew him over snow-drifted fields to an isolated farmhouse where an injured man was stranded, suffering with frozen feet. The helicopter-borne doctor, deposited in the yard of the farm, was able to bring medical aid to the injured man at least three hours before snow plows could clear a passage-way to the farmhouse. In the twilight hours of March 14, Carlson, operating the same helicopter, rescued two fishermen from the thawing ice of Lake Erie, near Buffalo. Carlson hovered his craft, its wheels just inches above the slush ice of the lake, while first one and then the other men climbed aboard. All previous rescue attempts, including those by the Coast Guard, had failed to reach the men and the Bell helicopter was summoned by the Coast Guard. The helicopter was unable to land on the honey-combed ice, but Carlson had no difficulty keeping the aircraft motionless in the air as each fisherman escaped a situation which threatened his life. Bell's plans in commercial aviation revolved largely around production of the helicopter in its Wheatfield facilities. Production of the Bell helicopter at first was to be limited to a two-place model with a 160 h.p. Franklin aircooled engine, capable of carrying two 200-lb. persons and 60 lbs. of baggage while operating at a 90-mile cruising speed in a range of from 275 to 300 miles. Top speed was 120 m.p.h.

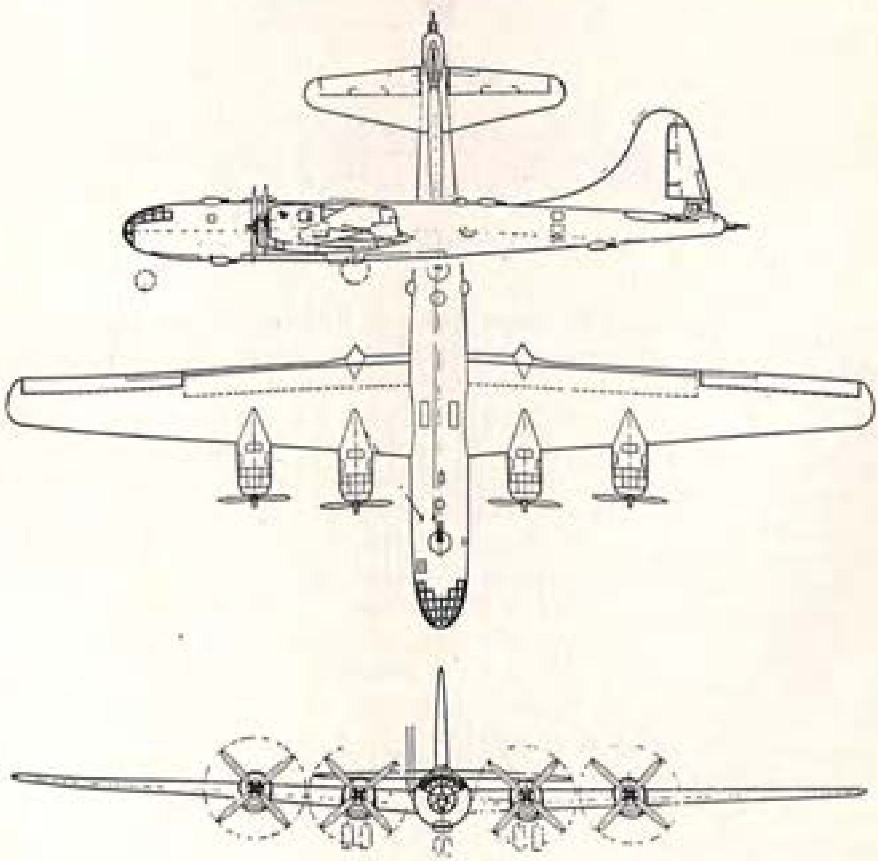
In addition, Bell also had a larger model, capable of carrying five persons or equivalent weight in payload or cargo. Unique with all the Bell helicopters was a stabilizing system for greater degree of stability and generally improved pilot's handling and precision control of the ship. Basis for the system was a stabilizing bar placed at right angles to the rotor blades and fastened to the mast, so that it was free to pivot vertically. This bar acted much like a gyroscope in that it governed the plane of the rotor in space and tended to maintain it horizontally despite the deviation of the mast from the perpendicular.

Bellanca Aircraft Corporation, New Castle, Del., until the end of the war did subcontract work for prime contractors, chiefly Curtiss-Wright Corp., Glenn L. Martin Co., and the Bechtol-McCone Corp. Included among the subcontract items produced up to V-J Day were cowling for the C-46 Curtiss Commando, flaps and ailerons for the C-46, landing gear fairings for the Curtiss Helldiver, floats for the Martin Mariner PBM-5 and floats for the Martin Mars Flying Boat, Model JRM-1. Production of .50-cal. gun turrets continued until V-J Day, and fuel tanks for the Consolidated Liberator Cargo C-109 were produced for Bechtol-McCone Corp. Early in 1945 a special department had been set up to construct the Company's first postwar airplane, the 1946 Bellanca Cruisair Senior. It completed its flight tests early in 1946. The Cruisair Senior, equipped with the 150 h.p. Franklin six-cyl. engine, on flight tests conducted January 11, 1946, over a measured course of 3.738 statute miles at New Castle at sea level had a top speed at 2,700 r.p.m. of 169.2 m.p.h., cruising speed at 2,435 r.p.m. of 153.6 m.p.h., rate of climb 1,130 ft. a minute, take-off run, no wind, 485 ft.; and stalling speed with flaps of 45 m.p.h. On those tests the Cruisair Senior was equipped with an Aeromatic propeller and loaded to full gross weight of 2,100 lbs.

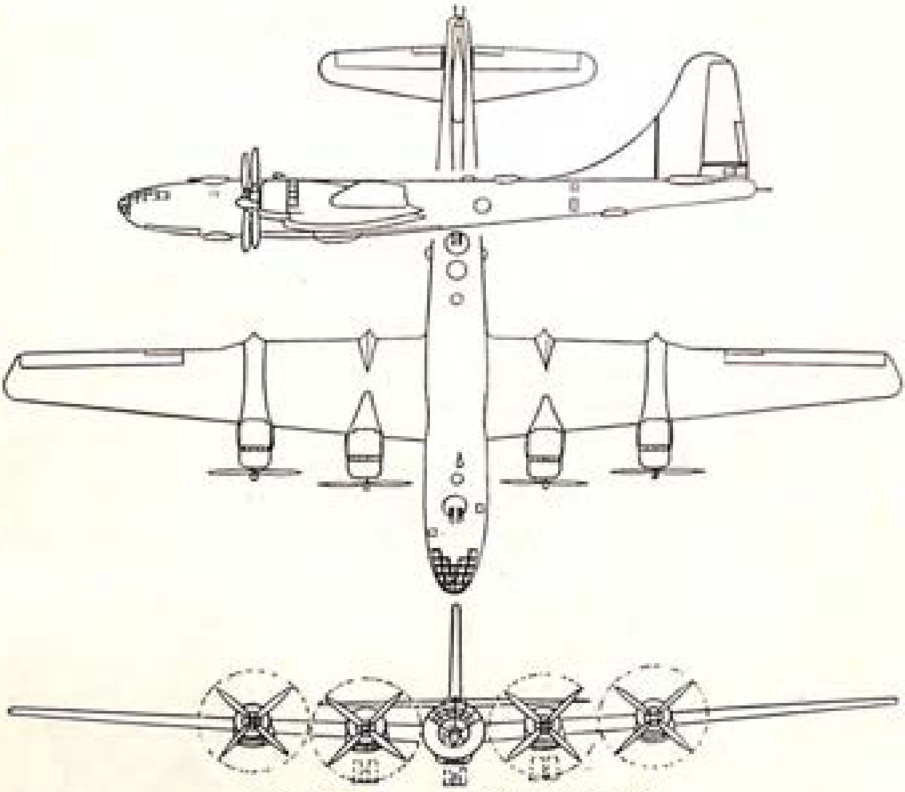
A nationwide system of distributors and dealers had been established, and 50 organizations were promoting sales of the Bellanca Cruisair throughout the United States. During the latter part of 1945 after V-J Day, the interior of the Bellanca plant was rearranged for production of the Bellanca Cruisair on a true production line basis. The airplanes rolled through the plant on tracks from the beginning stage to the point of final assembly operations.

Boeing Aircraft Company, Seattle, Wash., pioneers in the design and manufacture of long-range heavy bombers as represented by its B-17 Flying Fortress and B-29 Superfortress, had the extreme satisfaction of seeing them play decisive roles in the tragic drama of strategic bombing that knocked both Germany and Japan out of the war. The Army Air Forces used them on all major missions that hurled one holocaust after another into the homelands of our enemies. On March 9, 1945, 279 Boeing B-29s hit Tokyo with thousands of pounds of incendiary bombs and destroyed the capital's multitude of home work factories. During April, armadas of B-17s, continuing their hammering of vital transportation and communication facilities, destroyed remaining German industry in a final all-out bombing of Nazi-held territory. August 2 saw a new high total of 810 Superforts attack Japan in a single night's operation. Four days later a B-29, dropping a single bomb on Hiroshima, made history by catapulting the world into the atomic age. With the final surrender of Germany and Japan came admissions by Axis leaders that Allied air power, spearheaded by B-17 Flying Fortresses and B-29 Superfortresses, was the greatest single factor in the collapse of their war machines.

Not in combat alone, however, did Boeing planes make history. On November 20, three months after V-J Day, Col. Clarence Irvine of the 20th Air Force dramatically indicated to the American people the necessity of maintaining a hard-hitting air force to serve as the first line of defense in keeping the peace. Piloting his famous B-29 Superfortress Dreamboat, Col. Irvine established a new world's non-stop record, flying from Guam to Washington, D. C., a distance of 8,198 miles. Upon arrival at the nation's capital, Col. Irvine announced



BOEING ARMY B-29 SUPERFORTRESS



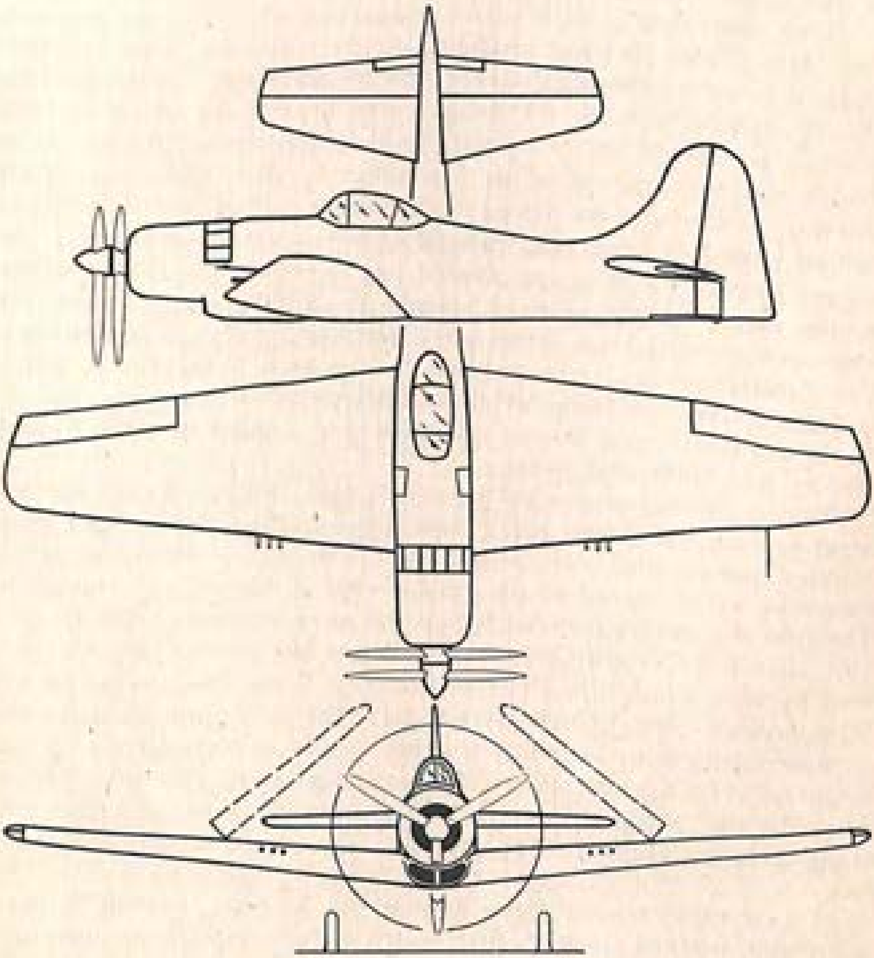
BOEING B-50 SUPERFORTRESS

that if the big bomber had been on a war mission, it would have been able to hit Seattle with 20,000 pounds of bombs. He added that despite his distance flight and the outstanding performance of the B-29s in the war against Japan, the Air Forces were only beginning to develop the full possibilities of the Superfortress at the time of the Japanese surrender. Irvine also pointed out that development of the B-29 had been progressing continuously as indicated by the record flight and that still higher B-29 performance could be expected in the future. A few weeks later he averaged 451 miles an hour in his Superfortress as he raced from Burbank, Calif., to Floyd Bennett Field, N. Y., in 5 hrs. 27 min., to set a new official all-type cross country speed record. The former record had been held by a P-51 Mustang fighter which averaged 376 miles an hour in a 6 hrs. 31 min. flight over the 2,464-mile course.

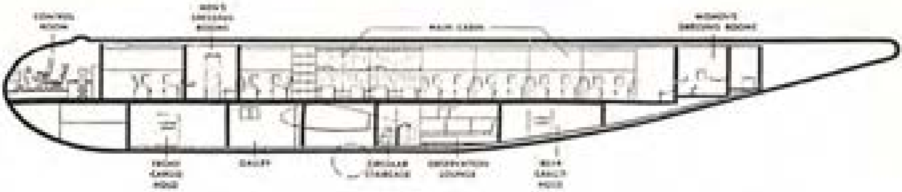
During the war period from December 7, 1941, to August 14, 1945, Boeing had produced a grand total of 16,149 aircraft. From its Seattle-Renton plants had come 932 Superfortresses, 6,835 Flying Fortresses, 226 DB-7B, 140 A-20C, three XC-97, one XPBB-1 and three XF8B-1 aircraft. From the Wichita division had come 1,508

Superfortresses, 5,682 PT-17 Kaydet primary trainers and 512 CG-4A gliders, while from Boeing's Canadian plant 275 PB2B-1 and 32 PB2B-2 planes had been produced—all the above during the actual war period. As a matter of record, however, Boeing before the end of 1945 had delivered 2,694 Superfortresses, 1,644 from Wichita and 1,050 from Seattle and branch plants operations. The standard PT-17 Kaydet had an amazing record before our entry into the war, and all told 10,346 of these primary trainers had been manufactured by the Wichita division up to the end of 1945.

Like all other companies in the aircraft industry, the end of the year found Boeing in the midst of conversion from expanded war production to a peacetime operating basis. With Boeing, however, this change-over was to be more severe than in many other companies because of the company's continued responsibility for the design and



BOEING XF8B-1 NAVY FIGHTER



INTERIOR OF THE BOEING 377 STRATOCRUISER

production of the B-29. It had been necessary for Boeing to produce at high capacity up to the very end of the war, not only on its own huge B-29 output, but also as the fountainhead for the nationwide cooperative B-29 manufacturing program. Obviously this left little time for postwar commercial design; and when the Superfortress program was substantially terminated, Boeing had no commercial product available for immediate delivery.

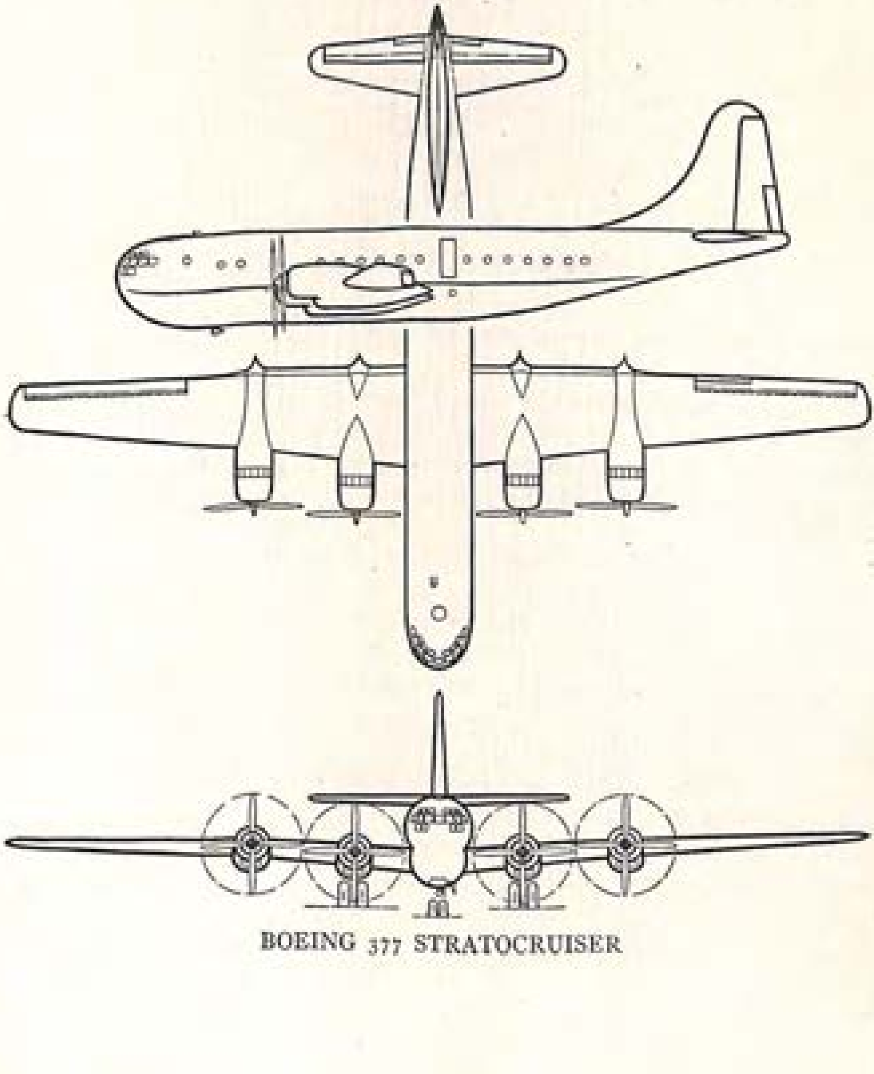
One immediate asset, however, was apparent. The same engineering "know how" that had produced the B-17 and the B-29, had been applied to an experimental Army military transport. Designated the XC-97, it proved to be the design forerunner of an advanced commercial transport, the two-deck, 81-passenger Stratocruiser, 20 of which had been purchased in November by Pan American World Airways. Scheduled for delivery in the latter part of 1946, the Stratocruiser embodied important wartime aerodynamic advancements. Designed to perform at unprecedented low operating costs, the Stratocruiser cruised at 340 miles an hour at an altitude of 25,000 feet. An improved pressurization system, first developed by Boeing for the prewar Stratoliners and later utilized by the high flying B-29s, maintained sea level conditions at all altitudes up to 15,000 feet.

In addition, a new Boeing transport type, smaller than the Stratocruiser, was in the design stage.

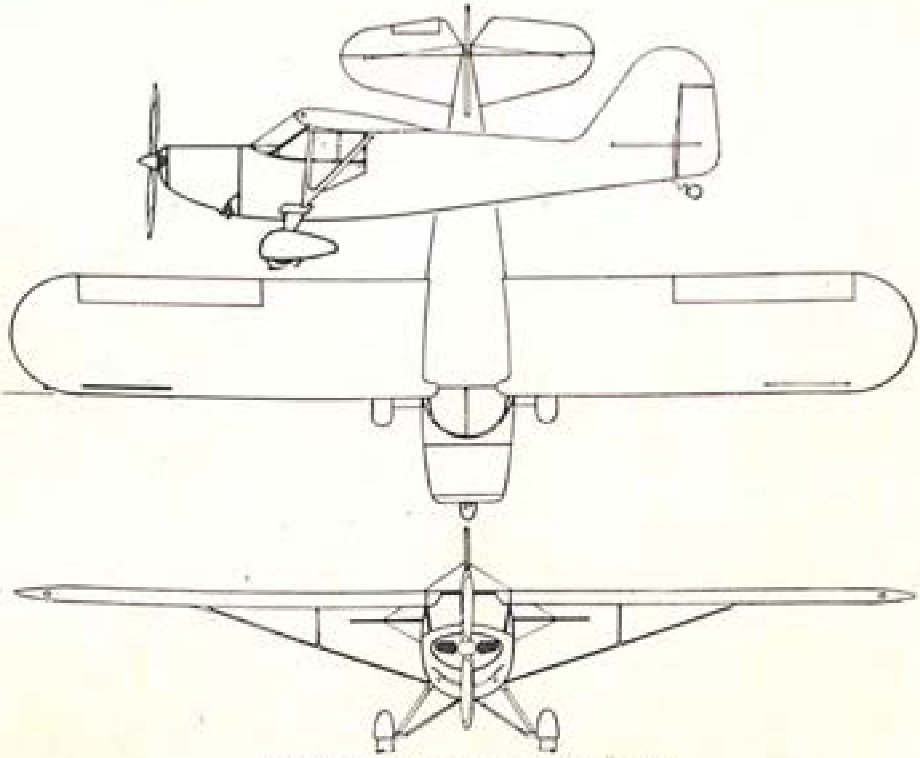
While Boeing engineers hastened final design details on the Stratocruiser, the Army Air Forces, impressed by the XC-97s cross country speed record and its all around performance during a year of extensive tests, ordered 10 advanced models of this military transport. The first six were scheduled to use the same engines as the B-29—four 2,200 h.p. Wright Cyclones—while the last four were to be powered by four 3,600 h.p. Pratt & Whitney Wasp Majors, as in the Stratocruiser. The YC-97s were to have the same dimensions as the commercial version, including a gross weight of 135,000 lbs., a tail height of 38 ft., a length of 110 ft. 4 in. and a 141 ft. 3 in. wingspread. Also like the Stratocruiser, the YC-97s would cruise at 340 m.p.h. at an operating altitude of 25,000 feet and a service ceiling of 30,000 feet.

A new experimental Navy fighter, the XF8B-1, of which three were built, marked Boeing's first return to fighter plane manufacturing since 1935, at which time the majority of shipboard Navy fighters were of the Boeing designed F4B series. The XF8B-1, one of the most versatile planes in the air, could be used as a torpedo plane, dive-bomber, fighter bomber or interceptor in addition to its regular fighter duties. Capable of speeds in excess of 450 miles an hour, it was powered by a single 3,600 h.p. Pratt and Whitney Wasp Major engine, and equipped with a pair of three-blade contra-rotating propellers. Armament included six 20-mm. cannons mounted in the wing and sighted by remote control. As a dive-bomber, the XF8B-1 could carry a 6,400 lb. bomb load. If used as a torpedo plane, it could carry two 2,000 lb. torpedoes.

Another Boeing military contract was for 60 of the Army Air Force's new bomber, the B-50. An improved version of the B-29, the B-50 retained the popular name Superfortress, and was powered by four 3,600 h.p. Pratt & Whitney Wasp Major engines, with newly developed reverse thrust propellers. It had a lighter, but stronger



BOEING 377 STRATOCRUISER



COMMONWEALTH SKYRANGER

wing. Newly designed nacelles simplified engine change and maintenance work.

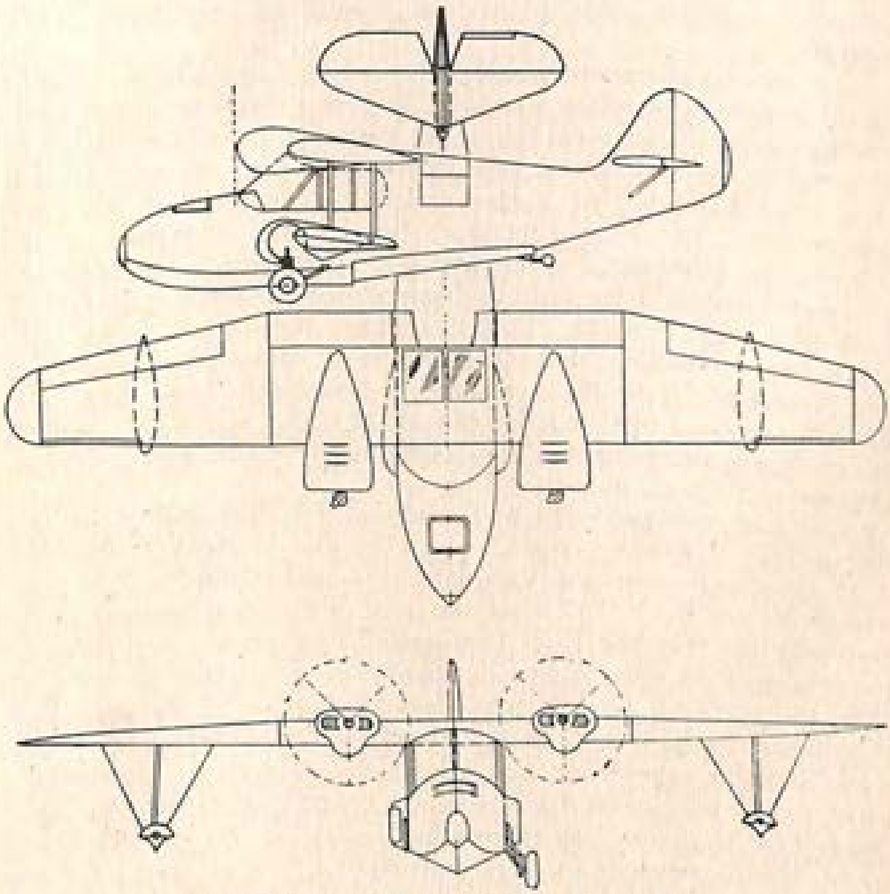
The Boeing-Wichita Division at Wichita, Kans., was retooling and expanding Plant I for production of parts for the B-50 and Stratocruiser and some experimental work. The large Government-owned Boeing-operated plant at Wichita was being held in a standby status by the RFC.

Cessna Aircraft Company, Wichita, Kans., early in the war produced AT-17 and T-50 trainers, and the UC-78, a personnel transport plane developed from the T-50, and later built component parts for B-29s and Invaders. After V-J Day, Cessna reconverted to a personal plane program, with two models, 120 and 140, two-place, high-wing metal planes, powered by 85 h.p. Continental engines. Two other models, 170 and 190, were being developed.

Commonwealth Aircraft, Inc., Kansas City, Kans., offered two different models for personal aircraft owners. One was the Commonwealth Skyranger, and the other was the Commonwealth Trimmer amphibian. Commonwealth had produced nearly 41 million dollars worth of Army CG-3A and CG-4A gliders and aircraft parts up to the cancellation of war orders after V-J Day. The company purchased the Columbia Aircraft Corporation at Valley Stream, Long Island, N. Y., and there tooled up for production of the Skyranger, at the same time continuing production on a new version of the Navy Duck, the XJL. Early in 1946, production was well under way on the Trimmer amphibian.

The Commonwealth Skyranger was a two-place land plane powered by a Continental 85 h.p. engine. Its wing span was 34 ft., length 21 ft. 9 in., height 6 ft. 7 in., wing area 164.6 sq. ft., wing loading 8.81 lbs./sq. ft., gross weight 1,450 lbs., baggage and extra equipment 55 lbs., 24 gal. fuel capacity, stated high speed 114 m.p.h., cruising at 103 m.p.h., landing speed 38 m.p.h., normal range 500 miles. The Skyranger had a custom-built interior and nearly five cu. ft. of baggage space.

The Commonwealth Trimmer amphibian was a twin-engine personal plane of molded plywood construction. It was powered by two Continental 85 h.p. engines. Its wing span was 35 ft. 6 in., wing area



COMMONWEALTH TRIMMER AMPHIBIAN

162.5 sq. ft., gross weight 2,200 lbs., weight empty 1,470 lbs., maximum fuel capacity 40 gal. With a gross load, the Trimmer's cruising speed of about 115 m.p.h. permitted a range of about 450 miles, while top speed with fixed pitch propellers was 135 m.p.h., landing speed with flaps 48 m.p.h. It had a stated take-off run of 637 ft. on water, with 10-degree flaps; land run of 532 ft. with 10-degree flaps and six m.p.h. wind; and a rate of climb of 870 ft. the first minute after take-off.

Consolidated Vultee Corporation, San Diego, Calif., was in full swing on its postwar program which included design and production of several types of military, commercial transport and personal aircraft. Even as the company's drafting tables revealed striking designs for the planes of tomorrow, the company reviewed a great wartime combat aircraft production record. Between Pearl Harbor and V-J Day in August, 1945, Consolidated Vultee had delivered more than 350,000,000 pounds of airframe, or nearly 13 per cent of the total output of the nation's aircraft industry. This poundage comprised 28,004 complete airplanes and approximately 5,000 equivalent planes delivered as spare parts, a production equal to more than 33,000 aircraft.

The 28,004 completed planes delivered by Consolidated Vultee's 13 divisions—11 of which were manufacturing plants or modification centers—represented, according to company reports, 30 per cent of all four-engine heavy bombers, with 57 per cent of all deliveries of that type being Consolidated Vultee designs. They included the B-32 superbomber, the B-24 Liberator, the PB4Y-2 Privateer search bomber, the Liberator Express and RY-3 transports. The company also stated that its flying boats and amphibians—the twin-engine PBY Catalina and four-engine PB2Y Coronado—represented 43 per cent of the total production; that 29 per cent of all liaison plane production was accounted for by the company's L-5 Sentinel "flying jeep" and the Voyager; and further its production of BT-13 and BT-15 Valiant basic trainers and Reliant AT-19 navigational trainers represented 22 per cent of the total output of those types.

Other aircraft produced by Consolidated Vultee during the war included the Vengeance A-31, A-35 and 72 dive-bombers, the Seawolf TBY torpedo bomber, the Vanguard P-66 and Lightning P-38 pursuit planes and the XP-54, a fighter. One of the latest bombers in the war program was the B-32 Dominator superbomber, a high-wing, long-range, high-speed heavy bombardment monoplane powered by four 18-cyl. 2,200 h.p. Wright Cyclone engines of the aircooled, double-row, radial type. The plane was designed to carry larger bomb loads at higher speeds on longer missions. The B-32 Dominator's gross weight of 100,000 lbs. was nearly double that of the Liberator. Span of the B-32 low-drag Davis wing was 135 ft. Its cylindrical, all-metal, semi-monocoque fuselage extended 83 ft. 1 in., and its single tail surface rose 32 ft. 2 in. in a taxi position. Five gun turrets provided effective protection. The extremely high tail gave the plane added maneuverability and ease of handling. The B-32 was equipped with one of the largest diameter propellers installed on any production airplane. These were the 16 ft. 8 in. Curtiss electric reversible pitch props which could be reversed to reduce landing run and increase the plane's maneuverability during ground operations. The plane was equipped with dual-wheel tricycle landing gear. Heat exchangers provided cabin warmth and internally heated the leading edge of the wing and tail to prevent forming and accumulation of ice.

During the peak production year 1944, Consolidated Vultee deliveries totaled more than 131,000,000 pounds of aircraft, a figure exceeding all previous production records. Convair-designed planes, including those produced by other companies, accounted in 1944 for more than 60 per cent of the nation's total heavy bomber production. In December, 1943, Convair reached its employment peak, with 101,624 men and women working in the company's 13 divisions. According to War Production Board figures, Consolidated Vultee in 1943 was the world's largest producer of airplanes by airframe weight, with a total airframe output of 126,000,000 pounds. The company that year turned out more than 12 per cent by number and 16 per cent by weight of total U. S. plane production.

This tremendous wartime production was attributed partly to the adoption of 20,086 time-and-money-saving ideas from a total of 71,968 suggestions submitted to the company by employees between May, 1942, and September, 1945. The suggestions which were placed in operation saved 39,108,072 manhours of labor at a cost-savings of $48,120,218. All the ideas originated with company employees. They bought $81,077,000 worth of war bonds between mid-1942 and August 31, 1945, through purchases made by payroll deductions and cash sales.

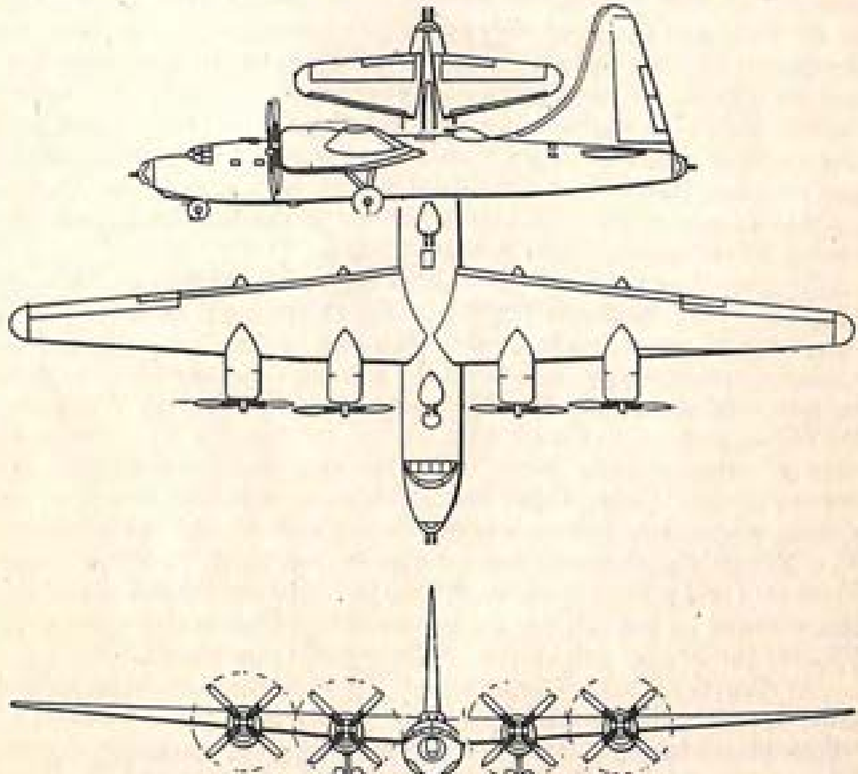
Dedicated and placed in operation at San Diego during 1945 was the 8,500 ft. concrete runway on Lindbergh Field, almost at the front door of the San Diego plant. Financed jointly by the company and the Navy Bureau of Aeronautics, the $4,000,000 runway was designed to handle the largest planes either under construction or contemplated. A company-built $524,000 aeronautical laboratory and wind tunnel, designed to test 10 ft. models at exceedingly high speeds, was expected to be in operation in 1946.

During 1945, cutbacks and cancellations in plane contracts were followed by a decrease in personnel of some divisions and outright closing of other divisions. In May, the B-32 superbomber contract with the Army Air Forces was cut back at Fort Worth and cancelled at San Diego, where other activity continued. Lockheed P-38 parts production was halted at Miami, Fla., in May, and a contract for component parts for the Seawolf TBY torpedo bomber—then under construction at the company's Allentown, Pa., division—was transferred from Miami to the Nashville division. Work on parts for Corsairs and Catalina PBYs also was completed at Miami and on May 31, 1945, the plant was formally closed. In July, the Navy contract for the TBY was reduced at Allentown. August brought contract terminations or adjustments to remaining divisions. The B-32 contract was cancelled at Fort Worth, where work was speeded on construction of the XB-36, one of the world's largest postwar bombers, and other experimental projects. The Privateer PB4Y-2 contract at San Diego was adjusted downward and later cancelled. Work stopped at San Diego on RY-3 transport production, but continued on construction of the XC-99, a huge troop carrier land-based plane, and other experimental projects. The Allentown division closed late in the year. Modification of B-29 Superfortresses stopped at the Tucson, Ariz., division and the plant was closed. Liberator B-24 modification halted at the Louisville division and the plant closed in September. The New Orleans division closed with cancellation of the PBY contract. Output of Sentinel L-5 flying jeeps at the Stinson division at Wayne, Mich., stopped in November, and the facilities at once were converted to production of the postwar Stinson Voyager 150 four-place personal airplane. The Elizabeth City, N. C., division closed as a result of modification contract cancellations. At Downey, Calif., Vultee Field work on PB4Y-2 parts stopped and the division continued its experimental plane projects. Nashville's production of P-38s halted and the plant was being geared early in 1946 for the manufacture of gas and electric kitchen ranges for The Aviation Corporation, the parent company. Stout Research division—moved from Dearborn, Mich., to Nashville—later was transferred to San Diego. On January 1, 1946, Consairway ceased operations. This was an air transport service airline under contract to the Air Transport Command, operated during the war between Fairfield, Calif., and various South Pacific points.

Early in 1946, Consolidated Vultee's wartime nationwide empire had been reduced to active operations in San Diego, Vultee Field, Fort Worth, Nashville and Wayne. At San Diego the new year was marked by increased tempo on engineering drawing boards resulting from the purchase by American Airlines of 100 Convair-240 twin-engine transports. This 40-passenger low-wing monoplane had a cruising speed of approximately 300 m.p.h., and high speed augmented by exhaust jet propulsion. Developed by Convair for military planes, this jet thrust increased the plane's speed by 20 m.p.h. Powered by two Pratt & Whitney 2,100 h.p. engines, it had a maximum speed of approximately 350 m.p.h. Gross weight of the Convair-240 was approximately 34,000 lbs. Its length was 70 ft., wing span 88 ft. With 40 passengers and baggage, it had a cruising range of more than 500 miles. Service ceiling was approximately 29,000 feet.

A revolutionary feature of the Convair-240 was the main loading door in the front rather than at the conventional rear location. The door, hinged at the bottom, opened outward and contained built-in steps which obviated the need of airport ramps. Three-blade, full-feathering, reversible pitch type propellers were to be installed on each engine. The propellers could be reversed upon landing to act as an auxiliary braking force. The pilot also could maneuver the airliner under an airport canopy in inclement weather, then back the plane away to operating position without ground crews or mobile equipment.

The Consolidated Vultee XC-99, one of the world's largest troop carrier land-based airplanes, was under construction at San Diego. The tail and wing sections were being built at Fort Worth and other parts at Vultee Field. This long-range, high-speed transport was the military counterpart of the Convair-37, projected 204-passenger luxury airliner ordered by Pan American World Airways. Powered by six pusher-type engines mounted on the wing's trailing edge, the XC-99 was 183 ft. long and had a wing span of 230 ft. Equipped with a tricycle landing gear, the mid-wing XC-99 could be used as a heavy cargo or hospital plane, as well as a carrier for more than 200 troops.



CONSOLIDATED VULTEE B-32 SUPERBOMBER

The XC-99 cargo version would carry a payload of 100,000 lbs. 1,500 miles. Loaded with 19,000 gal. of fuel, it had a range with a reduced payload of approximately 8,000 miles. The huge aluminum-alloy double-decked fuselage was made in two sections. Two large ramps were used in the bottom of the lower section for loading. Equipment included monorails and electrically operated hoists to facilitate loading in the upper and lower decks.

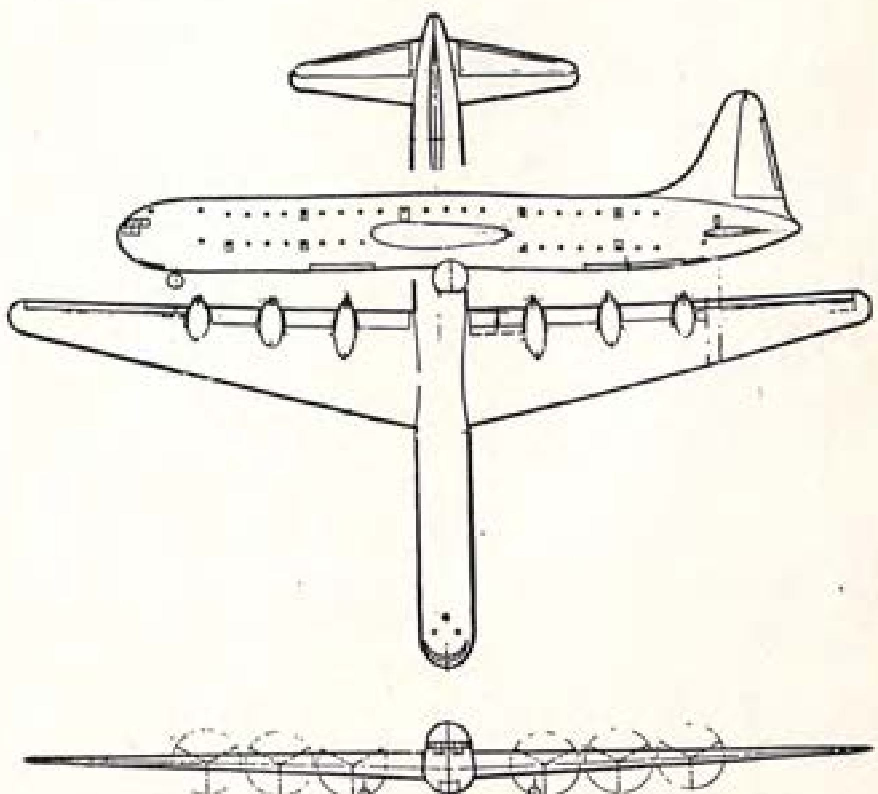
Engineering was virtually completed on the Convair-37. Consolidated Vultee had a contract to construct up to 15 of the giant transoceanic airliners for Pan American World Airways. With a weight of 320,000 lbs., the airplane was to be 12 times the size of present standard twin-engine commercial aircraft. It was designed to fly from New York to London in less than 10 hours. Its range was to be 4,200 miles. Cruising speeds were to vary between 310 and 342 m.p.h., according to altitude and power output. It was to be 182 ft. long, with a wing span of 230 ft., a span more than twice that of a Liberator B-24 and equal to the height of a 21-story building. The six 5,000 h.p. engines with which the plane was to be equipped would produce power equivalent to that of 353 average automobile engines. In order to take full advantage of laminar air flow, the engines were to be mounted on the trailing edge of the wing and equipped with pusher-type propellers. The plane was designed for a payload of 50,000 lbs., comprising the 204 passengers and 15,300 lbs. of baggage, mail and express. It was to be double-decked, with nine staterooms accommodating one to four persons each and 12 berths were to be provided in one section. Luxurious passenger facilities had been provided, complete with two lounges and a number of rest rooms. Additional activity at the San Diego plant included work on two secret military planes.

At Fort Worth the XB-36 bomber neared completion and was expected to make its initial flight in 1946. This huge bomber, with a wing span of 230 ft., 89 ft. greater than that of the B-29, mounted six 3,000 h.p. pusher-type engines on the trailing edge of the wing, three on each side of the fuselage. They were Pratt & Whitney Wasp Major radial, aircooled engines with 28 cyl. arranged in four staggered rows of seven cyl. each. Described as the most complicated engine yet developed, the Wasp Major was stated to create new economies in pounds-weight per horsepower developed and in fuel consumption. The XB-36 was designed for a range of 10,000 miles with a huge bomb load and gross weight of 287,000 lbs. At Fort Worth, work was concentrated on the XB-36, the construction of wing and tail assemblies for the XC-99, and on one of the secret Army planes.

At Wayne, Mich., Consolidated Vultee's Stinson division, the same assembly line which turned out more than 3,700 Sentinel L-5 liaison planes between Pearl Harbor and V-J Day, started producing Stinson Voyager 150 four-place personal planes. Powered by a 150 h.p. six-cyl. horizontally opposed Franklin engine, the Voyager 150 cruised at 125 m.p.h., and had a range of 500 miles. It could take off in 550 ft. and climb at 770 ft. per min. High altitude performance tests were given the Voyager 150 in the Rocky Mountains at Creede, Colo., 8,700 ft. above sea level. There, in repeated take-offs carrying a capacity load of four passengers, the Voyager 150 was airborne in less than 1,350 ft. Its service ceiling was 14,000 ft. It weighed 1,206 lbs. empty and had a gross weight of 2,150 lbs., of which 944 lbs. were useful load, or the equivalent of 78 per cent of its own weight. The Voyager 150 had smart exterior lines and the cabin was richly upholstered and soundproofed. It could be flown for two cents per seat mile, tests showed, and was equipped with a new, all-metal tail design which increased maneuverability. Wing slots tended to make it spin-resistant and improved brakes assured greater landing safety.

At Vultee Field, Downey, Calif., the company constructed a plane in the restricted category which was test flown early in 1946.

Culver Aircraft Corporation, Wichita, Kans., was one of the few aircraft manufacturers with production under a complete blanket of military censorship for the entire war period, and it was not until



CONSOLIDATED VULTEE XC-99 TROOP CARRIER

October, 1945, that Culver was able to reveal even what type of planes it was manufacturing. In October, 1945, the War Department disclosed its use of radio-controlled target airplanes for training aerial and anti-aircraft gunners, designated as PQ-8 and PQ-14. Culver was the sole production supplier of these planes to both the Army and the Navy. The radio-control program started in August, 1940, when the Army Air Forces invited Culver and some 20 other airplane manufacturers to Wright Field for the purpose of submitting bids and design studies on a plane which could be radio-controlled, for use as a target ship. The Navy had carried on some experimentation in radio-controlled flights as early as the 1920's, always with a pilot on board, but that program had suffered from lack of public interest and funds. One company had built a target of the OQ type for the Government, but it could not carry a pilot. PQs operated either with or without a pilot. The speed and ease of handling of the pre-war Culver were both characteristics needed in the proposed target plane, but there were many other features to be considered in converting the Culver to a plane suitable for radio-control. First, the ship had to be made practically stall-proof, and consequently, spin-proof, because a radio-controlled plane, once it went into a spin, could not be brought out of it. Culver engineers first set to work to redesign the wing to improve the stall characteristics. Then the landing gear was changed, and a tricycle gear substituted for the conventional gear of the old commercial Culver. The gear was non-retractable on the earliest PQ models; electrically retractable on later ones. Originally the engineers set out merely to make a few changes in its commercial model; by the time the first military model was ready, they practically had a new plane.

Culver had its prototype at Wright Field by December, 1940, and submitted a price of $2,875 a plane, probably one of the lowest prices at which the Army was ever offered an airplane. Later, when the company received its first contract, the Army raised the price to $3,275 a plane, realizing that Culver was inexperienced in military business and that they could not break even on the original price. The price set by the Army was about $150 more than the selling price of the prewar commercial Culver. In March, 1941, the company received its first Army contract. Some other manufacturers at the beginning of the program got planes of the PQ type in the air, but subsequently, Culver became the Government's sole production supplier of radio-controlled target planes.

The company had been outgrowing its factory facilities in Columbus, O., and had purchased a plant in Wichita. Many delays and difficulties followed before the radio-control unit could be made to function properly. Under the original contract, it was agreed that Culver would merely install radio-control linkages and Servo units, and the secret radio equipment would be put in by the Army when the planes were delivered to Wright Field. Through the early months of 1941, Culver continued to bring PQ-8s off the assembly line, and then store them in one end of the factory for protection, as the Army would not accept deliveries until it had the radio-control unit working properly. The first model of the PQ-8 was at Wright Field for a year before the radio-control could finally be perfected and deliveries accepted. In the meantime, Culver continued to build PQ-8s, and at the same time kept up its commercial production.

By that time, the country was at war, and all commercial production stopped. Culver immediately turned all of its facilities to the production of the PQ radio-controlled target planes for the Army and Navy. Much of the principle of radio-control had never been released by the Army, but certain facts about the operation were generally known. The PQs operated, either from a mother ship or from ground control, and three gyros were used for the operation of controls. At first only one unit was used, necessitating an inter-connection of the aileron and nose wheel for ground steering. The one gyro operation was not the best in the world, but soon three gyro units were put into use, and completely satisfactory results were obtained.

The PQ-8 (known to the Navy as TDC-1) was succeeded by the PQ-8A (TDC-2), and later by the PQ-14 (Navy designation TD2C-1), which had more horsepower, more speed, and resultantly greater performance. Several modifications were made of each model, as improvements were worked out. The PQs were tough, and stood up almost unbelievably under the "trial by fire" to which they were subjected constantly by the best gunners of the Army and Navy. There is one story on record where a commanding officer rebuked his gunners because they failed to bring down one of the little flying targets after eight runs across the field during which the ground troops fired at it with .50 and .20-cal. automatic machine guns, regular arms, and even a 26-mm. cannon. Many stories are on record where the PQs would land under their own power, out of gas and badly shot away, and the pilots would refuel them and fly the riddled ships back to the base. Few were actually destroyed, because of their toughness and because the wood construction could be easily repaired.

It is a matter of record that many Navy and Army officers attributed much of the superiority of American gunners to the training they received on these radio-controlled target planes, which could simulate every maneuver of an enemy fighter plane. They were used at many training bases in this country, and on almost every Allied front overseas. While they never fired a gun nor dropped a bomb, they are credited with saving the lives of thousands of American fighting men by providing the kind of gunnery training the boys never could have received with stationary targets. Production figures mean little unless they are considered in ratio to man hours required to achieve them. Culver's peak employment during the war was only

900 persons. From the beginning of its military contract, Culver produced 2,642 radio-controlled airplanes for the Army and Navy. In addition, on subcontract to other manufacturers, Culver turned out 1,500 empennages for the CG4-A glider, 2,500 sets of fuel tank covers for the glider, 75,000 smaller assemblies, fittings and parts for the glider, as well as several thousand wing ribs for the Boeing primary trainer. Culver never missed a scheduled production delivery, and often met emergency demands for extra deliveries beyond schedule. There were no strikes, and the ratio of non-productive to productive labor was one of the lowest in the industry.

In 1943, Culver had started design and experimentation on a new model of radio-controlled airplane, the XPQ-15, which offered still further improvement and advancement in the field of radio-control. Contract on the TD2C-1 (Navy version of the PQ-14) for delivery to the Navy projected the company's military production to June, 1946, so reconversion meant the establishment of two lines through the Culver factory—one for the military production, and another for production of the new commercial Culver. Out of Culver's experience in designing and building six models of radio-controlled target planes for the Government came the new Culver Model V, first test-flown in September, 1945. It was a low-wing, all wood monoplane, which bore some outward resemblance to its prewar predecessor, and showed some of the features of the military versions.

The sturdy tricycle landing gear of the military models was adapted to the new Model V, although the commercial model had a longer strut for smoother landings. It was electrically operated, with auxiliary manual operation. Engineering to improve the stalling characteristics of the military versions was carried over into the wing design of the new V, with the addition of a definite dihedral in the wing tip.

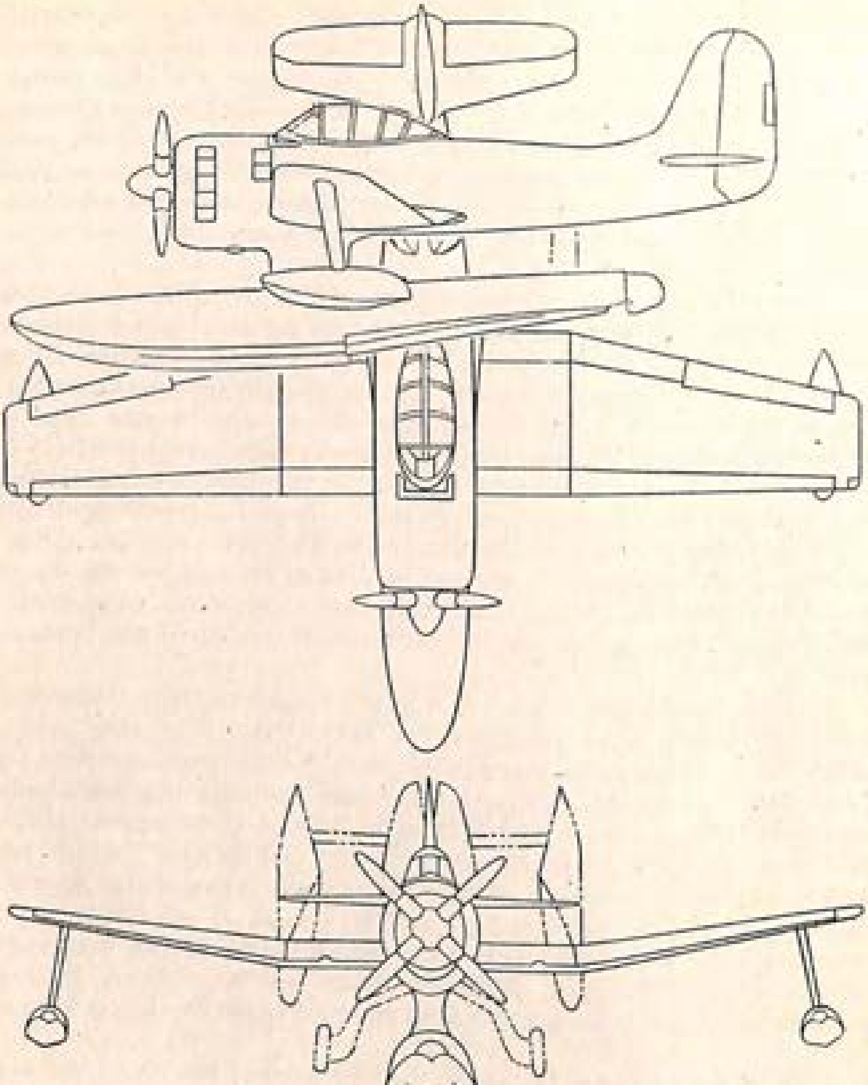
Most radically new feature of the new Culver, however, is the exclusive Culver Simpli-Fly Control. While the principle of Simpli-Fly had nothing in common with the automatic pilot or radio-control features of the military Culvers, the engineering experience in working with the military ships led to its development. When Culver designers and engineers saw the way the radio-controlled target ships could be maneuvered into every possible flight position solely by radio, without a pilot on board, they realized the possibilities of making flying as simple for the private citizen. Simpli-Fly Control involved the inter-connection of certain controls, which inter-connection at different settings was made visible to the pilot on a flight-control instrument that is measured in English rather than in complicated degrees. For example, when the pilot wanted to take off, he merely had to turn the flight-control wheel until the indicator on the flight-control dial pointed to "Take-Off," and the airplane automatically trimmed itself for take-off. The same held true for all other flight attitudes: "climb," "cruise"; and for landing, "glide" and "approach". And at all settings of the flight-control instrument, the airplane was automatically trimmed for optimum performance for that setting. Conventional rudder control is retained in the new Culver. Cruising range of the Model V was in excess of 720 miles; and other improvements over the pre-war commercial Culver included greater payload, roomier cabin, faster cruising speed, controllable pitch propeller, fuel injection engine, individually adjustable air-foam seats, and styled interior.

Curtiss-Wright Corporation, Airplane Division, New York, had a remarkable record of warplane production for the United Nations, and especially for the air forces of the U. S. Army and the U. S. Navy. Toward the end of the war, Curtiss-Wright still was contributing to the enemy's defeat by bringing out a radically new type of scout plane, the SC-1 Seahawk; a new model Helldiver, the SB2C-5; and more Curtiss Commando transports, the later models having double-door exits for parachute troops. In 1946, Curtiss-Wright was carrying on the tradition which it had created after the first world war, pioneering the design of new types of combat aircraft for the Army and Navy, and at the same time developing some of the most devastating types of guided missiles to be conceived thus far in the postwar era.

Curtiss late model Seahawks first were used in the pre-invasion bombing off the coast of Borneo in June, 1945. The single-place single float, low-wing seaplane designed to operate from catapults on battleships or cruisers greatly had increased speed, ceiling and climb, and added firepower. It had a Wright Cyclone 9-cyl. engine and a hollow steel Curtiss propeller with four "paddle-type" blades. A bubble canopy of plexiglas covered the cockpit, giving the pilot 360-degree visibility. The Seahawk also was used to advantage as a rescue plane. It was the only plane complement on the battleship Missouri when the Jap surrender treaty was signed. A limited number of SC-2 models with some modifications were to be completed in 1946.

The 5,000th Curtiss Helldiver was delivered to the Navy just before V-J Day. The new SB2C-5 model Helldiver also was announced then, with more than 35 important major changes over the older model. Fuel carrying capacity was increased 10 per cent extending the plane's range, the bomb bay was enlarged, and wing racks could carry heavier bomb loads than on previous models. The seven-ton dive-bomber was brought close to fighter performance with the late model's increased maneuverability.

The Curtiss XSB2C-6 was announced in November, 1945, with longer fuselage and larger propellers. The XF14C, an experimental fighter, was produced at Buffalo late in 1945. The Curtiss Helldivers figured in the great sea and air battles which marked the Navy's



CURTISS NAVY SC SEAHAWK

sledgehammer blows against Japan during the last few months of the war, and after V-J Day, they still were used for patrolling China and Korea.

In March, 1945, Buffalo-built Curtiss C-46 Commandos tumbled paratroopers from new double-door ships in the aerial crossing of the Rhine—the first time the C-46 transport had been used in European combat. The Commando already had made a name for itself over the Himalayan "Hump" route, in the China-India-Burma theater. The two-door Commandos each dropped 36 troops, just twice as many as previously had parachuted from transports.

A total of 22,977 planes was produced by Curtiss-Wright's Airplane Division plants from December 7, 1941, until the end of war contracts which followed August 14, 1945. They came off the lines at the Buffalo headquarters plant, the Kenmore, N. Y., plant, Columbus, O., St. Louis, Mo., and the Louisville, Ky., plants. Buffalo, the oldest plant, led in production with 14,043 planes, including P-40 Warhawks and C-46 Commandos. The Columbus plant turned out 6,473 units, including SO3C Seagulls, SB2C Helldivers and SC Seahawks. At St. Louis the production of 2,436 planes was chiefly C-46 Commandos and A-25 Army Helldivers. The Louisville plant did not begin operation until 1943, turning out C-46 Commandos and doing some work on B-29 modification before it closed. By the end of 1945, all plane production of Curtiss-Wright was centered at the Columbus plant.

On V-J Day the Columbus plant was in its 20th consecutive month of on-schedule production of Helldivers. In May the Columbus plant received a star for its E award flag, a renewal of the award for excellence in production.

Special machining fixtures were designed and developed at the Columbus plant which speeded production of motor mounts for Curtiss SB2C Helldivers by 70 per cent. The motor mount process was adopted by other aircraft companies. The Columbus plant also made use of a huge flash welding machine, one of the three largest in the country.

In October, 1945, the Curtiss-Wright Corporation Airplane Division's Research Laboratory at Buffalo announced that it had built flying devices which had obtained speeds in excess of 1,400 miles an hour, almost twice as fast as the speed of sound, and which might revolutionize high speed aircraft. Improved air conditioning methods also were being studied there, and steps taken toward solution of high speed problems. A telemetering system was developed by which it was possible to record and study performance data of an object in flight. This was accomplished by a mobile receiving unit while the flight was in progress, and images of the instrument panel were transmitted by television from the object in flight to the research experts on the ground. The Curtiss-Wright Research Laboratory late in 1945 was presented to Cornell University for a cooperative education-research program. Previously it was commended by the Navy "For distinguished service to the research and development of naval ordnance," and the Laboratory was designated to receive the Naval Ordnance Development Award.

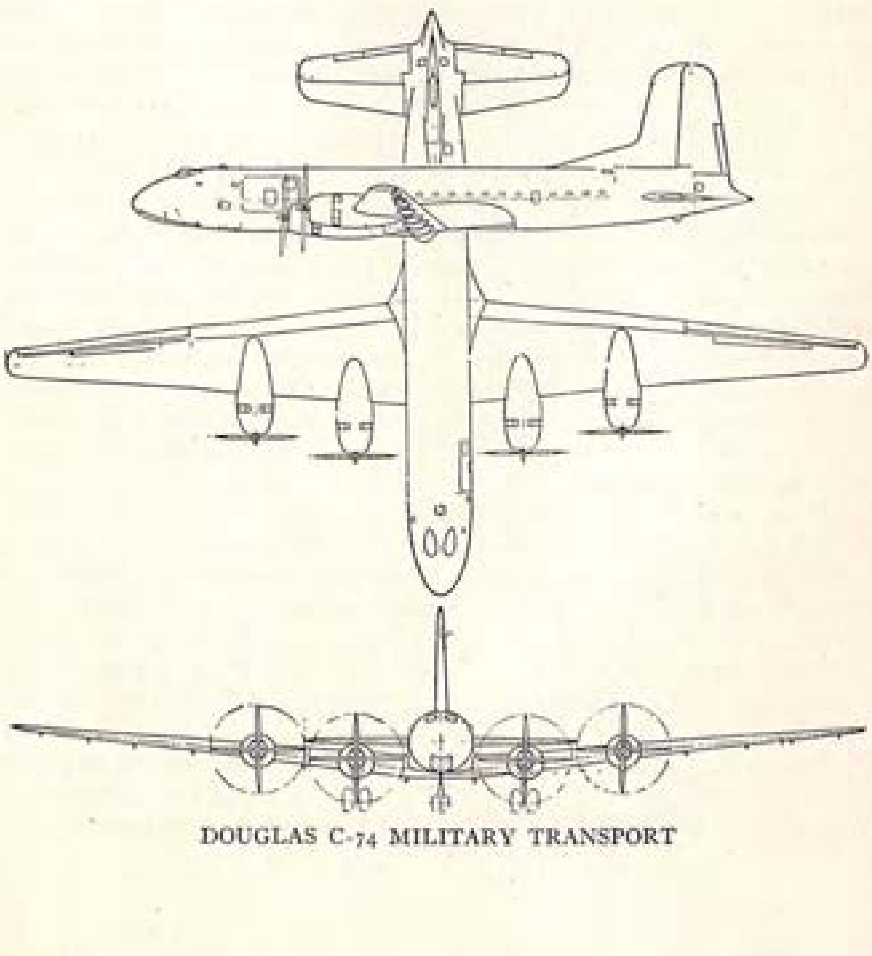
Douglas Aircraft Company, Santa Monica, Calif., was in full-out production on a postwar program providing for increasing numbers of military and commercial aircraft and a variety of research and development projects designed to help maintain this nation's high position in world aviation. During the war, Douglas had become the largest unit of the industry ever to exist under one management for production of both combat and transport planes for the Army and the Navy. Employing a total of 157,000 persons at peak production at the six Douglas plants in Santa Monica, Long Beach, Tulsa, Oklahoma City and Chicago, the company delivered a total of 31,268 airplanes of various types to the armed forces of the United Nations for defeat of the Axis powers—29,385 of that number between Pearl Harbor and the surrender of Japan. In four years of war production Douglas increased its rate of output by 3,500 per cent. During 1944, Douglas produced 180,000,000 pounds of airframe and spare parts. The six plants turned out 5,354 planes during the eight war months of 1945, 30 per cent attack bombers and 47 per cent transports. Much of the output was four engine equipment.

The Douglas C-74, an Army Air Forces transport, was completed and flight-tested September 15, 1945. It was the largest land plane in the air at the time, designed to carry 125 military personnel with full equipment. It was named the Globemaster because it could circle the earth with only two stops. It weighed 155,000 pounds fully loaded, had a wing span of 173 ft., length 124 ft., height 43 ft., speed in excess of 300 m.p.h. and maximum range 7,800 miles. It was powered by four 28-cyl. Pratt & Whitney 3,650 h.p. Wasp Major R-360 engines, and with reversible propellers could taxi backward as well as forward. The C-74 carried enough fuel to drive an average motor car 165,000 miles. The engine heat utilized to keep wings and empennage free from ice was enough to heat 20 six-room houses. Full-span flaps, a unique feature in airplane construction, reduced landing speed and take-off run. Both cabin and crew quarters were heated automatically, providing constant temperature regardless of outside air. Other scientific improvements included thermal de-icing, laminar flow wings, walkways in the wings for servicing the engines during flight and a built-in elevator and traveling cranes to facilitate cargo handling. The C-74 was in production at the Long Beach plant.

The C-74 was the military prototype of the DC-7 commercial transport, which was designed to carry 108 passengers and a crew of 13.

Another new type was the Douglas XB-42, with a radically new power plant that had kept it on the Army's secret list for 18 months in which it was put through the most exacting tests. On December 8, 1945, the XB-42 made a record flight from Long Beach, Calif., to Washington, D. C., non-stop in 5 hrs. and 17 min., an average of 433 m.p.h. It was a midwing, tricycle gear monoplane weighing 35,702 lbs. loaded. It could carry four tons of bombs internally. Its power plant was the most unusual feature. It was powered by two Allison V-1710 1,820 h.p. liquid-cooled engines located inside the fuselage a little more than 30 ft. from the tail and actuating two counter-rotating, coaxial 15-ft. propellers in the extreme rear behind the tail surfaces. The engines, located just aft of the pilot's cockpit, were connected to the dual rotating propeller reduction gear by steel drive shafts for 30 ft., the shafts being in five-foot lengths hinged at each joint by ball-bearing supports providing for air load deflections of the fuselage. Each propeller was independently driven, and either could be feathered. Single engine performance was exceptionally efficient because the propellers were located on the center line of the airplane; thus no adjustments in trim controls were required for single engine flight.

The XB-42 had a transport version, the DC-8, which was in production at the Santa Monica plant, and Douglas announced it as a worthy successor to its famous DC-3 airliners, more than 10,000 of which had gone into commercial and military service since 1933. The new DC-8 was to be 50 per cent faster and carry twice the number of passengers at half the passenger-mile operating costs. The DC-8 had a wing span of 110 ft. 2 in., length 77 ft. 10 in., height 25 ft.



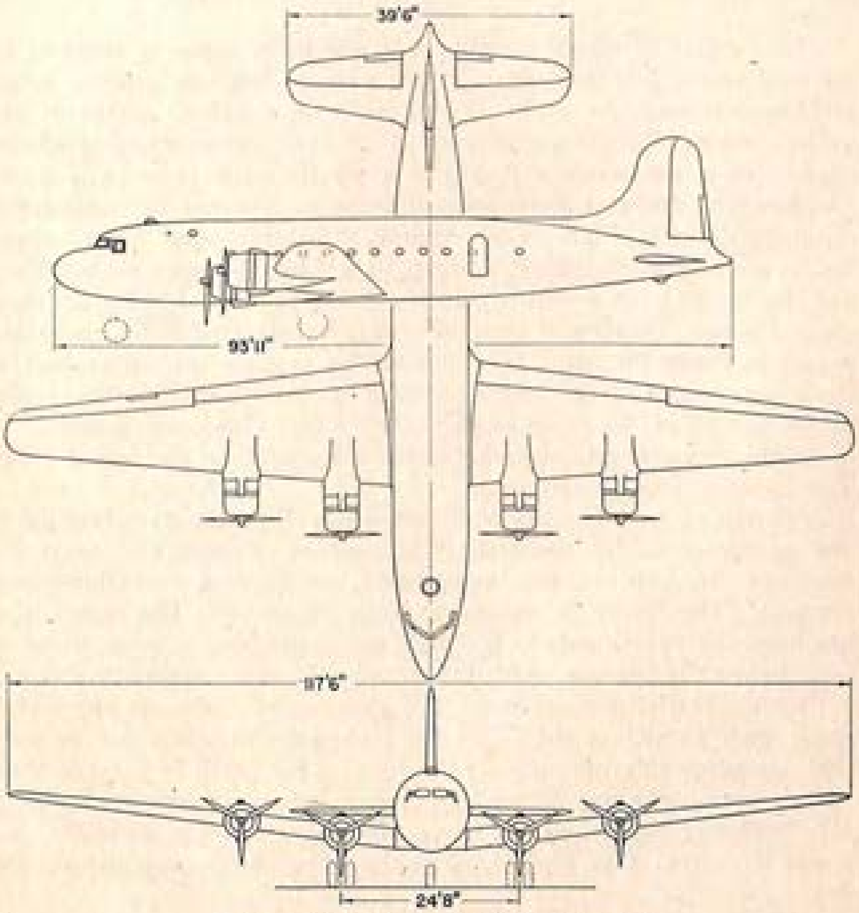
DOUGLAS C-74 MILITARY TRANSPORT

9.5 in. and wing area of 1,104 sq. ft. Its maximum take-off and landing weight was 39,500 lbs., weight empty 23,915 lbs., useful load 15,585 lbs. and useful load/gross weight 39.4. Its payload at 300 mi. range was 12,000 lbs., including 48 passengers and 2,400 lbs. of cargo in excess of baggage. Its cruising speed at 300 mi. range against a 10-mi. headwind was 223 m.p.h. as compared to the 170 m.p.h. of the DC-3. Its direct operating cost per plane mile was 41.6 cents against the DC-3's 36.5 cents and cost per 200 lb. mile 0.695 cents as compared to the 1.3 cents of the DC-3. Both old and new models had the same take-off run, 3,950 feet, while the DC-8 required only 640 more feet for landing than the 3,320 feet for the DC-3.

A cabin innovation of significance to operators was a movable partition that converted the DC-8 at short notice from an all-passenger to a combination passenger-cargo plane designed to secure for each flight a 100 per cent load factor. Other advantages for passengers over conventional craft made possible by the new principle of propulsion were listed by Douglas as major reduction in cabin noise level due to remote location of propellers; no wing motors nor nacelles to restrict window vision; a cabin floor level only 60 inches above ground for easy entrance and egress. Advantages claimed from the standpoint of design included greatly improved single-engine performance, with no offset thrust in case of engine failure; an overall drag coefficient 25 per cent less than an equivalent conventional plane; a higher rate of climb made possible by the large 15-ft. propeller diameter and increased efficiency of the propeller's location aft; better lift distribution resulting from the higher effective wing span; elimination of much weight from the shorter landing gear and hydraulic mechanisms; higher payload from these various combinations and lower ground costs. Passengers could be loaded without shutting off the engines, because propellers were aft and there was no prop blast. It also eliminated the necessity for mechanics to work in a slip-stream while making adjustments. The engines and accessories cowling opened like a bomb bay door, thereby making all maintenance work at waist level from the ground. The engines, of course, were accessible in flight.

Douglas also was in production on its huge backlog of DC-4 orders, some of which had accumulated before the war, and had done considerable work on reconversion of the war veteran C-54 transports into deluxe DC-4s for many airlines. While the DC-4 ordinarily seated 44 passengers and carried a crew of five, including two stewardesses, some C-54-to-DC-4 conversions seated as many as 56 passengers. Powered by four Pratt & Whitney 2SD13-G engines developing 1,450 h.p. at take-off, the commercial version of the C-54 Skymaster had a maximum speed of 243 m.p.h., using only 60 per cent of its rated power. At 10,000 feet the DC-4 cruised at 225 m.p.h. with a gross load of 65,000 lbs. The DC-4 had a wing span of 117 ft. 6 in., length 93 ft. 5 in., height 27 ft. 7 in., and wing area of 1,457 sq. ft. including 93.55 sq. ft. of aileron.

Still another transport was in production at the Douglas plant. It was the luxury airliner DC-6 in both day plane and sleeper models. The company described it as providing the utmost in luxurious comfort and conveniences for air travelers, and added: "Coupled with this comfort will be 300-mile-an-hour speed provided by four 2,100 h.p. engines, cabins sound-proofed with fibre-glass insulation and pressurized for 8,000 ft. altitude while the plane flies at 20,000 ft. Passenger and pilot compartments will be air-conditioned with the most modern heating and ventilating equipment. Nowhere in the plane are the final results more apparent, even to the casual eye, than in the DC-6 cabin interior. This plane is seven ft. longer than the C-54. It will carry a crew of five, including cabin attendants, 52 passengers as a day plane or 26 berth passengers as a night plane. On




DOUGLAS ARMY C-54 TRANSPORT

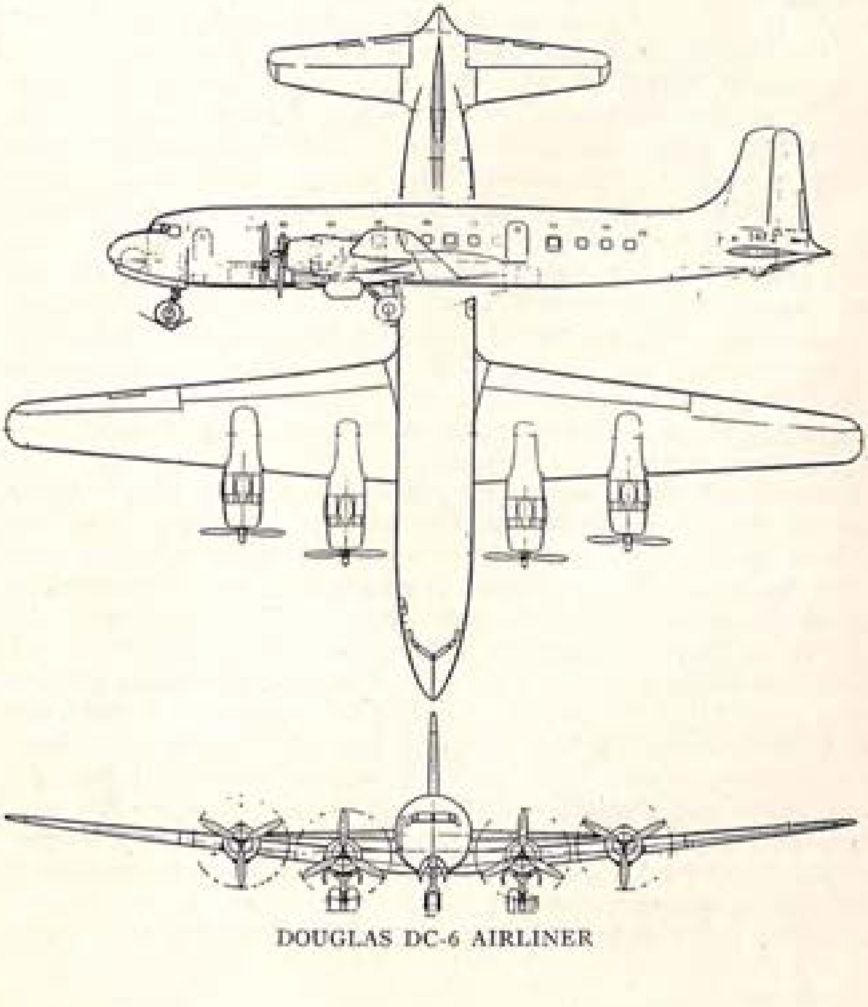
either side of the main cabin entrance are the buffet sections, one for cold food storage, the other for hot foods which are loaded just prior to the plane's departure. In flight, a folding seat and an attendant's desk occupy the entrance area. Opposite the cabin entrance is a large closet for passengers' wraps and a copious magazine rack. From a forward position, looking aft, the cabin gives the appearance of extreme roominess. This effect is achieved by wide, comfortable seats and the general color scheme of the cabin. The seats are approximately 20 in. wide, with tall, contoured backs. Ample leg room is provided between the seats which are 40 in. from center line to center line. Seat backs are adjustable from a vertical position to a recline of 38 degrees. Headrests attached to the backs are adjustable as well as removable. Individual tables attach to the seats. They are light and strong and are large enough for a portable typewriter and papers or for the commodious trays on which meals are served. Tables are also adjustable forward or aft, according to the user's desire.

"The effect of added roominess in the large cabin is attained by the wall and ceiling treatment. From window ledge to window ledge, arching overhead, the walls are finished with a porous synthetic fabric in a warm blue-grey, giving an air of both coolness and spaciousness. Below the window ledges is a plastic scuff plate of a warm London tan. Indirect fluorescent lighting is recessed in two curved channels on either side of the ceiling. In the sleeper plane, upper berths are concealed behind slanting panels in the upper walls. They may be readied for occupancy in less than 30 seconds. By pressing control buttons, seats and seat backs may be adjusted to be made into berths in about the same time it takes to prepare the upper berths. Both upper and lower sleeping spaces are commodious. The lower berths are 76 in. long, the uppers are 78 in. The lower berth is 41 in. wide, giving ample sleeping width for a mother and small child. The upper is slightly narrower.

"Berths in the DC-6 are equipped with call buttons, reading lights and conveniences for the orderly storage of clothing and toilet accessories. In addition, the upper berth has its own air-conditioning controls. The lower is ventilated from the cabin. The upper also has handy compartments in the wall, one containing a waste disposal bin. Below the bin is a small jewel case; the other compartment has a thermos bottle, a large wax cup, shaving or make-up kit, and a small shelf (which is the lid of the compartment when not in use) with an adjustable mirror. At the foot of the berth is a large shelf for an over-night bag. Each upper has its own window. Bedding for the lower berth and the temporary panel which separates one lower from the other are stored in the upper berth area during the day.

"The ever-present problem of sound has been as effectively handled by Douglas engineers as modern materials and design can do so. The cabin itself is shock mounted within the outer frame by rubber contact points and extrusions. The space between the outer and inner walls is sound-proofed by an impervious septum between two thick layers of cotton-like fibre-glass. Floor coverings are of Vynal-covered foam rubber in a deep blue. All these sound rebuffing measures reduce to a minimum propeller tip noise, the 'sing' of the air flow over the wing and fuselage surfaces and the engine exhaust roar. Realizing that commercial air travel will see an increase in women patrons, considerable thought has been given to their needs. Nowhere is this more apparent than in the ladies' lounge of the DC-6 sleeper plane, located at the aft end of the fuselage.

"This lounge is a large semi-circular room with a cove ceiling. Here, again, a soft, porous fabric is used for the wall covering, the color being an almost translucent sky blue. Smoky blue floor cover-



DOUGLAS DC-6 AIRLINER

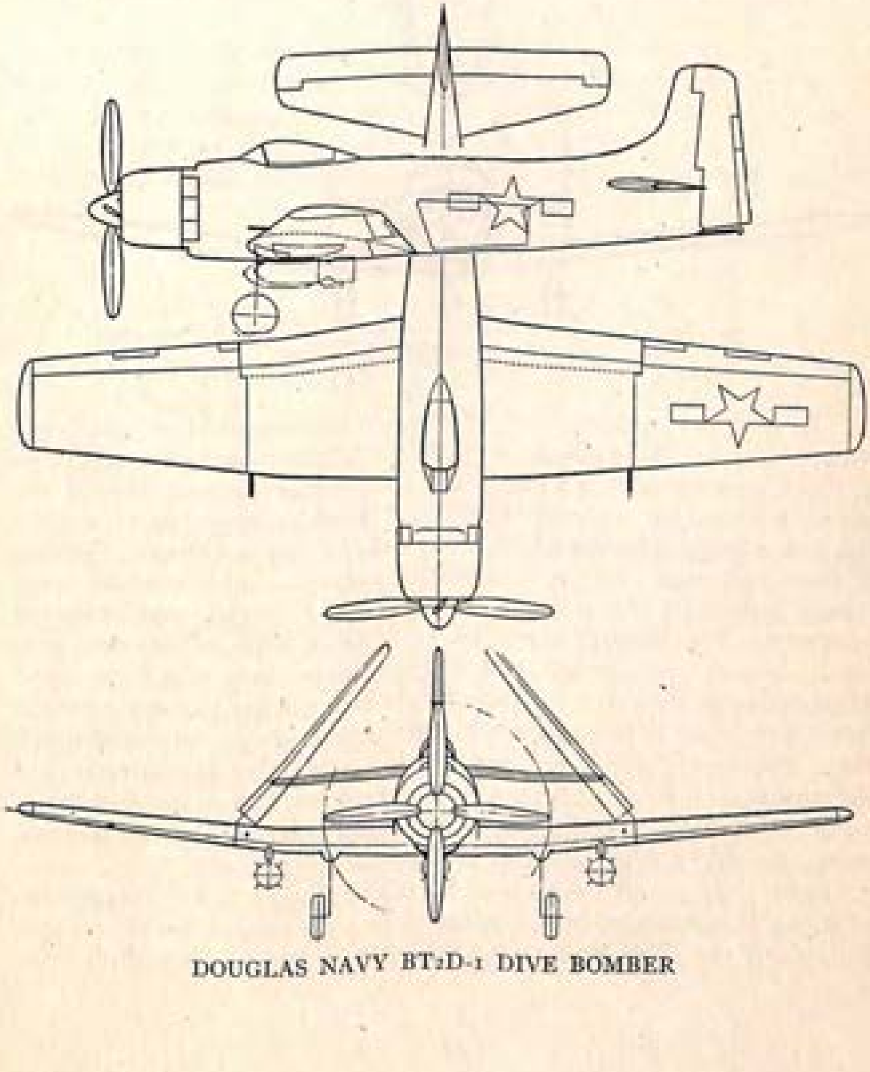
ing is moulded to the wall for easy cleaning. In the curve of the lounge which makes the rear wall is a three-section sofa in cocoa-rose. At either end of the sofa is a dressing table with an adjustable, fluorescent-lighted mirror. The dressing tables have built-in face-tissue dispensers, ash trays, waste disposal bins and large purse drawers. Linen supplies are stored under the sofa. There is a full-length mirror on the back of the door leading to the main cabin, and mirrors, with indirect lighting around them, over the wash basin and dental basin. Indirect lighting back of the dressing tables serves also for general illumination of the lounge. In the center of the back wall is a large sunburst design concealing the access panel to the control cable area in the tail cone. The men's lounge, in both day and sleeper planes, is immediately behind the forward fuselage cargo compartment. Walls and ceilings of this room are finished in a warm grey fabric. In the sleeper plane there are two wide seats, the one nearest the basins folding up to make a shelf during morning periods when the room is most in use, thus giving free access to the basins."

The Douglas 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. The DC-6 was powered by four Pratt & Whitney 2,100 h.p. Double Wasp engines and 13-ft. Curtiss reversible propellers. It had a cruising speed of 268 m.p.h. with 71,000 lbs. gross weight.

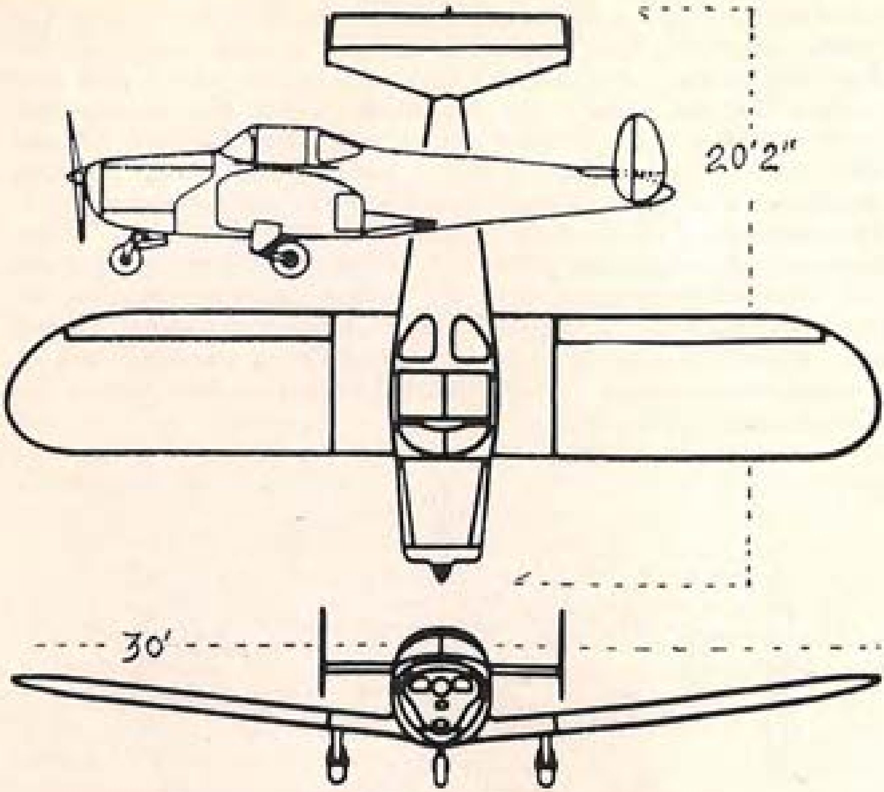
For the U. S. Navy, Douglas was in production on a new dive-bomber, the BT2D-1 for aircraft carrier service. The BT2D-1 was both dive and torpedo plane, with a range of 1,500 miles, bomb-torpedo-mine load capacity of 6,000 lbs., a battery of 5-in. rockets and 20-mm. machine guns in the wings and a speed in excess of 500 m.p.h. It was equipped with fuselage dive brakes. 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.

Among the highly secret projects completed at the Douglas plant was the Roc, a remote-controlled aerial bomb that could be guided to its target by television. Controls in a mother plane far above or at a vantage point miles away could cause the bomb to deviate from its free-fall course as much as one mile. Other details were a secret.

Engineering & Research Corporation, Riverdale, Md., developed and produced the Ercoupe, a two-place, low-wing monoplane for personal use. The Ercoupe was described as spin-proof. It had twin rudders, a tricycle landing gear, which permitted landing up to twice the minimum speed without tendency to leave the ground after the first contact, and a single control system. Both the ailerons and rudders were linked to the control wheel, thus eliminating the rudder pedals entirely and obviating the necessity of learning to coordinate the usual three separate controls. The Ercoupe had a 75 h.p. engine, a cruising range of 500 miles, cruising speed of 110 m.p.h., a maximum speed of 127 m.p.h., a rate of climb (sea level, first minute) of 750 feet and a maximum practical altitude of flight of 14,000 feet. Its gross weight was 1,260 lbs., empty weight 750 lbs. and useful load 510 lbs. The fuel mileage was 22 miles a gallon. The Ercoupe was simple and easy to fly. From flight tests conducted by the CAA and Parks Air College, it was reported that with equally well-prepared courses of instruction, the time required to solo an Ercoupe could be approximately 50 per cent less than for a conventional airplane. Some beginners soloed after two or three hours of instruction. Many cases were reported of learners, with just average dexterity (such as the ability to drive a car) who were ready to solo after four hours of flying time. The CAA regulations, which specified eight hours of dual instruction before soloing conventional airplanes, permitted soloing the Ercoupe after five hours.



DOUGLAS NAVY $BT_2D$-1 DIVE BOMBER

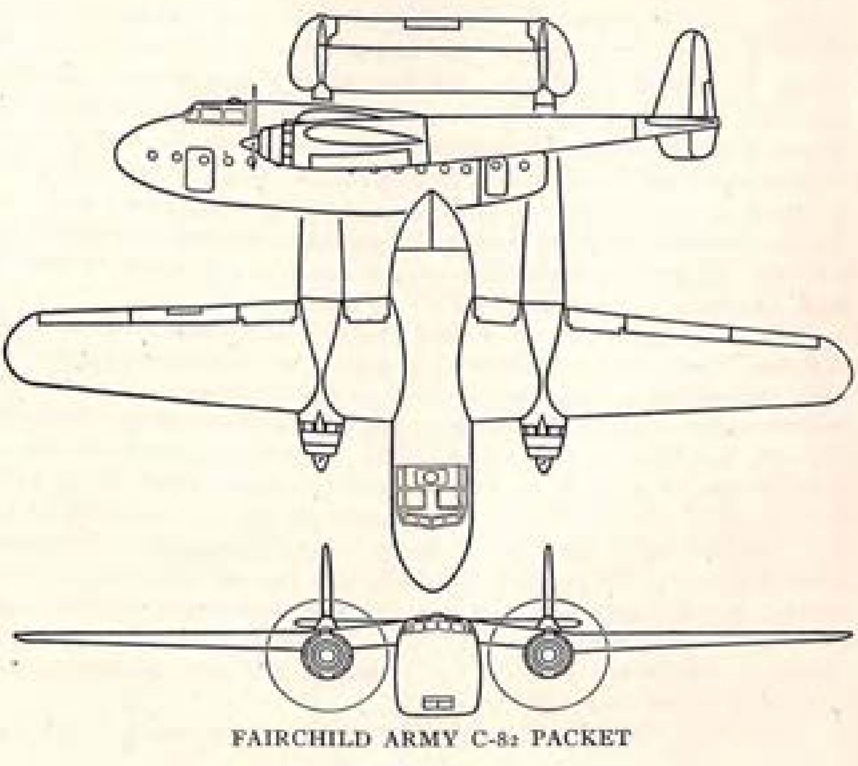



THE ERCOUPE

The Ercoupe was certified by the CAA "incapable of spinning." No one ever had been able to send it into a spin under any conditions of flight maneuver or loading, with or without power. Should the plane's nose go up with full throttle, it would not go out of control and into a dizzy spin, the cause of so many flying accidents. Because of that important fact, the insurance rates on all Ercoupes were greatly reduced. The flyaway price of the Ercoupe, with standard equipment, was $2,994. Optional equipment with self-starter, generator, battery, navigation lights and green sunshade was $156 extra. Engineering & Research Corporation, which during the war won the Army and Navy E five times for manufacture of gun turrets and airplane machinery, was producing machine tools for the aircraft and automotive industries, including Erco sheet metal forming and flanging machine, Erco shrinking and stretching machine, Erco automatic punching and riveting machine and other power tools.

Fairchild Aircraft Division of Fairchild Engine and Airplane Corporation, Hagerstown, Md., continued in 1945 to concentrate on production of the C-82 Packet for the Army Air Forces. Full scale production got under way early in the year and the first Packet rolled off the assembly line in May. One month later, Fairchild Aircraft's contract with the AAF was doubled and changed to a fixed price basis. Because its basic design incorporated many new features previously lacking in transport types, the twin-boom Packet represented a solution to many problems of air freight handling and loading. The huge fuselage actually was one big cargo compartment with straight sides, a level floor and flat ceiling. Two big doors formed the rear of the fuselage. When these doors were open, the entire interior was readily accessible. Cargo could move straight in without having to overcome obstacles such as sharp corners or curved sides. Direct loading from trucks or loading docks was possible because the level floor was four ft. above the ground, about the same height as that of standard truck beds. A door at the forward end of the fuselage also could be used for simultaneous loading and unloading of small cargo.

Nicknamed the "flying boxcar", the Packet had 93 per cent of the cubic capacity of a standard railroad boxcar, and its fuselage interior bore a striking resemblance to the interior of a freight car in shape as well as size. Capacity of the cargo hold was 2,916 cubic ft. Interior length was 38 ft., 28 ft. of which was eight ft. high and



FAIRCHILD ARMY C-82 PACKET

eight ft. wide by six and one-half ft. high. Cargo tie-down rings were located throughout the floor at intervals of 20 inches. Trucks and automobiles could be driven into the fuselage by means of 17-degree ramps which could be carried within the plane. Movement of trucks and trailers about the plane was unobstructed. The horizontal tail surfaces were 14 ft. above the ground, allowing ample room underneath for even the largest modern vans and trailers.

The Packet's cruising speed at 10,000 ft. was more than 200 m.p.h. despite its maximum military payload of nine tons operation. It had a service ceiling of 25,000 ft. and could maintain 8,000 ft. on one of its two 2,100 h.p. Pratt & Whitney Double Wasp R-2800C engines. At its design gross weight of 42,000 lbs., the plane's ground run for take-off was only 800 ft., which made possible the use of airports of limited size. Maximum range was 4,000 miles.

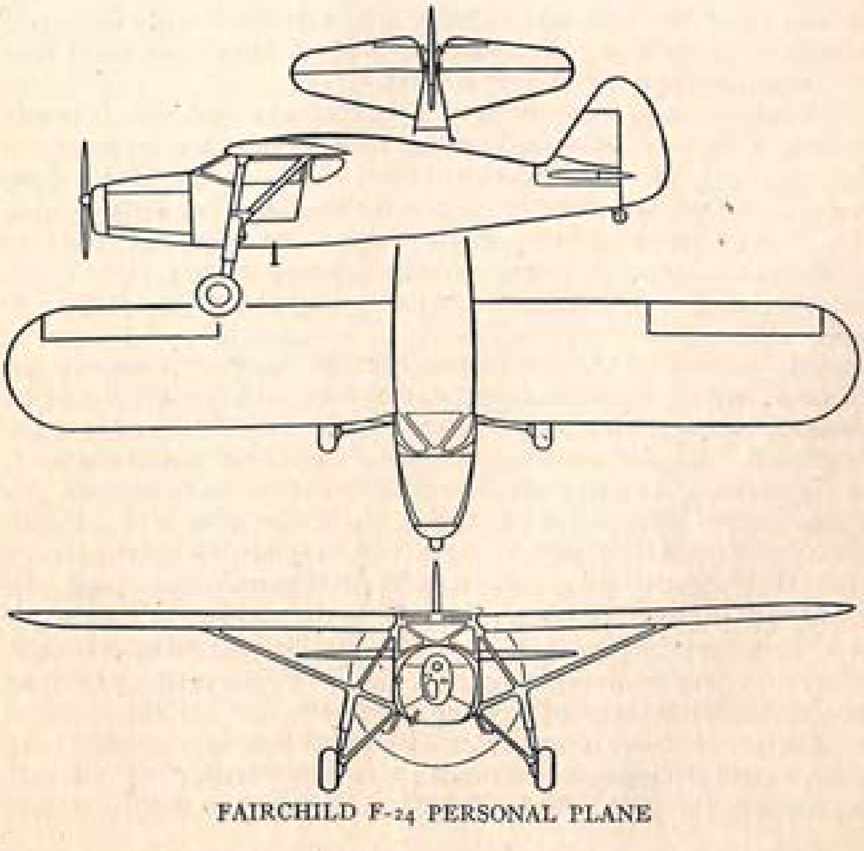
Based on performance and cost studies completed by Fairchild engineers, the Packet was expected to have one of the lowest direct operating costs of any existing two or four-engine transport in cargo operation for non-stop trips up to 500 miles. The Packet could operate in commercial service at less than seven cents per ton mile for trips up to 500 miles. A 1,000-mile flight with more than five tons of payload would cost 8¼ cents per ton mile.

On V-J Day, Fairchild Aircraft faced the future with exceptionally bright postwar prospects. Navy contracts were cancelled for the PBM Mariner wing panels which Fairchild had produced for the Glenn L. Martin Company, but the Army's procurement program for C-82 Packets was unaffected. A revised schedule of eight airplanes a month was to maintain high employment on military production until some time in 1947. Meanwhile, because the Packet was designed for use by airlines and air cargo shippers as well as by the Troop Carrier Command during the war, air shipping companies and leading industrial groups throughout the country were evidencing more than passing interest in the flying boxcar.

The Fairchild Personal Planes Division of Fairchild Engine and Airplane Corporation, Dallas, Tex., was created late in 1945 for design, manufacture, sales and service of private-owner aircraft. The new division relieved the pressure on the facilities of the Fairchild Aircraft Division at Hagerstown, Md., which continued to concentrate on military, naval and commercial aircraft. First plane to be built by the Personal Planes Division was an improved version of the F-24, known in World War II as the UC-61 Forwarder. The four-place high-wing cabin plane was planned for by sportsman pilots, charter service operators, small airlines, Government services, and by corporations as executive planes. At the end of 1945 tentative orders in substantial quantity had been received and production was to be well under way early in 1946.

The new Fairchild F-24 had luxurious appointments and was equipped for instrument flying. Standard equipment included a bank-and-turn indicator, rate-of-climb indicator, sensitive altimeter and all primary flight instruments. The F-24 was wired for landing lights and for optional two-way radio with engine shielded, airplane bonded and antenna mounted. With a roomy, comfortable cabin, plenty of space for baggage, and long range, the F-24 was reported by the manufacturer to be stable and easy to handle. It flew 5¼ hrs. without refueling and had a 60-gal. fuel tank. The F-24 was offered with a choice of two engines. Model F-24W-46 had a 7-cyl. Warner 165 h.p. aircooled radial engine, and the F-24R-46 had a Ranger 6-cyl. 175 h.p. aircooled inline inverted engine.

The Ranger-powered version had a top speed of 133 m.p.h. Its cruising speed, utilizing 75 per cent of power, was 118 m.p.h. and its maximum range 620 miles. Landing speed with flaps was 53 m.p.h. The plane was able to clear a 50-ft. obstacle after a take-off run of 1,100 ft. Landing over a 50-ft. obstacle required 1,000 ft. Service ceiling of both models was 14,000 ft. Manufacturing for the division was conducted in the former North American Aviation plant at Grand Prairie, Tex.



FAIRCHILD F-24 PERSONAL PLANE

G & A Aircraft, Inc., Willow Grove, Pa., formerly the Pitcairn Autogiro Company, and since 1943 a subsidiary of the Firestone Tire & Rubber Company, developed the XR-9 light weight helicopter for the Army Air Forces. The first machine was delivered to the AAF in 1945. Originally a single-place machine, the XR-9 was changed to two-place, and G & A Aircraft developed a two-place civilian model with side-by-side seating arrangement, with enlarged cockpit and more appealing fuselage design.

The engineering nucleus that introduced and popularized Pitcairn autogiros in the United States turned all its talent to helicopters. The new helicopter weighed less than half as much as a low-priced automobile, was responsive to control forces, and was free from the jolting vibration that long had been a problem in the helicopter field. It was easy to maintain and repair. The three-blade rotor had a diameter of 28 ft. It was powered by a 135 h.p. Lycoming four-cyl. aircooled engine, had dual controls (tandem) and tricycle landing gear. It was 27 ft. 7 in. long and was 8 ft. 6½ in. high. Width at landing wheels was 9 ft. The fuselage was of welded steel tubing with a nose section of lucite. Fuselage fairing was aluminum alloy. The boom had a balsa core with alclad outside skin. Preliminary performance data indicated that the helicopter would cruise at approximately 80 m.p.h. with a service ceiling over 10,000 ft., climb of more than 1,000 ft. a minute and a top speed of over 100 m.p.h.

To meet Army requirements for easy dismantling and shipment, the XR-9 had a tail boom section that could be detached by removing six bolts and disconnecting two control wires. Rotor blades were removed by taking out three bolts and three pins and by unseating three ball-and-socket joints. In three parts, the helicopter could be stowed easily in ordinary cargo aircraft. During the war, G & A produced more than 600 CG-4A troop-carrying gliders in addition to autogiros for the British.

The Globe Aircraft Corporation, Fort Worth, Tex., produced the Globe GC-1A Swift, a small, metal, two-place, side-by-side low wing land monoplane. It had a wing span of 29 ft. 4 in., length 19 ft. 7 in., height 6 ft. 2 in., and was powered by an 85 h.p. Continental engine.

Grumman Aircraft Engineering Corporation, Bethpage, N. Y., produced five different models during 1945, consisting of Navy F6F Hellcats, Navy F7F Tigercats, Navy F8F Bearcats, JRF Gray Goose, and J4F Widgeons, for a total of 4,067 aircraft, making a grand total of 17,135 airplanes delivered since December 7, 1941. Production reached a peak in March, 1945, when 605 Hellcats were delivered, which according to Naval authorities, "is a world's record for monthly production of one type of airplane from one plant." Delivery of all models for the month amounted to 658, which the Navy claimed to be "More combat planes in one month than any single plant has ever produced." Another record achieved in March was the delivery of the 10,000th Hellcat. "No other producer," according to the Navy, "has made 10,000 airplanes of one model designed and built since Pearl Harbor." The JRF Gray Goose, after eight successful years of production, was discontinued in September, and the last F6F Hellcat was delivered in November, 1945.

Production continued on the F7F Tigercat, a twin-engine Navy and Marine Corps fighter-bomber. The Navy credited the Tigercat with speeds up to 420 m.p.h. at low altitude and approaching 500 m.p.h. at critical altitude. It had a wing span of 51 ft. 6 in., an overall length of 45 ft. 4 in., with a wing area of 455 sq. ft. and a wing loading of 47.5 lbs. per sq. ft. Powered by Pratt & Whitney 2800-34W engines developing 2,800 h.p. each, it had a power loading of 3.9 lbs. per h.p. This versatile plane, although produced primarily as a day or night fighter, could carry an excellent bomb load, transport and deliver three torpedoes or carry enough auxiliary fuel tanks for long reconnaissance flights. Despite its size, speed, and tricycle gear, the Tigercat operated successfully from aircraft carriers of the Essex class.

Early in 1945, Grumman introduced the Navy F8F Bearcat, a compact, light-weight, high-powered single-engine, carrier-based fighter, credited with a sea level speed of 425 m.p.h., one of the fastest propeller driven airplanes in the world at low altitude, and a speed at critical altitudes in excess of 450 m.p.h. It had a wing span of 35 ft. 6 in. and an overall length of 28 ft. 3 in. Its wing area was 244 sq. ft. with a wing loading of 38.2 lbs. per sq. ft. It was powered by a Pratt & Whitney R2800-34W engine developing 2,800 h.p. and had a powerloading of 3.3 lbs. per h.p. The combination of light weight and high horsepower produced an extremely maneuverable airplane with a rate of climb in excess of 5,000 ft. per minute, and 6,500 f.p.m. with water injection.

The Grumman Widgeon, a 5-place twin engine utility amphibian was produced for the U. S. Navy and Coast Guard, and for the British, Brazilian and Portuguese Governments. It was operating successfully in practically every corner of the world. During 1945, modifications were made in the hull which improved the water handling characteristics, and all ships incorporating this modification were designated G-44A. Starting in February, 1945, Widgeons were licensed commercially and until V-J Day were delivered to high-priority manufacturers as executive and general utility transports. When priorities were lifted, deliveries continued on a normal commercial basis, and the Widgeon was one of the first postwar personal planes to reach private owners.

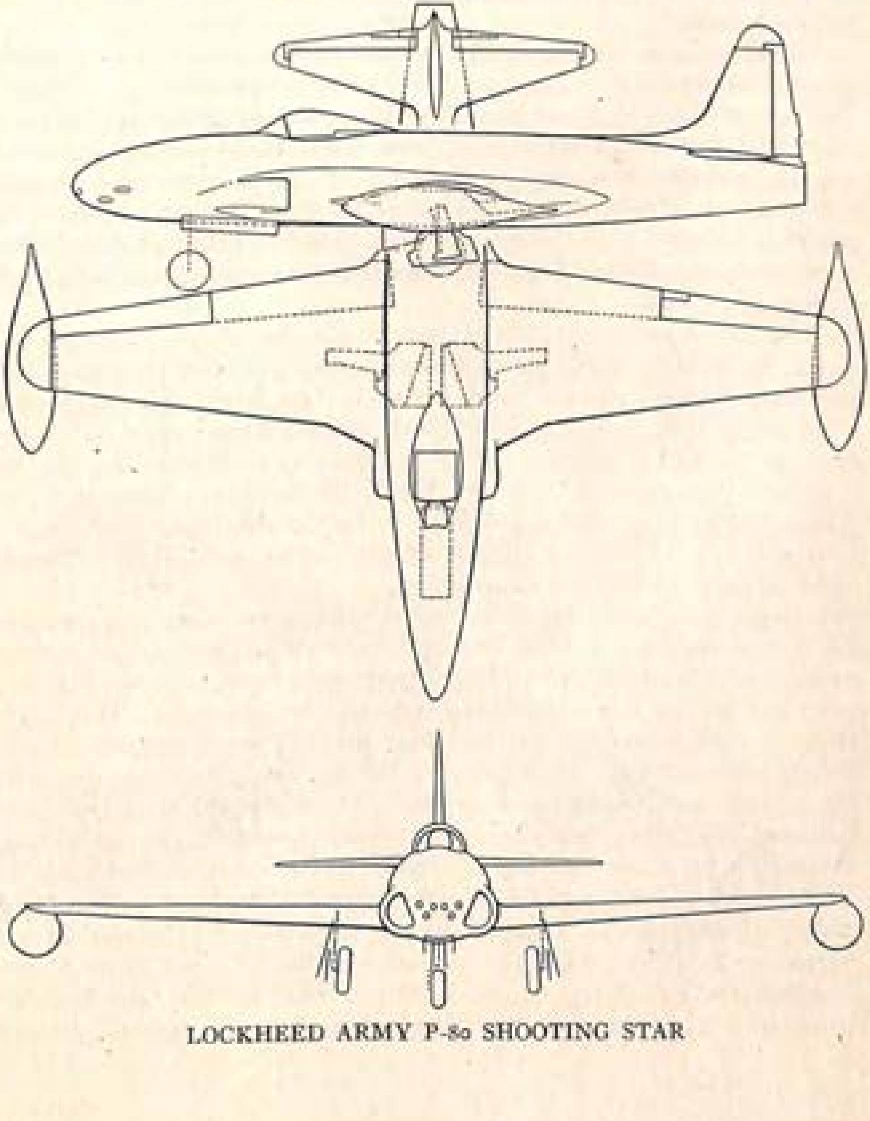
Kellett Aircraft Corporation, Upper Darby, Pa., found 1945—its 17th year of operation under one management—a year in which it attained the peak of wartime production, passed through the critical period of contract terminations after V-J Day when all but its experimental orders were cancelled and then made important strides toward conversion of its business by booking orders for several millions of dollars worth of aircraft and non-aircraft products for peacetime uses. During the early months of 1945, Kellett operated eight plants in the Philadelphia area on prime and subcontracts for combat aircraft parts and experimental helicopter work. In one month, deliveries were in excess of $2,000,000 worth of military products. This program came to an abrupt conclusion, reflecting the experience of the entire aircraft industry, in August and September. During the war period, Kellett had produced more than $35,000,000 worth of military work, principally aircraft parts for the United States and her victorious allies.

After the termination of more than $12,000,000 worth of pending orders, Kellett proceeded with its experimental contracts calling for the production of prototype two-place and multi-place helicopters for the Army Air Forces. Even after V-J Day, the larger of the helicopters remained a confidential project, but the Kellett XR-8 craft was termed by the AAF to be one of the most maneuverable and promising of advanced helicopters. The XR-8 incorporated two pairs of rotors, intermeshing and rotating in opposite directions. It was powered by a 245 h.p. Franklin aircooled engine.

Entering 1946, Kellett was prepared, through an extensive development program projected over a considerable period into the future, to translate its experience with experimental military helicopters into commercial types. Confident of the ability of the American helicopter industry to produce useful, practical and reliable helicopters for transport, survey and other specialized applications, the company planned to pioneer in that direction. Kellett also was participating in the Army Air Forces C-82 Packet cargo plane program as a subcontractor to Fairchild, producing the complex tail pylon assembly in quantity.

Lockheed Aircraft Corporation, Burbank, Calif., produced 19,273 warplanes in the six and a half years beginning in 1939, when it started delivering warplanes to the British. In 1945, Lockheed production was 2,827 planes, including 1,553 P-38 Lightning fighters, 231 P-80 Shooting Star jet-propelled fighters, 26 Model 49 Constellation transports, both military and commercial, 466 new Navy PV-2 Harpoon search bombers and 551 B-17 Flying Fortress bombers. Experimental and prototype models also were in production, including a new long-range Navy transport and the P2V Neptune, Navy patrol bomber.

After V-J Day, contracts were cancelled for the P-38, military Constellations and the PV-2 Harpoon bombers. Experimental contracts continued for both the Army and the Navy, and the Shooting Star, the first jet plane to go into mass production, continued on Lockheed assembly lines with schedules for delivery of more than 900 planes in 1946 and 1947. The Shooting Star had a wing span of 39 ft., length 46 ft. 6 in., height 11 ft. 4 in., weight of 8,000 lbs. empty and a service ceiling of 45,000 feet. It was powered by an I-40 gas turbine unit developing a jet thrust of 4,200 lbs. Three Shooting Stars were flown across the country from Burbank to New York at record speeds on January 26, 1946. Their pilots were Col. William H. Councill, Capt. Martin L. Smith and Capt. John S. Babel. They left the Army Air Base at Long Beach, Calif., taking off on instruments because of fog that hid half the runway. Captains Smith and Babel were flying Shooting Stars with standard wing tip tanks holding only 150 gallons each; so they planned to refuel at Topeka, Kans. Col. Councill's Shooting Star had an extra large droppable fuel tank



LOCKHEED ARMY P-80 SHOOTING STAR

on each wing tip, and this let him carry 400 gallons more fuel than that carried in a loaded DC-3 transport. He took off with 1,145 gallons of kerosene jet fuel. The gross weight was 16,900 pounds.

"The flight as far as Kansas was very much routine for all of us," said Col. Councill. "We leveled out at about 35,000 feet, using oxygen to supplement our pressurized cockpits. We all wore the regular leather summer flying jackets and were plenty warm. It is hard to convince yourself that you are flying the fastest plane of the Army Air Forces. The forward motion seems too effortless to maintain flying speed. The clatter of a trainer at 100 miles an hour gives a greater sensation of speed than the quiet cockpit of the Shooting Star traveling almost six times as fast. Unless you keep your eye on the gauges all the time and believe your indicated air speed, that plane will fool you every time.

"There was no roar of a giant engine—only a quiet swishing sound which reminded me of coasting downhill in a free-wheeling Packard. The super General Electric turbo jet was developing up to 4,000 pounds of thrust just behind my back, but I could hardly hear it. I was at sustained cruising speed nearly all the way to save on fuel consumption. There was no vibration at all. I felt smooth, surging power whenever I advanced the single throttle lever slightly. But there was never the quick acceleration that snaps your head back with its forward thrust.

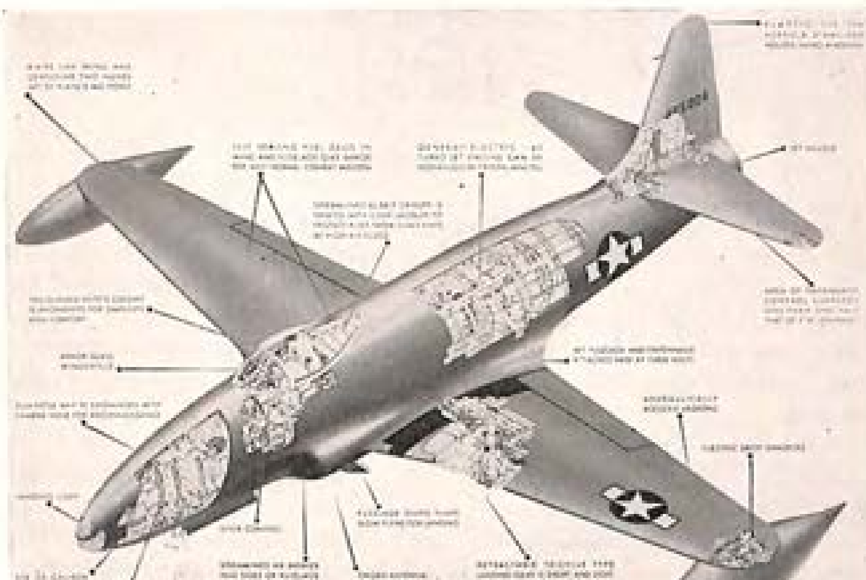
"At first I could not believe the old familiar check points on the Great Circle Course as I noted them on the flight plan. My knee pad recorded: 870 miles to La Junta, Colo., in 1:38; 1,020 miles to Garden City, Kans., in 1:55; 1,190 miles to Salina, Kans., in 2:09; 1,350 miles to St. Joseph, Mo., in 2:28; 1,475 miles to Kirksville, Mo., in 2:38½; 1,700 miles to Chanute Field, Ill., in 3:02; 2,050 miles to Akron, O., in 3:34; and 2,470 miles to La Guardia Field, New York, in four hours, 13 minutes and 26 seconds, an average speed of 584.82 miles an hour from coast to coast.

"Capts. Smith and Babel landed at Topeka for what was probably the fastest refueling job on record. Fourteen Lockheed field service experts were ready with four fuel trucks and a crew of ground men to meet and service the planes from any angle of approach. They were ready to change an engine if necessary in less than 18 minutes. Completely serviced, Capt. Babel was in the air again four minutes after his wheels had touched the ground. Capt. Smith, who had been bothered with a landing wheel door which wouldn't quite close, was delayed an extra two minutes while the special crew worked on it.

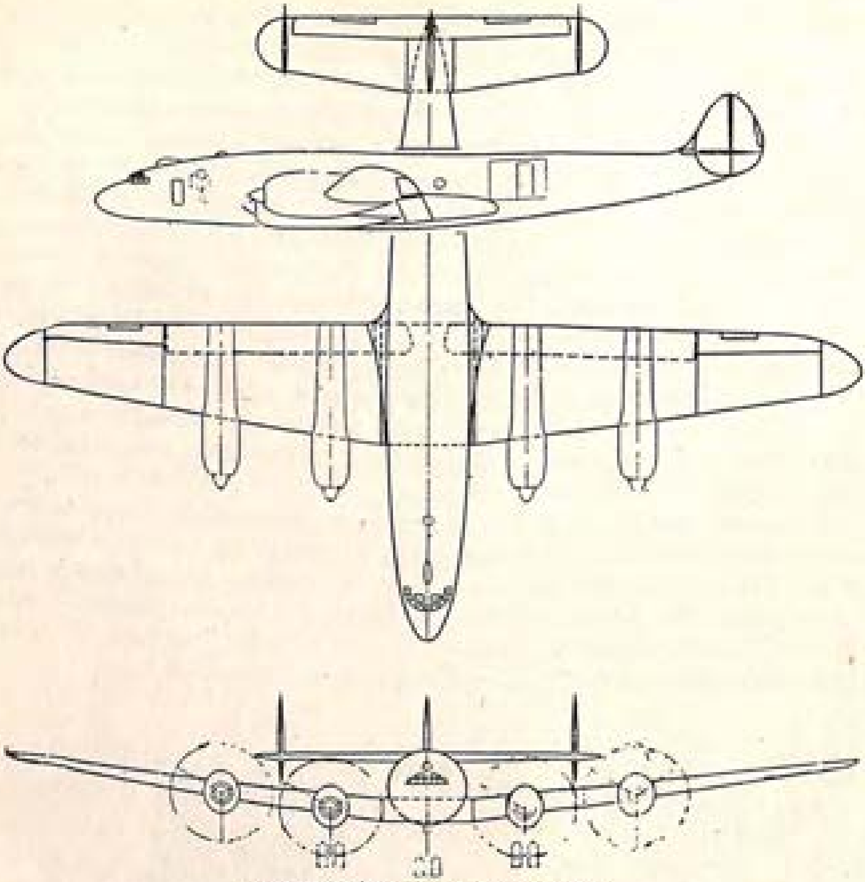
"Just after I jettisoned my extra large fuel tanks, I passed Capt. Smith climbing out of Topeka. In the vicinity of St. Joseph, Mo., I moved up to 41,000 feet. The perfect weather held out until Akron. But from there on, I was on instruments most of the way, and hit some turbulence when crossing the Alleghenies. In spite of that, I made my highest airspeed on that leg when I approached the rate of sound. I started my let down from 41,000 feet at Sunbury, Pa., and buzzed La Guardia at 2,000 feet. My indicator registered 615 miles an hour across the field. Upon landing, I still had left 120 gallons of kerosene."

Reconversion of the Lockheed Constellation transport, drafted for service with the AAF Air Transport Command, was accomplished swiftly. Designed before the war for luxury commercial transport, the Constellation was re-adapted readily to airline use when immediate cancellation of Army orders after V-J Day permitted concentration on commercial versions. To speed delivery for airline travelers, frills were omitted on these first reconversions. Later ships included all luxury items originally planned. During three years of wartime test-flying, Constellation performance was proved. The ship became the first of the postwar liners to go into service. Nine airlines flying global routes, announced purchases of more than 100 Constellations costing about $80,000,000.

The postwar Constellation, Model 649, carried 60 passengers and a crew of six. Its wing spread was 123 ft., length 95 ft. 1 in., fuselage height 18 ft. 8 in., tail height 23 ft. 8 in., cruising speed on 60 per cent of power 300 m.p.h., maximum range 5,000 miles, and over 3,000 miles with eight tons of payload. It was powered by four Wright Cyclone engines, each with a take-off rating of 2,500 h.p.



THE LOCKHEED ARMY P-80 SHOOTING STAR



LOCKHEED CONSTELLATION

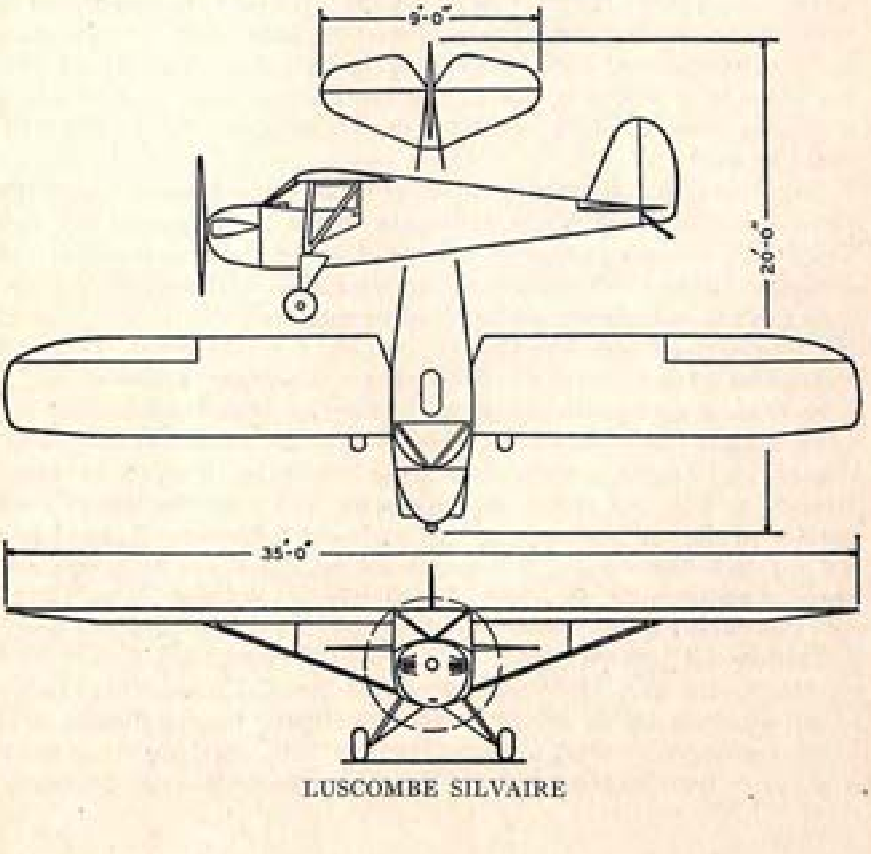
On the secret list, Lockheed was developing a still larger Constellation for the Navy and Lockheed had under development the Saturn regional transport, a twin-engine, 14-passenger airliner designed for feeder line service. Lockheed also was experimenting with a private plane, but did not intend to put it on the market until the company was assured that it had developed an outstanding aircraft for private owners.

One of Lockheed's important contributions to victory was the P-38 Lightning fighters, of which 9,923 were delivered to the Army Air Forces in 18 successively improved versions. The Lightning was used in all AAF combat zones as both high and low altitude fighter, escort, bomber, interceptor, photo reconnaissance, high altitude precision bomber, tank buster, ground strafer, smoke screen layer, and rocket carrier.

The Lockheed Navy P2V Neptune patrol bomber was a twin-engine, long-range plane designed for fast speed over great distances.

It had a speed of about 300 m.p.h. and a maximum range of 4,500 miles. It carried 8,000 lbs. of bombs, or huge aerial rockets. Wing rockets and machine guns covered every angle of the plane. It carried a crew of seven.

Luscombe Airplane Corporation, until V-J Day, manufactured all metal elements for military aircraft at its three plants in Trenton, N. J. More than 20 such elements were produced in large quantities, including bomb-bay doors and air scoops for the Grumman Avenger, fuel tanks for the Curtiss Commando, rudders and ammunition boxes for the Grumman Hellcat. Symbolic of its excellence in meeting these war demands, Luscombe was awarded the Army-Navy E. Early in 1945, Luscombe had acquired 700 acres of land at Dallas, Tex., and made plans for erection of a modern plant covering more than 100,000 sq. ft. Ground was broken for the plant in July, and in a short space of time the company was able to resume prewar production of the Silvaire line of all metal civilian light planes. Silvaires were rolling off the assembly line of the Texas plant in September. More than 500 persons were employed at the new factory. By the end of 1945, output had reached three planes a day and production was reported to be on a constantly upward trend.



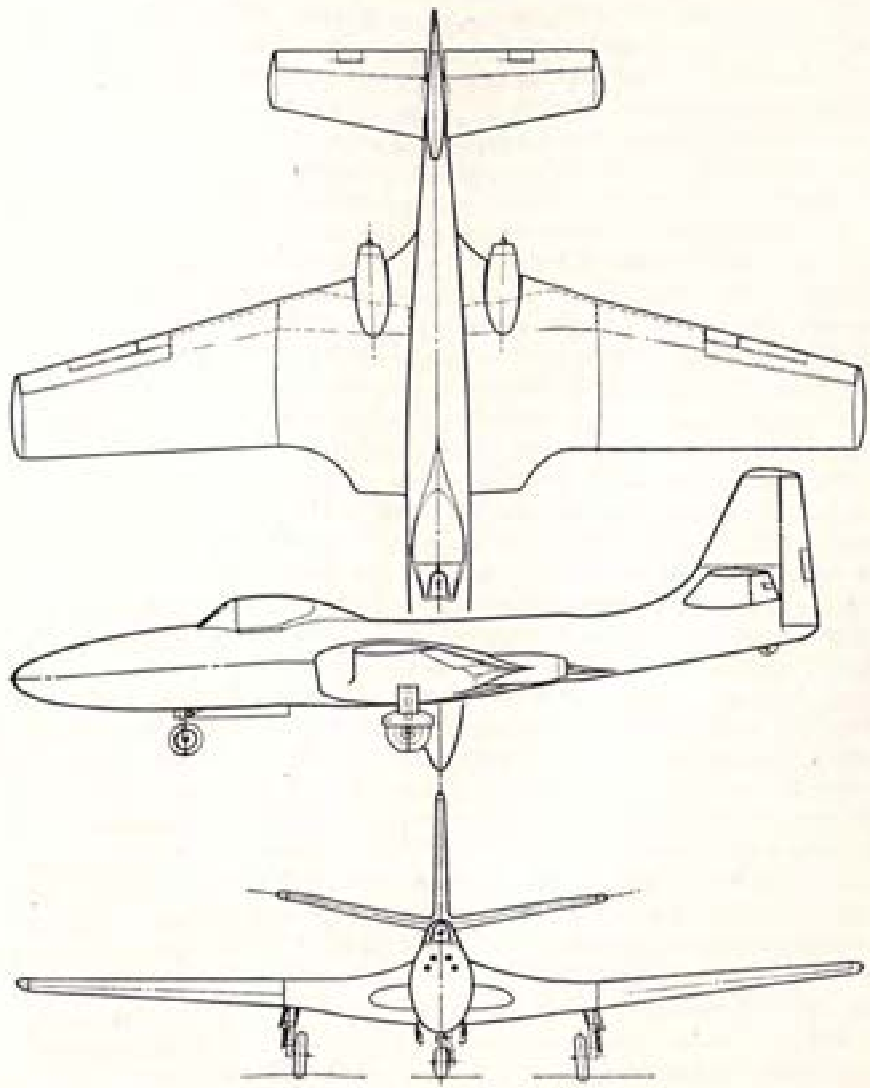

LUSCOMBE SILVAIRE

The Luscombe 8A Silvaire was a two-place, side-by-side, all metal, high-wing monoplane powered by a 65 h.p. Continental air-cooled engine. It had a top speed of 115 m.p.h., cruising speed 105 m.p.h., and landing speed of 40 m.p.h. With two persons and 55 lbs. of baggage, the plane carried sufficient fuel for more than three and a half hours of flight at cruising throttle. It had a stated rate of climb of approximately 750 ft. per min. with full load, and a ceiling of 15,000 ft. Early in 1946, Luscombe also was engaged in tooling for an 85 h.p. Silvaire, and its experimental department was engaged in several new models ranging from one to four-place planes.

McDonnell Aircraft Corporation, St. Louis, Mo., climaxed its long list of contributions to the war effort by designing and producing the first all-jet plane for the U. S. Navy. It was the FD-1 Phantom which was carried on the secrecy list until after the war. The Navy described it as follows: Already extensively flight-tested, the FD-1 had a service ceiling of well over seven miles and was the first Navy fighter to attain speeds in excess of 500 miles an hour. Primarily designed as an interceptor, it had an extremely high rate of climb and a range of approximately 1,000 miles. It was a significant milestone in the history of Naval Aviation as it opened the field of carrier operation to the all-jet interceptor. Power for the Phantom was furnished by twin axial-flow Westinghouse turbo-jet engines built into the wing roots. The engines, which were of exclusively American design, contained no long scoops or ducts. For conditions where take-off assistance was needed, either standard carrier catapults or JATO units could be used.

Built of light aluminum alloy, polished to glass-like finish, the FD-1 presented only slight resistance to the air it passed through. The Plexiglas cockpit canopy, set ahead of the engines, resembled an elongated bubble. All rivet heads were set flush, and the tricycle landing gear was completely enclosed when retracted. Total weight with full combat load was less than 10,000 lbs. A single-seat, low-wing monoplane of conventional monocoque design, the Phantom had a wing span of approximately 40 ft. The wings folded electrically, and when rigged for stowage the plane was only 16 ft. wide. Rocket devices and auxiliary belly fuel tanks could be dropped in flight. Despite its high top speed, the new plane had a landing speed comparable to that of conventional carrier-based fighters, and could take a flight-deck "wave-off." Armament, as the FD-1 was designed, consisted of standard fighter armament mounted in the nose. The XFD-1 was thoroughly flight tested and additional planes for further experimentation and service testing were to be delivered soon.

During the war, McDonnell produced about seven million pounds of airframe, largely on subcontract and including tens of thousands of control surfaces, cowlings, pressurized sections, anti-drag ring cowlings, more than 59,000 pieces of gun turret parts for the Liberator, pressurized sections for the B-29 and nearly 60,000 parts for Douglas planes. The AT-21 bomber-trainer was manufactured by McDonnell in its Memphis plant. The company also performed engineering services in connection with five other war planes of different manufacturers. McDonnell designed and built the XP-67 bomber destroyer and the XFD-1 jet fighter which was the prototype of the Phantom. McDonnell worked for some time in the field of guided missiles. Among them was the 1,000-pound, self-propelled, armor-piercing bomb flying by radio control at a speed of more than 600 m.p.h. as it



McDONNELL NAVY FD-1 PHANTOM

sought its target. The bomb, named the Gargoyle, was developed after more than a year of experimentation by the Navy and McDonnell Aircraft.

The war proved the necessity for pinpoint accuracy in the bombing of ships and ground installations and gun emplacements. From high altitudes it was difficult to make direct hits on targets of that type even with the finest of bomb sighting equipment. Variations in cross winds, surface winds, or evasive action taken by ships could cause misses by even the most accurately dropped bombs. Low level or dive-bombing eliminated some of the difficulties, but it forced the pilots to fly well within the range of enemy anti-aircraft fire and exposed them to considerable personal danger. The Navy foresaw the requirement for some type of missile which could be launched from a carrier-based airplane at such an altitude or such a distance from the target as to minimize the danger to the pilots and still could be relied upon to score hits with the pinpoint accuracy required. The Navy Bureau of Aeronautics studied this problem at considerable length, and came up with the specification for a bomb-carrying glider capable of being guided in flight by special remote control equipment. It was specified that this glider or aerial bomb must be capable of high speeds and have adequate control response so that the pilot, after launching it, could make corrections in its flight path and guide it to the target. The Gargoyle was the result. It was decided that a rocket type propulsion would be included which would be fired after release from the parent airplane and which would speed the aerial bomb up to the velocity required and push it out ahead of the airplane, so that visual contact could be maintained by the pilot. To assist the pilot in maintaining visual contact with the bomb, a powerful flare was placed in the aft fuselage of the Gargoyle, the flare being timed to start after release from the parent airplane. The flight of the aerial bomb was further stabilized by the incorporation of a system of gyroscopes. The gyroscopes or automatic pilot stabilized the flight against gusts or changes in attitude and held the missile on a straight flight path. The pilot, by radio control, changed the settings of these gyroscopes to effect changes in the course required to hit the target. The structure of the Gargoyle was designed to withstand extremely high speeds and to withstand the loads imposed by maneuvering at these speeds. The Gargoyle could carry either a general purpose bomb or a semi-armor-piercing bomb to provide for flexibility in use against various targets. It had a wing span of 8 ft. 6 in. and an overall length of 10 ft. 1½ in. A normal tail arrangement with vertical and horizontal surfaces would make it impossible to attach the Gargoyle under the fuselage of an airplane because the vertical tail would interfere. For this reason the V-tail was chosen for the Gargoyle so that it could be nestled up tight under the bottom of the fuselage of a carrier-based airplane without this interference. The V-tail provided both directional and altitude control, both surfaces operating together for altitude, or "pitch" control, and operating differentially for directional control. It appeared that the Gargoyle would be most useful in accurate bombing of small targets. It was the first in the line of development by the Navy of missiles to make possible pinpoint bombing of targets at less risk to pilots.

Before the war, the training of anti-aircraft gunners was accomplished by practice firing against cloth sleeves which were towed at some distance behind an airplane. In the early stages of the war, it was realized by our armed forces that this type of gunnery practice was not representative of all of the various types of attacks that could be made by aircraft. For this reason it was felt that the development of a target for use in gunnery practice which could be made to simulate all types of air attack was imperative. The Army Air Forces and the Navy Bureau of Aeronautics worked with a number of contractors and developed small target aircraft which were capable of flying under their own power and capable of remote control by radio. These small target aircraft, called "Drones," could be flown and controlled by a ground stationed observer and made to simulate high level bombing runs, dive-bombing attacks, low level torpedo runs, and most of the other tactical methods employed by enemy aircraft. With the progress of the war, the speeds of enemy aircraft increased, and it became apparent that target Drones which would operate at higher speeds and with general improvement in performance were necessary. With the introduction of "Kamikaze" attacks or suicide attacks by the Japanese, it also became apparent that a target Drone which presented a good target directly from the front was necessary. It was further recognized that Drones of sufficient size and performance to enable them to be used for aerial gunnery practice, in air to air firing, would be extremely useful. Our pilots and aircrew gunners would benefit from practice against these realistic targets.

With these requirements in mind, the Navy worked together with McDonnell Aircraft in the development of a somewhat larger, heavier, and higher performance target Drone. The result of this work was the KDD-1 aircraft, called the Kadydid. The power plant chosen for the KDD-1 was a resonating jet engine of the type used by the Germans in the "buzz bomb." This type of power plant was extremely simple and of light weight. It could be manufactured very inexpensively. The power plant was approximately 7 in. in diameter and 6 ft. long. It produced roughly the equivalent of 45 h.p. at the speeds at which the target operated. The jet engine also was designed, developed, and tested by McDonnell Aircraft working in conjunction with the Bureau of Aeronautics. For flexibility in operation, provisions were made for launching the Kadydid either from a catapult or from a carrier-based airplane in flight. It was so designed that it could be suspended from a conventional bomb rack—thus enabling the control or parent airplane to take the Kadydid to the firing area at sea and release the target. The target carrier then became the target control or parent plane. The V-tail configuration was chosen for the same reason that it was chosen on the Gargoyle—to provide clearances on an airplane carrying it and, in addition, to simplify the power plant arrangement. The Kadydid was provided with a parachute packed under the forward hatch, which could be released by radio signal. When the parachute was released, the jet engine was turned off automatically. The Kadydid then floated down to earth on the parachute, and was recovered for future use. It had a wing span of 12 ft. 2.6 in. and an overall length of 11.1 ft. The speed in level flight was in excess of 200 m.p.h., and it could be increased at some expense in range and endurance. It was designed for an endurance of 40 minutes and could simulate during flight all maneuvers normally performed by enemy aircraft. Drones of the Kadydid type proved most useful during the war, and they were to be used in peacetime to assure that our gunners were the best trained in the world.

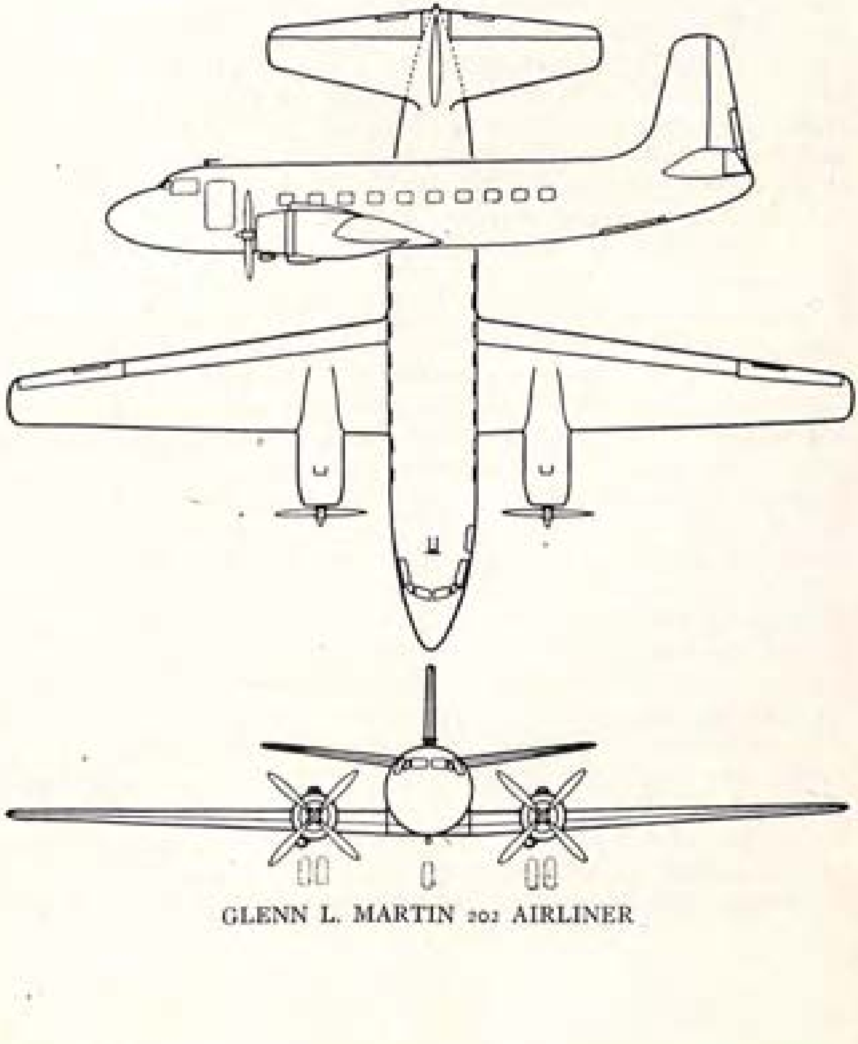
McDonnell Aircraft also was doing development work on four-place personal airplanes and utility twin-engine helicopters.

The Glenn L. Martin Company, Baltimore, Md., which during the war had produced many different types and models of aircraft for the air forces of the Army and Navy, had an expanding postwar program for development and production of new planes for the Services and the airlines.

The beginning of the last year of war had found Martin's Baltimore and Omaha plants engaged in production on four major war contracts, PBM Mariners and the JRM Mars at the Baltimore plants, both for the Navy; and B-26 Marauders at Baltimore and B-29 Superfortresses at Omaha for the Army Air Forces. Production of power-operated turrets for use on Marauders, Liberators, PV2s, Havocs, RAF Lancasters and other planes had topped 40,000, making the Martin organization the leading supplier of this type of equipment. The Marauder contract was completed in March, 1945, because the AAF had enough of those planes to complete the European campaign, due to the remarkable loss ratio of the Marauder—less than one-half of one per cent—and, too, because the medium bomber was not especially adapted to Pacific warfare. The planes needed there could be reassigned from the European theater.

Production on a reduced order of PBM Mariners patrol bombers for the Navy continued throughout 1945. At the same time, production on the first of the giant 72½-ton JRM Mars flying boat was nearing completion; and on July 21, the Hawaii Mars, first of the line of 20 was launched with full Naval ceremonies at Martin's Strawberry Point seaplane base. During 1945, four more Mars were turned over to the Naval Air Transport Service to complete partially the reduced Navy contract of six.

Shortly after V-J Day, which brought about military contract cancellations and reduced employees from 55,000 to about 13,000, Martin engineers directed their efforts to finishing the design of the new Model 202, a 40-passenger luxury airliner, with the optional installation of auxiliary exhaust jet propulsion, which Martin had pioneered in 1939 on the B-26 Marauder. Designed from information culled by Martin field representatives who surveyed the executive and operations personnel of the largest airlines, the Model 202 went into tooling and primary production immediately on orders, which at the end of 1945, totaled more than $31,000,000 from five of the leading airlines for 155 of those new twin-engine transports. The Martin 202 was designed for domestic airline operations. It was a low-wing passenger-cargo transport designed for maximum speed of 306 m.p.h. and cruising at 270 m.p.h. Jet propulsion as an auxiliary would add 20 m.p.h. Its wing area was 860 sq. ft., length 71 ft. 11 in. and height



GLENN L. MARTIN 202 AIRLINER

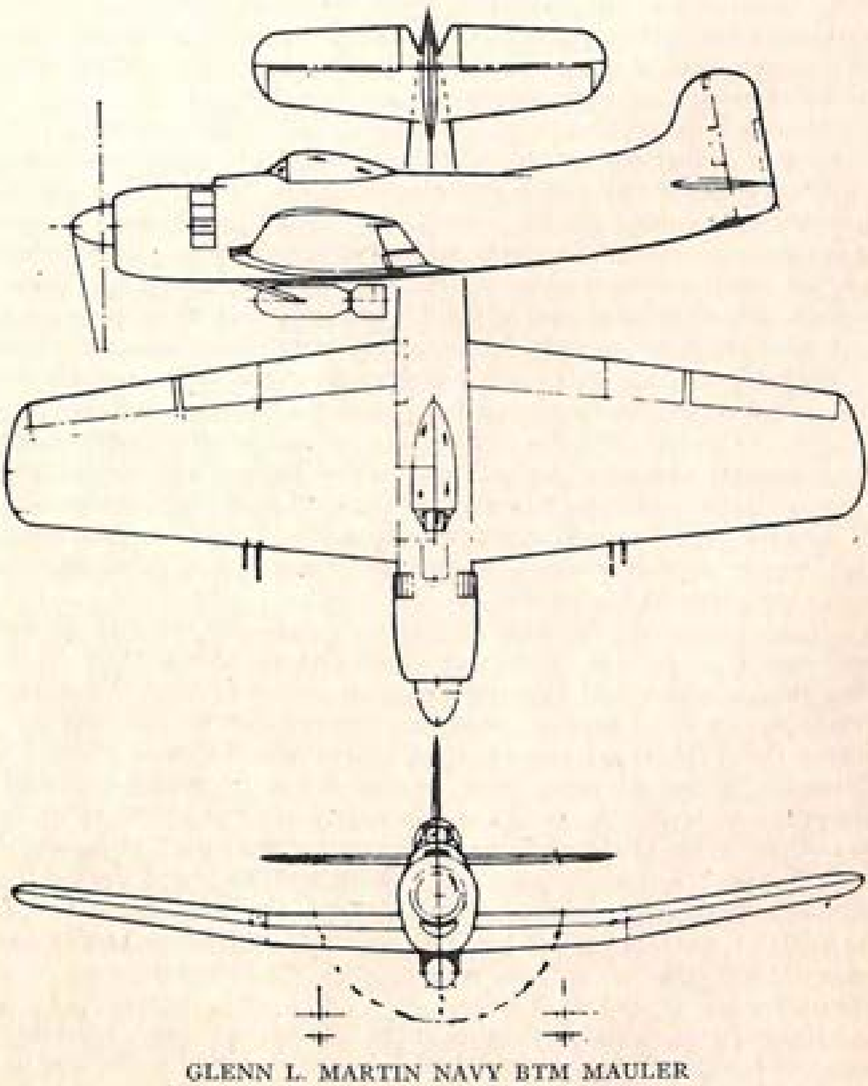
25 ft. Its wing spread was 92 ft. 9 in., its gross weight was 34,300 lbs. It was designed for a crew of three—pilot, co-pilot and a hostess. It could be equipped to carry 40 passengers. The 202 had a hinged door which dropped from the bottom of the engine nacelles. When it was lowered, a single step fitted into brackets and converted the floor into a working platform from which all oil pressure and fuel systems as well as fuel mixing equipment could be adjusted and inspected. A large reduction in the time necessary for ground servicing was made possible by a removable panel installed in the firewall between the engine and the wheel well. This panel made all engine accessories readily accessible to the mechanic. Another feature was the equipment arrangement in the under-floor plan of the fuselage directly beneath the passenger cabin. This space was divided into three separate compartments, each of which was reached from the bottom by an individual door in the outer skin. In addition to being lighted, equipment in each of the compartments was conveniently arranged on a relative basis so that all work on one particular type could be completed in one of the three sections. To airlines purchasing the Model 202, the Martin organization proposed a new service project in which the major overhaul work would be done at the company's plants where special facilities would be installed. This plan eliminated the necessity of each airline having extensive ships, parts, supplies and mechanics for heavy work. In addition Martin planned to build several ships and maintain them on a "stand-in" status, to be turned over to the airline on "lend-lease" when a ship had to be brought in for overhaul.

Martin also had an order for 35 Model 303 transports designed to meet specifications of United Airlines. United planned to create a "world's first fleet of 300-mile-an-hour twin-engine planes having pressurized cabins for low altitude comfort at high altitudes." Other new features were jet thrust augmentation for extra speed, heat deicing for the wings and tail and electronic automatic pilots for use in automatic instrument landings, as well as in regular airway operations. United's order called for 35 of the planes at a cost of approximately $9,000,000, with an option to purchase an additional 35 planes.

With an eye to future overseas operations, the Martin organization announced design of a larger Mars. The new proposed double-decked ship was scheduled to have ultimately a gross weight of 82½-tons, as compared to the 72½-ton weight of the Navy's JRM Mars. An important feature of the air giant was that fully 52.5 per cent of its gross take-off weight would be devoted to useful load in the cargo model. The proposed passenger version was to have a useful load of 48.1 per cent.

In November, 1945, Martin completed for the Navy the XPBM-5A, the largest amphibian airplane ever built. A modification of the PBM Mariners, the huge 30-ton amphibian was specifically designed for use in areas where climatic conditions are quick-changing and exceptionally hazardous. The amphibian utilized a new tricycle landing gear of Martin design, the main wheels making a 180-degree turn to rest in the side of the hull and the forward wheel folding into the nose hull area.

The best features of the Martin Mariner were retained throughout the new amphibian. The flight deck and tail assembly were identical with the PBM-5; the hull section forward, where the landing gear was located, had been completely redesigned, with bulkheads reinforced to carry loads, new floor frames and stronger beams. The land-



GLENN L. MARTIN NAVY BTM MAULER

ing gear was so constructed that the main wheels operated on a single steel trunnion. Hydraulic power hoisted as well as lowered them, and they automatically operated into a locked position. Although the new gear was exceptionally strong, its weight plus that added by the consequent hull redesign, had increased the total weight of the ship only 4,500 lbs. With this addition, the airplane had a gross take-off weight of only 64,000 lbs. on land and 56,000 lbs. on water.

One of the latest Martin developments was the BTM Mauler, a Navy torpedo-bomber designed for operations off the new large aircraft carriers of the Midway class. It was a heavy, long-range multipurpose plane which the Navy pronounced the most powerful single-place plane of its type. Its level flight speed was over 350 m.p.h., maximum range over 1,700 miles, 4,000 lbs. of bomb or rocket load, or alternate load of one torpedo with bombs or rockets. It was built to withstand vertical dive speeds of more than 500 m.p.h.

Meyers Aircraft Company, Tecumseh, Mich., had a wartime production of numerous welded, machined, and sheet metal assemblies for various prime contractors manufacturing the Army CG4-A glider. In addition to this, Meyers manufactured spare parts, such as gas tanks, fairings, oleo shock struts, welded tubular structures, and other aircraft components for naval aircraft. Hundreds of 2,200 h.p. motor mounts also were fabricated at the Tecumseh factory. The company's war activities were brought to a successful conclusion before the end of 1945. During the war, in addition to the parts mentioned above, the company had manufactured three models of Meyers trainers, the OTW, OTW-145, and the OTW-160 for use on the Government pilot training program. Large quantities of various assemblies used on Link trainers also were produced. Early in 1946, two new models of personal type planes were under construction. One was a low-wing, twin-engine executive type airplane, and the other a single-engine, low-wing personal type plane.

North American Aviation, Inglewood, Calif., at the end of the war was in production on the latest versions of three aircraft of its own design which had been rolling from assembly lines when Jap bombs fell on Pearl Harbor. With wartime refinements and improvements, the AT-6 Texan trainer, B-25 Billy Mitchell bomber and P-51 Mustang fighter still were being produced for the armed forces at the war's end. North American Aviation had been called upon to keep three different types of planes in continuous production throughout the war. The latest trainer, the AT-6F and SNJ, and the P-51D Mustang were in production at Dallas, Tex., the B-25H and B-25J and PBJ-1 were being produced at Kansas City, Kans., while the parent plant adjacent to Los Angeles Municipal Airport was concentrating on the P-51H Mustang.

Ready for quantity production at the West Coast plant, following successful tests of experimental models, was the unique and versatile

P-82 Twin Mustang, the world's first twin fuselage military aircraft.

The Dallas plant also was swinging into production on the Fairchild C-82 Packet cargo plane for the Army Air Forces when the war ended. Starting preliminary work in January, 1945, the plant rushed its tooling program to conclusion in time to complete and fly the first "flying boxcar" on August 3, just 30 days ahead of schedule. At the Kansas plant, a remarkable tooling job also was done for production of another company's design, the Lockheed P-80 Shooting Star jet-propelled fighter. Tooling was 80 per cent complete, the first airplane 78 per cent complete, and detail parts were in production when the Army Air Forces cancelled the contract on May 26, 1945. The tooling programs at the Dallas and Kansas plants were carried out in the midst of high speed production. In January, 1945, the Kansas plant reached its peak production with 315 planes turned out in 23 working days, plus an equivalent of 20 more in spare parts.

North American's West Coast plant set a national production record in January, 1945, for a single type airplane from one plant by production of 571 Mustang P-51 fighters during the month. The C-82 Packet produced at Dallas was the fourth type of plane built in the Texas facilities, marking the fourth complete tooling program carried out from the time the plant opened in March, 1941. Besides the AT-6 Texan, P-51 Mustang and C-82 in production at the war's end, the Dallas plant previously had produced the B-24 Liberator.

With Japan's surrender, North American Aviation ceased operations in Kansas City and Dallas and returned those facilities to the Government. All operations again were centered at the company's West Coast plant, where the P-51H was in production until November. It was supplanted by the P-82 Twin Mustang, while tooling, engineering and research work continued on five secret type airplanes.

With completion of the P-51H program, North American had built 15,302 fighters since the start of the national defense program in July, 1940, representing 14.1 per cent of all the fighters produced in the United States during that period. North American also produced 10,784 B-25 Mitchells and B-24 Liberators during this time, 11.2 per cent of the nation's bomber production, and 15,117 AT-6 Texans, 25.8 per cent of all the trainers built in the United States for the corresponding period. From the start of the national defense program until cancellation of war contracts, North American Aviation produced 41,203 trainers, fighters and bombers, more than 13.6 per cent of the total produced in the United States during that period.

That the start of 1945 found the armed forces "over the hump" in aircraft requirements was indicated by the gradual decline in airframe pounds for the first six months compared to 1944. After peak production in January, 1945, production schedules were tapered gradually. During the first six months, North American produced 49,974,327 airframe pounds compared to 67,319,346 for the corresponding period of 1944. Continued production efficiency during 1945 brought renewals of Army-Navy E Awards, and the company ended the war with a total of nine separate awards or renewals for the three plants.

During the year, Mustangs became part of neutral Sweden's air force when the U. S. Army sold 50 P-51s to that country, while production of the fighter was started in Australia by the Commonwealth Aircraft Corporation under a licensing arrangement. At Dallas, a limited number of Mustangs were modified for training purposes at the request of the Army Air Forces, the first front line single-seater plane adapted to dual instruction. The two-place version was designated the TP-51.

Developed in cooperation with the Air Technical Service Command, North American designed a standardized armament control panel to eliminate operational errors and confusions, and to give pilots instant mastery over the armament in all types of pursuit planes.

With the switch of all hostilities to the Pacific, Mitchell bombers and Mustang fighters continued to play a leading role in the aerial war against the enemy. The eight-gun nose version of the B-25H was thrown into action, and U. S. Marine Corps pilots surprised the Japs by adapting the PBJ to night fighting, with deadly results. Mustangs scored another first in April when they raided Tokyo from Iwo Jima, the first land-based fighter planes to strike the Jap capital. From Iwo, the Mustangs ranged far and wide, escorting the B-29 bombers and bombing and strafing enemy installations.

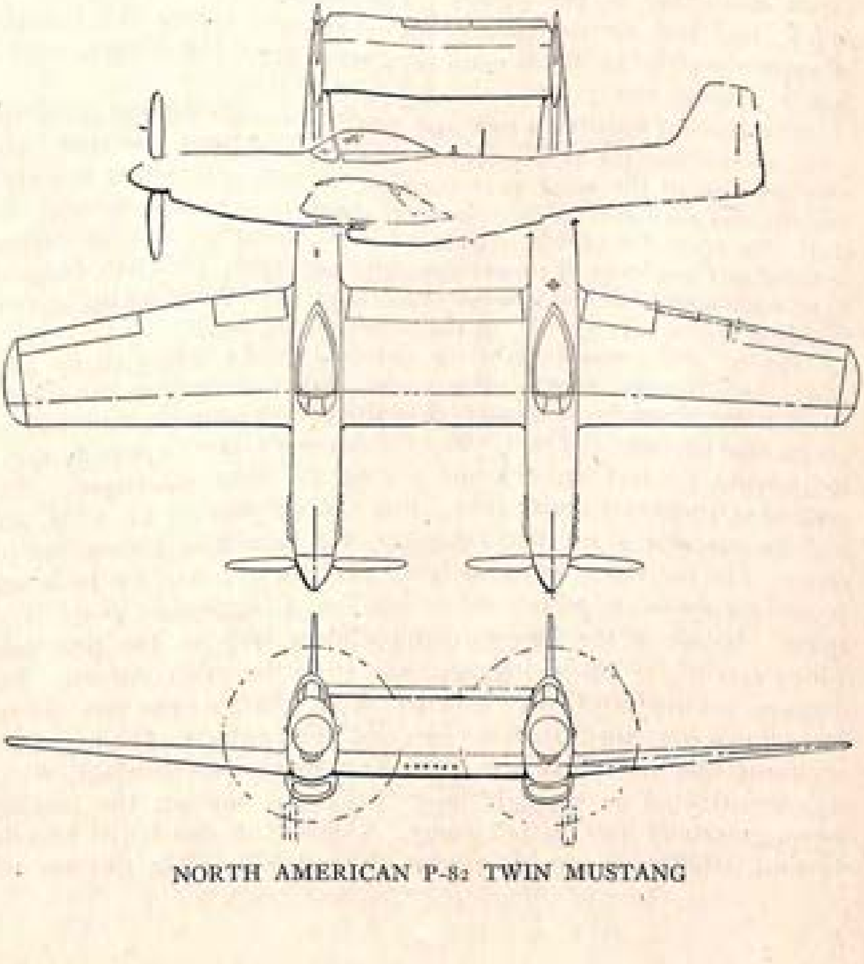
Development of the P-51H represented the ultimate in refinement of the Mustang, first fighter designed on the basis of World War II combat experience. Radically different under the skin, the P-51H had greater range, ceiling and speed than its predecessor, which had won recognition as one of the world's fastest propeller-driven airplanes. North American engineers reduced Mustang weight 700 lbs. in the H model, and at the same time strengthened the plane 10 per cent throughout. The engine mount alone was 40 per cent lighter. Aerodynamic improvements made it possible to boost the effective combat range 37 per cent without adding to the fuel load. The power plant was developed around a Packard-built Rolls-Royce V-1650 engine, utilizing a fuel injection pump and a new four-bladed Aeroproducts propeller.

In November, 1945, North American announced the P-82 Twin Mustang, the world's first twin fuselage military airplane. Designed for ultra long-range duty, the P-82 could be adapted as a light bomber, attack bomber, escort, photo reconnaissance or night fighter. Carrying a pilot in each fuselage, the plane was joined by the wing and horizontal stabilizer. It could fly at over 475 miles an hour and had a combat range of over 2,500 miles carrying its full armament. Its ceiling was 45,000 ft. Powered by two Packard-built 12-cyl.

V-1650 Rolls-Royce engines each generating 2,200 h.p., the Twin Mustang had full feathering, four-blade Aeroproducts propellers. A unique feature was the four-wheel landing gear arrangement of two main gear assemblies and two steerable tail wheels.

The Twin Mustang's armament was six .50-cal. machine guns, 25 rockets and four bombs. The six guns were in the center wing section. The five rocket launching racks could carry five rockets each. Each of four bomb racks, one on each outer wing and two on the center wing section, could carry a 1,000-pound bomb. A special shackle in the center wing section could carry a nacelle of eight .50-cal. machine guns, a 450-gallon droppable fuel tank, camera installation or radar equipment. The Twin Mustang's wingspread was 51 ft. 3 in.; length 38 ft. 3 in.; height 13 ft. 8 in.; total wing area 408 sq. ft.; weight empty 14,350 lbs.

North American had in use a new altitude-pressure chamber, one of the largest in the aircraft industry. With the Twin Mustang



NORTH AMERICAN P-82 TWIN MUSTANG

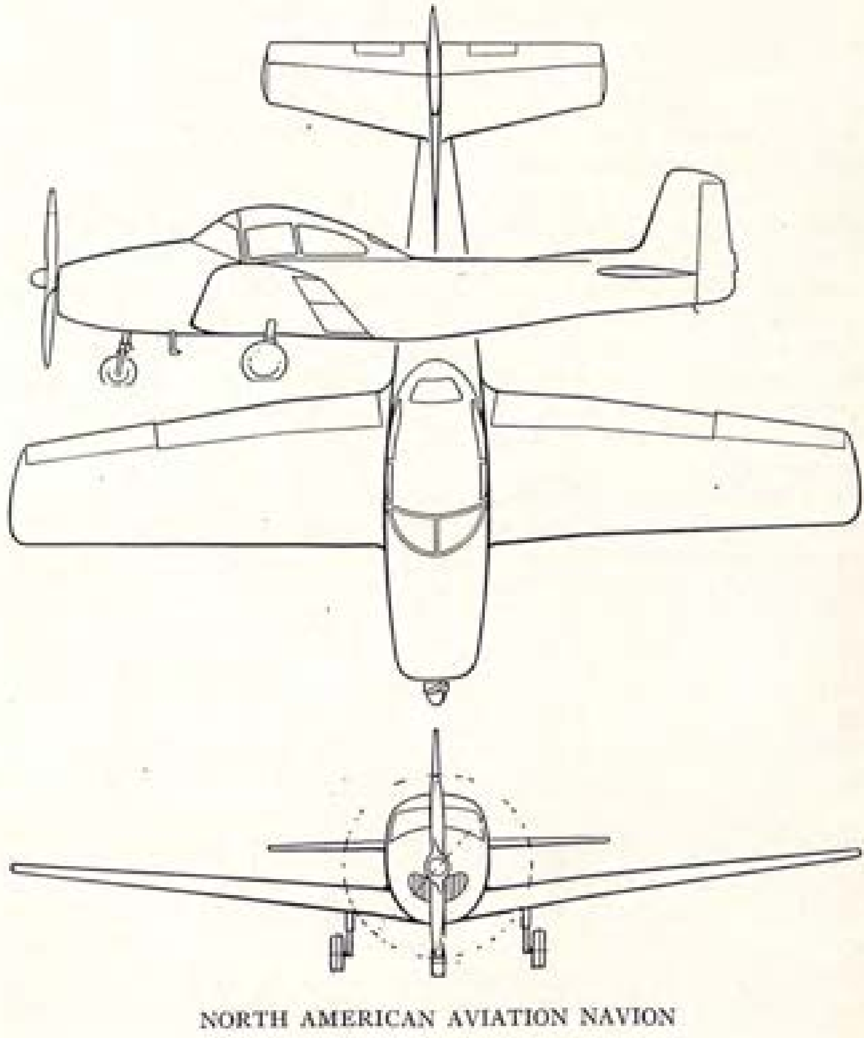
in production, and five secret type airplanes in development stages, the company embarked on the most extensive engineering and research program in its history. Capable of creating any kind of climatic condition, the new chamber provided test facilities for future aircraft with vast improvements in speed, altitude and performance, and radical changes in design.

North American Aviation entered the personal airplane field in April, 1946, with the Navion, an all-metal, 4-place airplane, with dual controls, a full vision canopy and a power retractable tricycle landing gear with a 20-degree steerable nose wheel for easy handling on the ground. The Navion had a wing span of 33 ft. 5 in., length 27 ft., height 9 ft., weight empty 1,551 lbs., gross weight 2,570 lbs. with useful load of 1,019 lbs. The useful load included 10 quarts of oil and 40 gallons of gasoline in the two 20-gallon pressed steel wing tanks. It was powered by a Continental aircooled 185 h.p. engine. Its top speed was about 160 m.p.h., cruising at about 150 m.p.h., with maximum range about 700 mi. Its take-off run was 695 ft. and its climb about 830 ft. per minute. The stalling speed was about 53 m.p.h. and the service ceiling approximately 15,600 ft. Landing at approximately 54 m.p.h. with 40-degree flaps, the Navion used a 605-ft. ground run.

The Navion featured a new and specially designed wing providing good aileron control at low speeds when approaching the stall. The root sections of the wing were the first to stall, eliminating tendency to roll, and maintaining good aileron control up to and through the stall. An up-in-the-middle curvature of the wing tip sections further reduced any tendency of those sections to stall first. This was designed to provide a smooth and gradual flow of air over the wing tip section, avoiding the abrupt "bend" in the conventional wing.

Taking into consideration the personal pilot's desire to fly anywhere on pleasure, sports or business, North American installed a large nose wheel to eliminate difficulties normally encountered on rough field landings and take-offs. The Navion's interior was designed to provide comfort, luxury and styling for four passengers. The ventilated enclosure under the sliding canopy was 43 in. wide, and had the roominess and appointments 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, which carried 80 lbs. of luggage, was from the cabin interior. 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. A dorsal fin was faired into the vertical stabilizer to provide 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 removed easily.

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 six-cylinder engine could be reached easily 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



NORTH AMERICAN AVIATION NAVION

pedal controls for the pilot and co-pilot. The co-pilot's controls could be removed easily and quickly, so the right front seat could accommodate a non-pilot passenger. The rubber-mounted instrument panel was designed so that the basic instrument arrangement would not be altered radically when additional instruments for night or instrument flying were installed. Designed and constructed for practical use in all types of personal flying, the Navion interior offered possibilities for wide and diversified uses of the airplane. Through removal of the rear seat and the right front seat, additional space could be obtained for farmers, salesmen or sportsmen desiring to use most of the space for heavy and bulky loads. The luggage compartment could be converted to carry photographic equipment for aerial surveys, or equipment for any other special purpose.

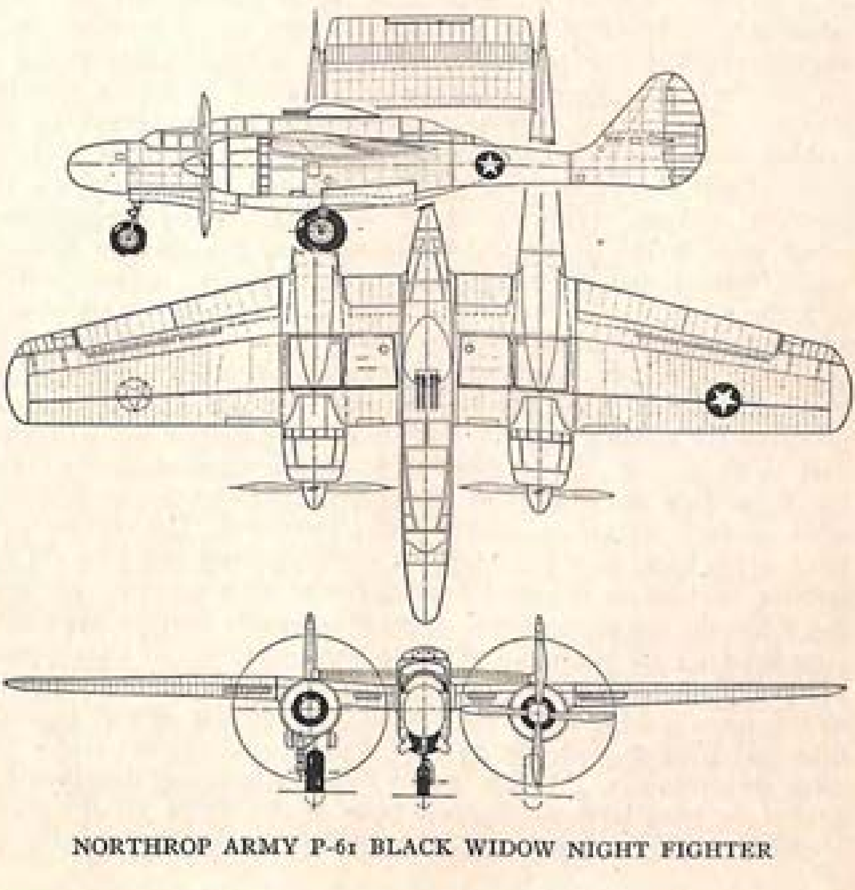
Northrop Aircraft, Inc., Hawthorne, Calif., delivered the last of its production order of P-61 Black Widow night fighters in January, 1946, and continued development work on secret military orders, at the same time carrying on important conversion and reconversion work on various types of passenger and cargo planes. The Black Widow had won lasting fame as one of the most deadly combat planes of the war, and the Japanese pilots feared it as an avenging angel whenever they encountered the night fighter over the vast battle fronts of the far Pacific. The Black Widow had a wingspread of 66 ft., length 48 ft. 9 in., and a crew nacelle 33 ft. 10 in. long and only 49 in. wide. It was powered by two Pratt & Whitney 2,000 h.p. Twin Wasp engines. Its armament consisted of 20 mm. cannon and in a revolving turret four .50-cal. machine guns or other combinations fired by remote control. It had a high speed and exceptionally long range, and could stay up over enemy territory for hours searching for bombers.

Speed, maneuverability, heavy firepower and the "cat's eyes" imparted by radar in the midnight skies, made the big and powerful pursuit ship a formidable adversary on the western front as well as in the Pacific. Hundreds of Nazi and Japanese planes were reduced to junk heaps by the "black magic" of the Widow, which was the first plane specially designed for the job of night-fighting. Enemy supplies, installations and mobile equipment flamed into ruins under her .50-cal. machine guns and 20 mm. cannon, and long troop columns were broken up by the onslaught of the savage night fighter, which also blew up many ammunition trains.

As the invasion army slammed hard at German forces in France, Black Widows went along—striking at enemy mechanized convoys, troop columns, supplies and aircraft. They ranged into Germany at night and struck down enemy raiders over Allied lines. The deadly results were recorded in news dispatches after D-Day, which credited Black Widows with being "largely responsible for 239 German planes destroyed and 209 probables." Junkers 88s, FW-110s and Messerschmitts alike were prey for the Black Widows, which showed themselves capable of destroying anything in the air—including the lethal German buzz bombs that were sped across the channel toward England. The spectacular night fighter was used effectively in defense and intruder missions. When von Rundstedt gathered his forces and pounded a salient through the Allied lines late in 1944, Black Widows were credited from unofficial sources at the front with having had a large share in the job of hammering back the bulge. It was described as a "holiday of hell" when the P-61s swarmed over the breakthrough area to dissipate aerial strength mustered by the enemy.

Meanwhile, the Black Widow was earning the respect of pilots in the South Pacific, where it was eminently successful in driving off Jap bombers which had been keeping them awake night after night. The night fighters knocked down twin-engine enemy bombers which were raiding Biak and Owi islands; smashed Jap attacks on the B-29 Superfortress bases on Saipan; broke up Jap attempts to sink American shipping participating in the Philippines invasions.

Northrop Aircraft's total war production included 674 Black



NORTHROP ARMY P-61 BLACK WIDOW NIGHT FIGHTER

Widows, 24 N3PBs, 400 Vengeance dive-bombers, 1,309 sets of tail surfaces, 1,291 sets of nacelles and cowls for PBY5s and 44,832 cowls and 25,068 nacelles for Flying Fortresses.

In order to maintain the staff which had become exceedingly proficient in production techniques of aircraft and light metals, Northrop diversified its activities; acquiring two subsidiaries, Northrop Gaines, Inc., manufacturers of industrial wheels and materials handling equipment, and Salsbury Motors, Inc., producing 6 h.p. gasoline engines, automatic clutches, variable speed transmissions, scooters and turret trucks. Another affiliate, Northrop-Hendy, Inc., was owned jointly in equal shares by Northrop and Bechtol, McCone Corporation.

One of the Northrop wartime developments applicable in postwar aircraft was the Northrop retractable aileron, described by the company as follows in part: "It was designed to incorporate in the Black Widow fullspan flaps which made it possible for the plane to land at slow, safe speeds on small landing strips under conditions of extreme low visibility, and to give the Black Widow, which was as big as a medium bomber, an unusual degree of maneuverability. The retractable aileron system of the Black Widow was a combination of the conventional type and four 'retractable aileron' panels linked to the aileron control system. These panels worked in unison with the ailerons. The entire system was controlled by the wheel in the cockpit. Roll was induced almost entirely by the retractable ailerons. Under flight conditions, there was an opening moment on the retractable ailerons. Were it not for the small conventional ailerons which were linked to the retractable ailerons, this opening moment would be translated into a disposition to over-balance. In other words, once the wheel was moved from the neutral position, the retractable aileron would tend to continue its travel out of the wing until fully extended. There was, naturally, a trailing moment on the small conventional aileron. This trailing moment was just great enough to overcome the opening moment of the retractable ailerons and to impart 'feel' to the system. As the speed of the airplane increased, the opening moment on the retractable ailerons and likewise the trailing moment on the conventional ailerons were increased. The trailing moment on the latter increased at only a slightly greater rate than did the opening moment on the retractable ailerons. As a consequence, control forces did not increase with speed in anywhere near the same proportion as did the forces of ordinary aileron systems. At high speeds, because of the fact that less force was required, the control could be moved more quickly and, hence, a more rapid rate of roll attained than was possible with the average conventional system under the same circumstances. At slow speeds with the flaps up, the effectiveness of the retractable ailerons was equal to that of the usual system. However, with the flaps down, effectiveness (as expressed in terms of rate of roll with full aileron deflection) was approximately 40 per cent greater than that of the average conventional installation. In addition, the retractable ailerons retained effectiveness down to and past the stall. The ship would roll from side to side in quick response to the wheel. Likewise, the ship could be held straight during a stall with one engine windmilling, while the other was at take-off power."

Among the important projects which Northrop Aircraft had under way early in 1946 were the Northrop Flying Wing XB-35 experimental bomber for the Army Air Forces, the Northrop F-15 Reporter photo reconnaissance plane for the AAF and the Northrop Pioneer, a plane for private owners. The XB-35 was the latest of the all-wing designs of John K. Northrop which he had conceived first in 1923. More than a dozen flying wing models had been produced during the years prior to 1942 when work was started on the XB-35. The Northrop Jeep, first flown in 1940, had made hundreds of successful flights. The N9Ms, which were smaller models produced in connection with the XB-35 project, were flown successfully. The XB-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 four 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 XB-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 XB-35 carried a crew of nine—pilot, co-pilot, bombardier, navigator, engineer, radio operator and three gunners. Cabin space was available for six 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 nine 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 XB-35 was produced at an estimated overall cost of $13,000,000.

The Northrop F-15 Reporter 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 Reporter was designed for photo reconnaissance.

Northwestern Aeronautical Corporation, St. Paul, Minn., produced combat gliders of Waco design during the war; and after V-J Day, acquired special Government contracts, besides doing reconversion work on C-47 planes.

Piper Aircraft Corporation, Lock Haven, Pa., had a war production of more than 5,000 Cub two-place Army liaison planes which were nicknamed "grasshopper" and used over all our battlefronts. From V-J Day to March 1, 1946, Piper delivered more than 1,400 planes for the private owner, and was expanding plant facilities for production of 50 planes a day. The company stated that it had cash deposits on orders aggregating more than 6,000 planes.

The Piper "grasshopper" plane for the Army at first was designated the O-59, a two-place observation, and later it became the L-4 liaison. During the war, Piper production facilities were only 50 per cent operative, because Army requirements for the L-4 airplanes were not sufficient to keep the plant working at full capacity. Having extensive, well-equipped welding facilities and spacious assembly halls, Piper was awarded a contract for the manufacture of sorely needed secret radar equipment for the Signal Corps. This project, known as the ESD, consisted of a large welded steel tube structure, which with its component electrical control parts, was the reflector screen of radar units used to detect aircraft. During the peak production period, over 300 such units were made monthly. Toward the end of the war, Piper was awarded another contract for an improved radar device, the TPX. It was a portable radar set of a 17-foot sectional mast with reflector mounted so that it could be turned through a 360-degree arc. With all electrical equipment installed, this improved unit was receptive in a 1,000 sq. mi. area.

For the Navy, Piper subcontracted and manufactured a parabolic radar reflector. It was a steel reinforced aluminum reflecting antenna which, when connected with its electrical chassis, was used for radar protection aboard Navy ships. Effective range of this type of radar unit was 22,000 yards. In addition, a Navy TDZ chassis and test harness also were produced. Both items involved aluminum fabrications and welding, as well as a large amount of basic electrical assembly work. These items were integral parts of a new Navy radio development.

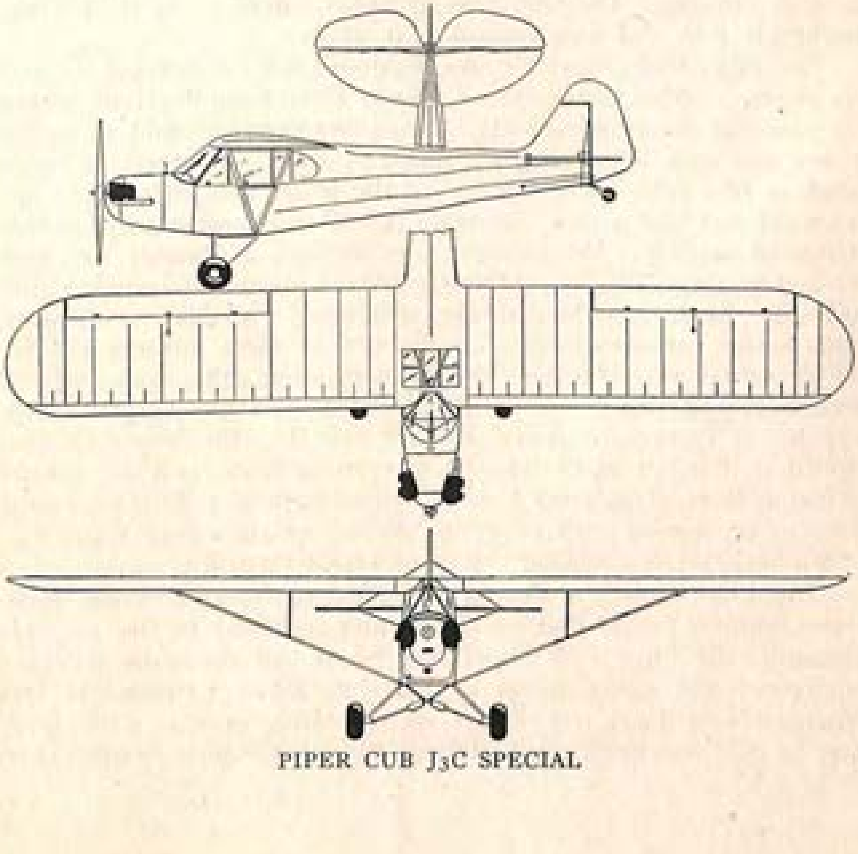
A specially designed Navy Ambulance plane, designated the Piper AE-1, was manufactured and sold to the Navy. Those planes had Lycoming 100 h.p. engines and were capable of carrying a pilot, a medical attendant and a casualty in a standard Navy litter.

Perhaps the most interesting, and most secretive of all Piper projects was the Glomb or glider bomb. This glider, carrying a 4,000 lb. bomb was towed by another aircraft. In operation, it was released from its tow ship and guided to the target by remote control from the tow ship, utilizing new television principles. The glider in appearance resembled a sleek, fast fighter plane. Its fuselage was made with a plywood covered steel framework. The one-piece 34 ft. wing was of wood construction, plywood covered. Several of these glider bombs were built and flight tested. However, with the use of the atomic bomb, further development on the Glomb became unnecessary.

At the request of War Department officials, a new airplane was designed and built by the Piper organization especially for liaison with field artillery. It was the L-14A, and production began in June, 1945. The L-14A was powered by a 125 h.p. Lycoming engine with electric starter and generator. With a complete panal of blind flight instruments and a controllable pitch propeller, it had provision for four occupants, including one litter case. Several L-14A planes were shipped overseas to the Pacific theater where they first tried their combat wings during the closing days of the Japanese war. After V-J Day, all military contracts were cancelled.

More than 1,000 of Piper's personnel were in active service. An appreciable percentage were military flyers; several flew the grasshoppers that they had helped to build. Thirty-four were killed. By March 1, 1946, 516 veterans were back building Piper planes again.

On August 14, 1945, the first civilian Cub manufactured since



PIPER CUB J3C SPECIAL

Pearl Harbor was completed. Because of long range plans projected months before V-J Day, exactly 1,000 Piper Cub Specials, personalized versions of the famous grasshopper, were produced between August 14 and December 27, 1945. A peak of 50 Cubs daily was projected for June, 1946, including the current Piper Cub production models—J3 Cub Special, the J5C Super Cruiser and the two Sea Scouts.

The Piper Cub Special embodied all the characteristics of safety and maneuverability which made the military Cub the outstanding liaison plane of the war. The two-passenger Special's 65 h.p. engine had been quieted to a husky purr by the addition of a new muffler. The one-piece plexiglas windshield with which it was equipped, contributed to increased visibility; while the Piper tandem seating arrangement, with dual controls, enhanced ease of flying. The Special was finished in Cub yellow with black trim. Standard equipment included hydraulic brakes with controls for both passengers, cabin heater, compass, carburetor heater, carburetor air filter, steerable tail wheel plus wires and brackets for navigation lights. Capable of carrying a useful load of 540 lbs., the Cub Special operated at a high speed of 83 m.p.h., cruised at 75 and landed at 39 m.p.h. With a cruising range of 206 miles, its gas consumption was only 4.4 gallons an hour cruising. The Cub Special had a length of 22 ft. 4½ in., height 6 ft. 8 in. and wing span of 35 ft. 2½in.

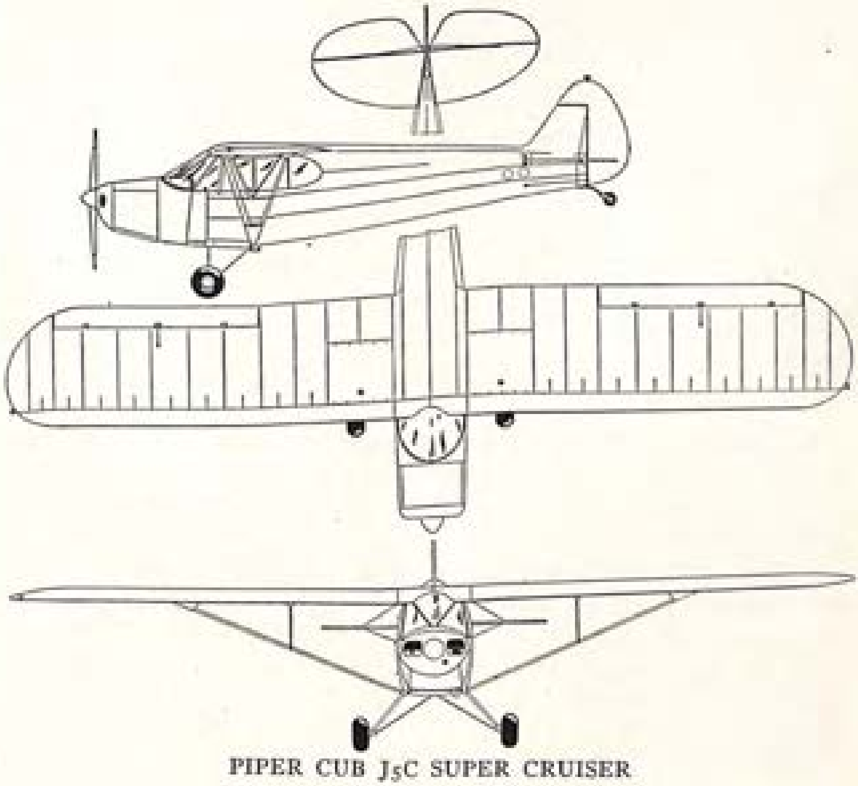
The Piper Cub Super Cruiser, equipped with a direct-drive 100 h.p. engine, carried three persons. It was flown from the front, where the pilot had excellent visibility. Two other persons could sit in the roomy rear seat. Possessing a cruising speed of 103 m.p.h., it had a range of 600 miles. The interior of the plane was attractively upholstered and had a new indirectly lighted instrument panel which facilitated reading. The exterior was finished in durable two-tone red and cream colors. In addition, standard equipment included dual hydraulic brakes, parking brake, one-piece plexiglas windshield, cabin heater, carburetor heater, carburetor air filter, mixture control, full-swivel tail wheel, 12-volt battery, navigation lights, motor-driven generator, and provisions for blind flying instruments and radio. Capable of carrying a useful load of 750 lbs., the Super Cruiser landed at 48 m.p.h. and consumed, at cruising speed, only 6.4 gallons of fuel an hour. The Super Cruiser had a length of 22 ft. 6 in., height 6 ft. 10 in., a wing span of 35 ft. 5½ in., weight empty 1,000 lbs., useful load 750 lbs., making the gross weight 1,750 lbs.

The Piper Cub Sea Scouts were float-equipped, offering quick transportation to the thousands of water locations in the country. Basically, the Piper Cub Super Sea Scout had the same standard equipment and specifications as the Cub Super Cruiser. It was equipped with floats and regular wheel landing gear as well. Each type of gear was interchangeable with the other, which meant that in about two hours it could be converted from a seaplane to a landplane—with the consequent advantages that go with each type.

Another model, the Piper Cub Sea Scout, had the same basic equipment and specifications as the Piper Cub Special. It, too, offered floats and wheel landing gear, each interchangeable with the other.

Anticipating the demand for the much discussed family airplane, Piper developed the Skysedan, a low-wing, cantilever, metal monoplane powered by a 165 h.p. Continental engine, which gave it a cruising speed of 125 m.p.h. It was designed to carry four persons. Incorporated in the design were such refinements as electrically retractable landing gear, electric starter and generator, radio and in addition, easy-to-read automotive type instruments. Indicated performance was 145 m.p.h. high speed, 50 m.p.h. landing speed, with flaps; cruising range 600 miles (plus ½ hour for reserve); weight empty 1,250 lbs., useful load 1,050 lbs.

Republic Aviation Corporation, Farmingdale, N. Y., fulfilled its final P-47 fighter contracts late in November, 1945, with delivery of the 15,329th Republic-built Thunderbolt. The termination of hostilities in August, and the subsequent termination of P-47 contracts before the end of the year, found Republic with continuing military



PIPER CUB J5C SUPER CRUISER

contracts for new types of aircraft, and plans and preparations in advance stages for the production of two new types of commercial and personal planes. Through C-54 reconversion contracts with American Airlines, Republic was able to retain large numbers of skilled and key personnel throughout the period of plant rearrangement and change-over from exclusive production of military planes to the varied operations of developing and building new types of military aircraft, four-engine commercial transports and four-place amphibian planes for the personal aircraft market.

Throughout 1944 and most of 1945, Republic had produced P-47 Thunderbolts both in its home plant at Farmingdale, N. Y., and in a Government-owned plant at Evansville, Ind. Combined floor area in the two plants on V-J Day was approximately 2,700,000 sq. ft. Production at the Indiana plant stopped a few days after V-J Day and as rapidly as terminations could be affected this plant was relinquished to the Government.

Employment, which had reached a peak of approximately 23,000 during the war, dropped to a low mark of 3,700 subsequent to V-J Day, but with the Evansville plant closed, payrolls of the Farmingdale plant alone had risen to 6,000 employees engaged in peacetime aircraft production by March, 1946.

From December, 1941, when the Army Air Forces accepted the first of the production model P-47 Thunderbolts, to the completion of the last P-47N late in November, 1945, Republic Aviation had built and delivered to the Army:

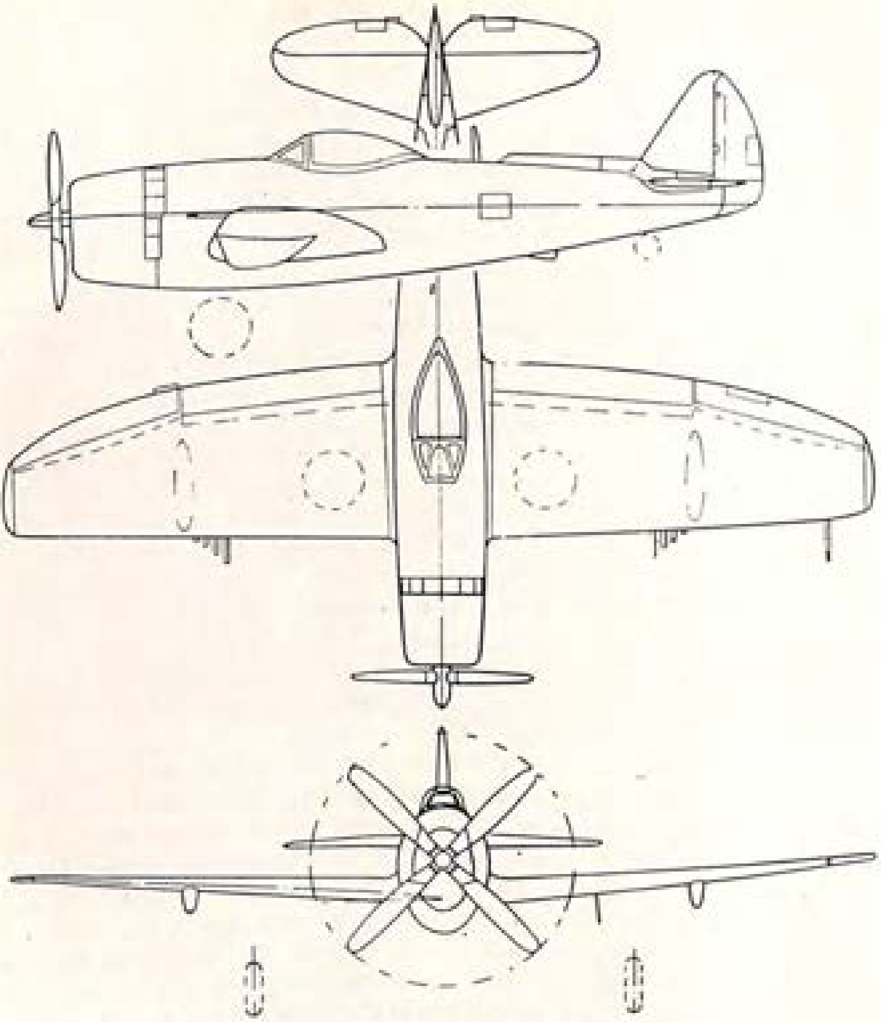
| Type | N. Y. Plant | Indiana Plant | Total |
|---|---|---|---|
| P-47B | 171 | 0 | 171 |
| P-47C | 602 | 0 | 602 |
| P-47D | 6,515 | 6,093 | 12,608 |
| P-47M | 130 | 0 | 130 |
| P-47N | 1,669 | 149 | 1,818 |
| Total | 9,087 | 6,242 | 15,329 |

In addition to these completed aircraft deliveries, spares and parts were produced and delivered, equivalent to another 3,000 Thunderbolts. Constant experimental work paralleled fighter plane production, and during the war period, the following experimental aircraft were developed by Republic working in close coordination with the AAF Air Technical Service Command: The P-47E, first fighter plane with fully pressurized cockpit; P-47F with laminar flow wing; the P-47J which in August, 1944, set a speed record for conventional reciprocating engine and propeller driven aircraft of more than 500 m.p.h. in level flight; the TP-47G which was a two-seater Thunderbolt for advanced combat pilot training; the P-47H which was a D-model modified to test flight performance of a new Chrysler inline, liquid cooled engine; the P-47K which was the first Thunderbolt, and the first American fighter plane, to use the bubble canopy to increase pilot visibility; and the P-47L which increased the plane's internal fuel capacity. The P-72 also was developed and flown, a Thunderbolt powered by the newer and larger Pratt & Whitney Wasp Major engine, but production contracts for this fighter subsequently were cancelled in favor of Republic's still newer designs for a jet-powered fighter of greater speed and range.

The story of how aircraft production in American aviation plants was translated into victory over the battlefields is one which has been told from as many angles as there were battles fought or air force commands to fight them. But perhaps no story from production line or combat theater more vividly portrays the toll taken against the enemy by any one phase of American aircraft production (typical as it is of the achievements of other companies as well), than does the summation of P-47 Thunderbolt accomplishments released by the Army Air Forces. Republic-built Thunderbolts, from March, 1943, when they first went into action over Europe, through August, 1945, flew over 546,000 combat sorties and dropped 132,000 tons of bombs and 60,000 rockets on enemy targets. They expended against the enemy more than 135,000,000 rounds of .50-cal. ammunition. In the air, Thunderbolt pilots destroyed 7,067 enemy aircraft and scored 578 probably destroyed and 4,229 visibly damaged.

Against ground forces in the final year of the war in Europe, as well as in the operations in the Pacific theaters, the Thunderbolt became as effective a weapon as it was against enemy combat aircraft in the skies. Thunderbolt squadrons in the various combat zones, from D-Day to the collapse of Germany exacted a terrific toll of German ground equipment, destroying 86,000 railroad cars, 9,000 locomotives, 68,000 motor transports, 6,000 armored vehicles and tanks and 60,000 horse drawn vehicles. In accomplishing these significant results against the enemy, P-47s flew 1,934,000 hours overseas, consuming more than 204,500,000 gallons of high octane gasoline. In addition to the flying in the combat zones, Thunderbolts flew 2,416,000 hours of training flights in the United States, consuming 241,600,000 gallons of gasoline.

Two-thirds of all of the Thunderbolts eventually found their way to overseas theaters as Army Air Forces combat aircraft. Although the P-47s were used principally for escorting heavy bombers during the early stages of the strategic bombing campaign of the Eighth Air Force, they later were used heavily by the Ninth Air Force as dive-bombers and low altitude strafers in cooperation with ground activity. One example of their effectiveness cited by the War Department was that, during the first five months of 1945, the P-47s flew an average of 1,677 sorties and dropped 541 tons of bombs a day.



REPUBLIC ARMY P-47N THUNDERBOLT

Upon the completion of P-47 contracts, Republic Aviation had under development and process of initial production three new types of aircraft, two of which were to utilize the highest powered aircraft engines thus far developed in both the conventional and jet propulsion fields. All three of these types of planes had been test flown by March 1, 1946. They included the XF-12, a revolutionary giant photo reconnaissance plane, capable of cruising at 400 m.p.h. and with a range of more than 4,000 miles. This military version also was to be the forerunner of the Republic Rainbow transport, a 46-passenger global liner carrying a crew of seven and capable of negotiating transcontinental flight schedules in less than six hours and crossing the Atlantic to the cities of western Europe in approximately nine hours. The Republic new jet fighter plane was the XP-84, designed to be very fast and yet easily maneuverable. Republic's all-metal four-place amphibian family plane was the Seabee.

The first XF-12 was test flown February 4, 1946. The XP-84 jet fighter underwent its initial test flight on February 28, 1946, at the Army Air Forces testing base at Muroc Field, Calif. The Seabee amphibian prototype had been under test since December, 1944, and the first production models underwent tests and demonstration flights during the closing weeks of 1945 and the early months of 1946, with assembly line production scheduled to start in April, 1946.

The XF-12 was the first four-engine aircraft designed expressly for long-range, high-speed photo-reconnaissance. It was powered by four 28-cyl. 3,000 h.p. Pratt and Whitney Wasp Major engines turning 16-ft. 2-in. four-blade Curtiss propellers. Engineers expected the plane to operate at very high altitudes at speeds comparable to wartime fighter planes. Slightly smaller than the B-29, the cigar-shaped fuselage of the XF-12 was 93 ft. 10 in. long, wingspread 129 ft. 2 in., height to the top of the stabilizer 28 ft. 4 in. Its weight loaded was about 101,400 lbs., service ceiling over 44,000 feet, and fuel capacity over 5,000 gal., giving it a range of 4,500 miles for sustained mapping operations at high altitudes. The high speed was over 450 m.p.h. Housed in nacelles the size of P-47 fuselages, the four engines had 2-speed cooling fans. Each engine was equipped with two General Electric superchargers. The long engine nacelles were tapered over exhaust turbines which supplied additional thrust of an estimated 100 h.p. per engine from the jet utilization of the exhaust gases. The crew of seven rode in a heated, pressurized cabin. The air intake was in the leading edge of the wings. Both wings and tail had heat de-icing equipment.

The XF-12 was virtually a flying photo laboratory, carrying complete radio and radar equipment and armorplate. The "bomb-bay" could carry 18 photoflash bombs for night photography. There were three camera stations—one split vertical, one trimetrogron and one vertical camera station.

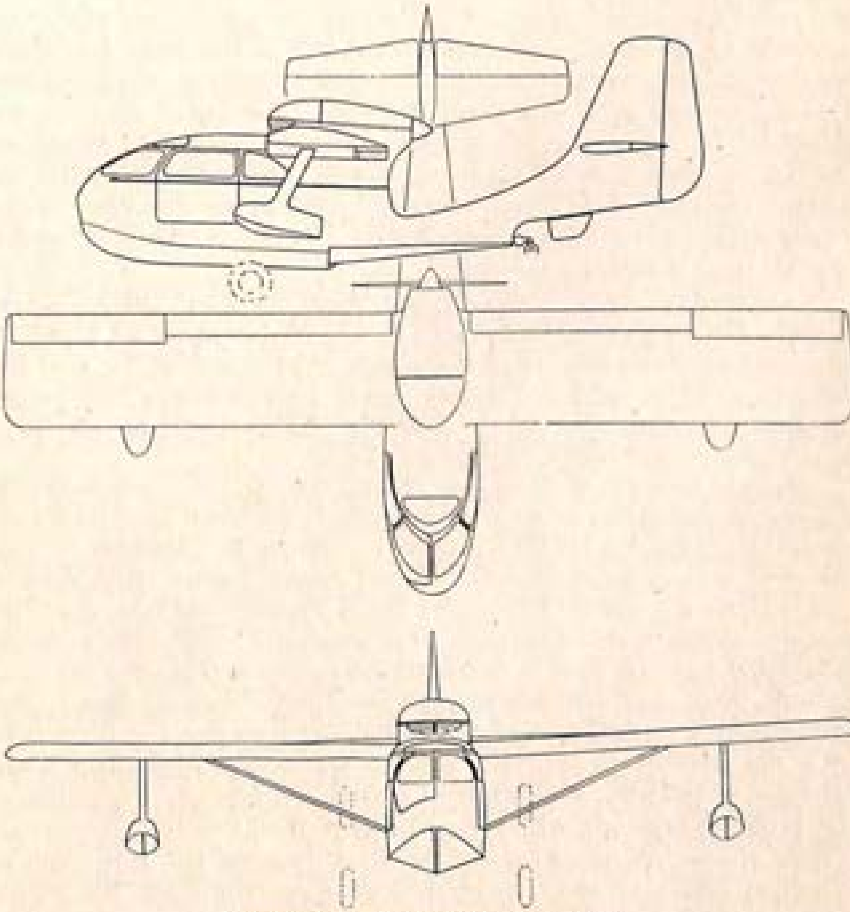
The commercial transport version of the XF-12, designated as the Republic RC-2 Rainbow was one of the fastest long-range four-engine transport-type airplanes. It cruised at 400 m.p.h., had a top speed of more than 450 m.p.h., and with a fully pressurized and air conditioned interior from nose to tail, normally cruised at altitudes around 40,000 feet, which placed it above, and therefore impervious to, all effects of weather. The Rainbow, like its XF-12 predecessor, was powered by four Pratt & Whitney Wasp Major engines. The transport plane, however, had a more powerful version of the Wasp Major, generating from its four power units a minimum of 13,800 horsepower. It had a gross weight of 116,500 lbs. and an empty weight of 68,000 lbs. The

Rainbow had a wing spread of 129 ft. 2 in., was 98 ft. 9 in. long, and the tail section rose 29 ft. 11 in. above the ground in taxi position. In addition to a seven man crew, the Rainbow seated a maximum of 46 passengers and its freight compartments could hold 4,477 lbs. of baggage and cargo. Its maximum fuel capacity was about 5,900 gallons and its service ceiling above 41,000 feet. It had a rate of climb of 1,550 ft. per minute with four engines and at 5,000 ft. altitude could climb at the rate of 300 ft. per minute on only two engines. The interior of the main passenger cabin was 44 ft. 10 in. in length and 6 ft. 2 in. in minimum height. The fuselage was 10 ft. 3 in. in diameter. Republic's first contract for the Rainbow transport was with Pan American World Airways for six of the global passenger liners at a price of about $1,121,000 apiece. First deliveries of the Rainbow transport version were scheduled for 1947.

Republic Aviation was one of the first aircraft corporations to undertake the development and experimentation of "buzz bombs" for the War Department. With engineers of the AAF Air Technical Service Command, Republic commenced the design of the XP-84 jet fighter plane in November, 1944. The new fighter was still on the secret list early in 1946, but after initial tests at Muroc Field, it was disclosed that the P-84 was powered by the newest General Electric axial flow jet propulsion unit and was capable of extraordinary sustained speeds and long ranges. It was the first jet fighter with the air scoop flush in the nose. This feature, combined with the operational principals of the axial flow engine, provided a distinctive principal by which the air moved virtually in a continuous straight line from the time it entered the nose of the plane until it was ejected as the propulsive force from the controllable jet nozzle in the tail. At the time of the XP-84's initial test flight, the Air Technical Service Command disclosed that it had entered into a production contract with Republic for more than 100 of the new jet fighters.

Republic's new four-place amphibian, the RC-3 Seabee, was an all metal high-wing monoplane embodying a simplified design, outfitted to include the comforts and confidence-inspiring appointments of an automobile interior, and suitable for a wide range of utility. Its list price, fully equipped with basic CAA and ball bank flight instruments, two-way radio, electric starter, and ground adjustable propeller, was $3,995. A controllable and reversible pitch propeller was optional equipment, factory installed, for $333 additional. In performance the Seabee had a cruising speed of 103 m.p.h. at 75 per cent power, and a high speed of 120 m.p.h. It was powered by a 215 h.p. Franklin Aircooled engine, Model 6A8-215-B7F. The Seabee's gross weight was 3,000 lbs. and its empty weight 1,950 lbs., and its useful load 1,050 lbs. Its wing span was 37 ft. 8 in., its length 28 ft. and its maximum height 9 ft. 7 in.

Both main landing gear and tail wheel of the Seabee were retractable. The span of the main gear was 8 ft. and its wheel base, from center of main gear to center of tail wheel was 12 ft. 10 in. The amphibian's cabin was 46 in. wide, 50 in. high and 110 in. long. In addition, it had a baggage compartment of 20 cu. ft. The Seabee had a range of 560 miles, or 5½ hours at cruising speed, on a 75-gallon fuel load. It climbed 700 ft. a minute. It could take off over a 50-ft. obstacle in 800 ft. from land, or 1,000 ft. from water. It required a landing run of only 400 ft. on land or 700 ft. on water, and had a landing speed of 58 m.p.h. The engine was mounted above and behind the passenger cabin, with a pusher type propeller. This minimized noises, eliminated engine odors in the cabin and constituted an additional safety factor. The retractable landing gear was manually operated and the tail wheel was of the lockable, swivel type. Fully loaded and at rest, the Seabee had a water draft of only 18 inches. Volume production on the Seabee was scheduled to start in April,



REPUBLIC SEABEE AMPHIBIAN

1946, to be stepped up from 100 planes in May to 600 in August, with quotas increasing from month to month in line with Republic's plan to build by the end of the year 5,000 of the planes, which it had on order.

Design simplification of the Seabee had been under way by Republic engineers throughout the entire development period. As a result, the airframe of the amphibian was reduced from 1,800 parts to less than 450, and the fabricating time from 2,500 man hours to 200 man hours. Tooling costs were reduced from an estimated $1,750,000 for the conventional Seabee prototype to less than $400,000 for the production model. In every instance the simplification was accomplished without sacrifice of quality, performance or strength.

At the beginning of 1946, Republic Aviation had slightly more than $50,000,000 worth of aircraft manufacturing business under contract, of which more than 50 per cent constituted military contracts for the production of the XF-12 photo reconnaissance plane and new types of fighter planes. This sum did not include any of the work on the Rainbow commercial transports which were not scheduled for delivery until 1947. It did include, however, the C-54 conversion contract with American Airlines. The latter contract was scheduled for completion in the spring of 1946, in time to permit the XF-12, Rainbow and XP-84 production to proceed in the parts and assembly plants which during the war were devoted entirely to the manufacture of the P-47 Thunderbolts. The Seabee production line was set up in a separate building.

In October, 1945, Republic purchased outright the Aircooled Motors Corporation of Syracuse, N. Y., and with it all rights to manufacture Franklin aircooled engines. At the end of the year this subsidiary had a backlog of $7,000,000 in aircraft engine orders, and Republic placed orders for 5,000 of the 6A8-215-B7F model for its first year's production of Seabees.

Ryan Aeronautical Company, San Diego, Calif., responding to urgent requests from Navy air commanders with our task forces opposing the Japs, rushed into production during the Summer of 1945 its new, jet-pushed, propeller-pulled Fireball fighter. Designed to out-perform any enemy fighter, the FR-1 Fireball was considered the possible means of downing the all-too-successful suicide plane attacks which the Japs launched in desperation as our forces neared the home islands. First conceived late in 1942, the Navy Bureau of Aeronautics called upon Ryan to assist in the design, development and production of a new combat plane which would combine the advantages of jet propulsion (which is most efficient at high altitudes and high speeds) for peak performance, with the well-known merits of the conventional piston engine and propeller for the short take-off and long cruising range necessary for aircraft carrier operation. The Ryan FR-1 Fireball not only was the first plane in the world to combine conventional reciprocating engine power with jet propulsion; it also was the Navy's first airplane to utilize jet propulsion. Because of the urgency of the Navy's need for advanced type combat planes, Ryan continued in full production right up to V-J Day and was one of the few plants in the country which still was on an accelerating production and employment program when the Japanese signed the surrender terms. At that time reconversion officials asked the Army and Navy for a realistic downward readjustment of aircraft production programs and accordingly the full $103,000,000 Fireball contracts were not completed.

Despite decreased need for combat planes, the Ryan Aeronautical Company continued into peacetime its military airplane program. New development work for the Navy was in progress and was being carried along on an expanding basis.

Manufacture of specialized stainless steel products, principally exhaust manifolds and allied aircraft engine accessories, in which Ryan was a pioneer, was continuing, though not on as high a level as formerly.

Studies were being conducted in the commercial and private airplane markets with a view to reentering that manufacturing field. Ryan already had readjusted its total personnel and production to the realistic demands of peacetime requirements, but retained 1,700 employees, which was a substantial employment level compared with postwar years. Ryan went through a very progressive development during the war, having gone from building small numbers of relatively simple primary training planes to design, engineering and volume production of its Navy Fireball jet-pushed, propeller-pulled fighters of extremely advanced design. With this experience and with the necessary key personnel retained in the Ryan organization, the company planned to continue to serve the nation's preparedness program by development of new military aircraft types. This was evidenced by the high employment in the engineering department where much in new and advanced development work was in progress. Importance of the activities in new design was illustrated by the nature of work being accomplished in advanced applications of jet propulsion, supersonic speeds and electronics.

The Ryan-developed Fireball fighter had many unique characteristics. It could be operated on either its jet engine alone or on the conventional power plant only, but for peak performance the two power sources were used together. Flying on the jet engine alone, the Ryan Fireball had a speed of more than 300 m.p.h., on the conventional engine alone, 320 m.p.h. Speed with both engines operating together at peak power was a Navy secret. Because its conventional engine was most efficient for take-off and at lower altitudes, and the jet engine most efficient at higher levels and speeds, performance of the Fireball on both engines was extremely high at all altitudes. It was very maneuverable, and had a very high sustained rate of climb. As a result, the pilot of the FR-1 was able to maintain combat advantage at all times.

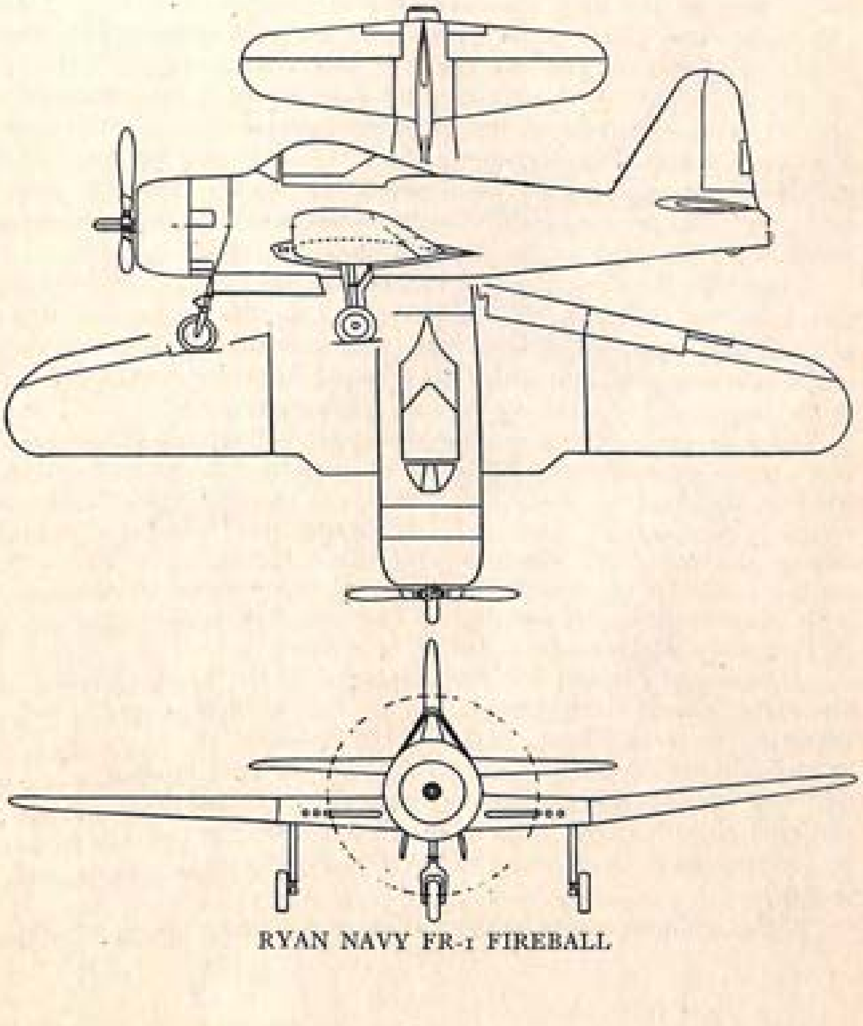
The unique engine combination in the Fireball made it possible to operate a jet plane from an aircraft carrier. Without the added power and thrust of the conventional engine, a plane powered with jet alone could not operate effectively from a carrier deck. In all jet engines, efficiency increased with speed. But once speed had been reduced, all-jet planes lacked full combat effectiveness. The Fireball fighter had the best combination of desirable fighter plane characteristics—high speed over the widest range of altitudes, high sustained rate of climb at all altitudes, short take-off, extreme maneuverability, slow landing speed, good combat radius and heavy firepower—each with its relative degree of importance to the others. It could climb a mile a minute. Although this first Navy fighter to use jet propulsion never saw combat, knowledge gained from its manufacture and flight performance was immediately translated into an improved Fireball design as well as utilized in developing other new planes.

The Fireball's unique power combination embraced a Wright Cyclone radial engine in the front and a General Electric jet propulsion engine in the rear. Because the speed curve varied very little from sea level to 25,000 ft., the Fireball pilot would not have to hunt a favorable altitude at which to tackle an enemy. Firepower of the Fireball included four .50-cal. machine guns, each fed by 300 rounds of ammunition. The guns could be serviced with the wings of the Fireball folded. Two 1,000-lb. bombs could be carried under the wings, and detachable rocket mounting posts could be installed under each outer panel. Steel armor plate and laminated bullet resistant glass in the windshield front panel protected the pilot.

The Fireball was a conventional appearing, low-wing, single-seat monoplane with a tricycle landing gear. At first glance, it appeared to be a single-engine plane. The air intakes for the jet unit were in the leading edge of the wing near the fuselage. The jet unit was enclosed in the after section of the fuselage with the jet exhaust opening coming out under the tail. Because of the more even distribution of the weight longitudinally—with an engine at each end—the Fireball's plastic-canopied cockpit was installed slightly forward of the leading edges of the wings, permitting a greater range of vision. Interior of the cockpit was compact—yet roomy enough for the pilot to stretch his legs and relax. An oxygen system for high flying and equipment to service the pilot's anti-blackout suit which were necessary to make full use of the short turning radius and sharp pull-ups possible with the Fireball, were provided. The tricycle gear permitted the plane to approach and land within a wide range of speeds. For land-based operation, the tricycle gear permitted cross-wind take-offs and landings without danger, and "on-a-dime" turns in taxiing.

Placement of the cockpit and the high visibility permitted by the canopy gave the pilot an unusual range of vision. He could look straight ahead without being blinded by the nose or look down directly under his wings. Because of the exceptional forward vision, it was possible to keep the number one arresting wire in view over the nose until the pilot had nearly reached the "cut" position before setting down on the deck of a carrier.

The Fireball had the lighter weight of a single-engine plane, but if one of its power plants was knocked out, it could continue to fly without the pilot having to counteract the swing which follows the loss of power from one engine in a twin-engine aircraft. This resulted in a tremendous safety margin over a single-engine fighter, and also an advantage over planes of conventional, twin-engine arrangement. Rated at 1,350 h.p., the Wright Cyclone model R-1820 engine



RYAN NAVY FR-1 FIREBALL

could be boosted with water injection. It made possible a maximum range of 1,500 miles (with droppable tanks). The front engine was fitted with a Curtiss Electric fast feathering, three-blade constant speed propeller. Far more powerful than a conventional engine of the same weight was the General Electric-designed I-16 thermal jet engine. Like all jet engines, its efficiency increased with speed. The conventional engine, however, prevented loss of speed upon which the jet depended for its best performance. The first Navy carrier fighter squadron to be equipped with the Ryan Fireball was VF-66, which was in combat training at the time of the Japanese surrender.

In order to build better airplanes, aircraft components and exhaust manifold systems, the Ryan company used every wartime resource available for the development of technical improvements. Technicians in the laboratory, engineers and production experts in the plant and employees through their shop suggestion system contributed in a major way to the high standard of production at the Ryan plant. For some time it had been known that the post-aging (heat treatment) of aluminum and other metals increased their strength substantially. It had not been practiced extensively in manufacture of aircraft because it reduced the corrosion resistance. Ryan developed a procedure involving post-aging the alloy, oxidizing the surface of the metal and applying a coat of primer to provide corrosion resistance, and the process resulted in a considerable saving in weight which was translated into greater payloads and higher speeds.

Ryan also developed a new molten salt bath for stress-relieving and defluxing 18-8 stainless steel exhaust manifold parts. Institution of a salt bath furnace in place of the conventional air furnace for these stress-relieving and defluxing jobs resulted in savings of 75 per cent of the time and $100,000 in the costs formerly required.

Ryan devoted a great deal of research to development of fluxes, and announced three new fluxes which permitted faster and sounder welding and brazing; one, a new flux for welding high chromium-nickel content steels; the second, a backing flux to permit welding thin gauge, austenitic stainless steels; and the third, a flux which made possible for the first time, the brazing of austenitic stainless steels with zinc-free copper base alloys. This last flux opened the way to brazing steels which formerly had to be welded.

A new tool for forming rivet dimples in the hard, heat-treated aluminum alloys of thicknesses up to and including .081 in., was produced by Ryan. Ryan used multiple hydraulic riveting techniques extensively, with huge machine riveters which could upset as many as 32 rivets with one blow of their hydraulically actuated anvils. Used in conjunction with an overhead monorail conveyor, the multiple hydraulic riveting machines accounted for a savings of 15,000 manhours a month.

A basic improvement in the design of assembly jigs and holding apparatus for aircraft parts was made by Ryan engineers. The design incorporated a three point suspension type of jig for all sizes of equipment instead of the many-legged type of jigs formerly used. Perfect alignment on unstable floors was assured by that design. By using heavy, cylindrical, welded structural members, internal strains resulting from misalignment were eliminated. One of the first aircraft companies to use atomic hydrogen welding, Ryan perfected new light-weight electrode holders weighing half as much as those available, and discovered which alloys and designs were most adaptable for use with this process. Ryan also pioneered the use of automatic atomic hydrogen welding of stainless steel exhaust manifolds, resulting in faster production.

Schweizer Aircraft Corporation, Elmira, N. Y., was in production on two new model gliders.

Sikorsky Aircraft, Bridgeport, Conn., a division of United Air-

U. S. Coast Guard photo

SIKORSKY HELICOPTER RESCUE TECHNIQUE

U. S. Coast Guard testing their new U-type rescue harness which is lowered from a hovering helicopter to a castaway. He then is hoisted to the cabin of the rescue "ship".

craft Corporation, produced its new four-place S-51 helicopter, and it was undergoing test flights late in February, 1946. It was a commercial modification of the military R-5. The S-51, like the R-5, had a 450 h.p. Pratt & Whitney Wasp Junior engine, a disc diameter of 48 ft. with 57 ft. overall with blades extended. It had a high speed of 103 m.p.h., cruised at 80 m.p.h., a service ceiling of 13,000 feet, and hovered at 3,500 feet. The gross weight was 4,900 lbs. and the useful load 1,250 lbs. The pilot's place was in the nose of the aircraft with a three-passenger automobile-type seat immediately to the rear. An adequate baggage compartment was provided. Cabin appointments and upholstery emphasized comfort and convenience.

Indication of the performance of the S-51 was given by figures established by a standard R-5 on January 10, 1946, when it climbed to an altitude of 21,000 feet and later averaged 114.6 m.p.h. over an official course. Those figures, subject to official calibration of the instruments, replaced German-held records of 11,243 feet altitude and 76.151 m.p.h. Shortly after its record flights, the same R-5, equipped with jury seats on each side of the cabin, took aloft 16 men in addition to pilot and passenger in the cabin—a total of 18 carried on a single trip.

Up to the cessation of hostilities in 1945, Sikorsky Aircraft placed major emphasis on the production of the Army Model R-5 while continuing research in rotary wing design. Meanwhile, two other Sikorsky models were giving good account of themselves. The R-4, world's first production helicopter, built in Bridgeport, a two-place, side-by-side design powered by a 180 h.p. Warner Scarab engine, was in service in many theaters of operation as well as at home, performing tasks far in excess of its projected operational sphere. The R-6, a streamlined development of the R-4, with a 235 h.p. Franklin engine, also was doing yeoman service as far away as China. The R-6 was designed and proved by Sikorsky at Bridgeport and produced in quantity by Nash-Kelvinator, Detroit. Together the 4s and 6s established service records in moving key personnel and emergency aircraft parts and in performing difficult rescue missions in China, Burma, Saipan, Europe, Alaska, Labrador and at home stations.

Working out of Goose Bay, Labrador, an R-4 from the Coast Guard Base at Floyd Bennett Field, piloted by Lt. August Kleisch, saved nine crash victims from the heart of the Labrador wilderness in April, 1945. Rescue by dog team or snowmobile was impossible through the 10 feet deep, extremely soft snow and across open streams. A helicopter was the only hope. An R-4 was rushed from Floyd Bennett to Goose Bay in an ATC C-54, and in the course of three days, carried all nine crash victims to safety at Mecatina, an isolated A.A.C.S. Range and Weather Station.

Across the world in China, three Sikorsky R-6s of the Army Air Forces 8th Emergency Rescue Squadron, led by Capt. Knute W.

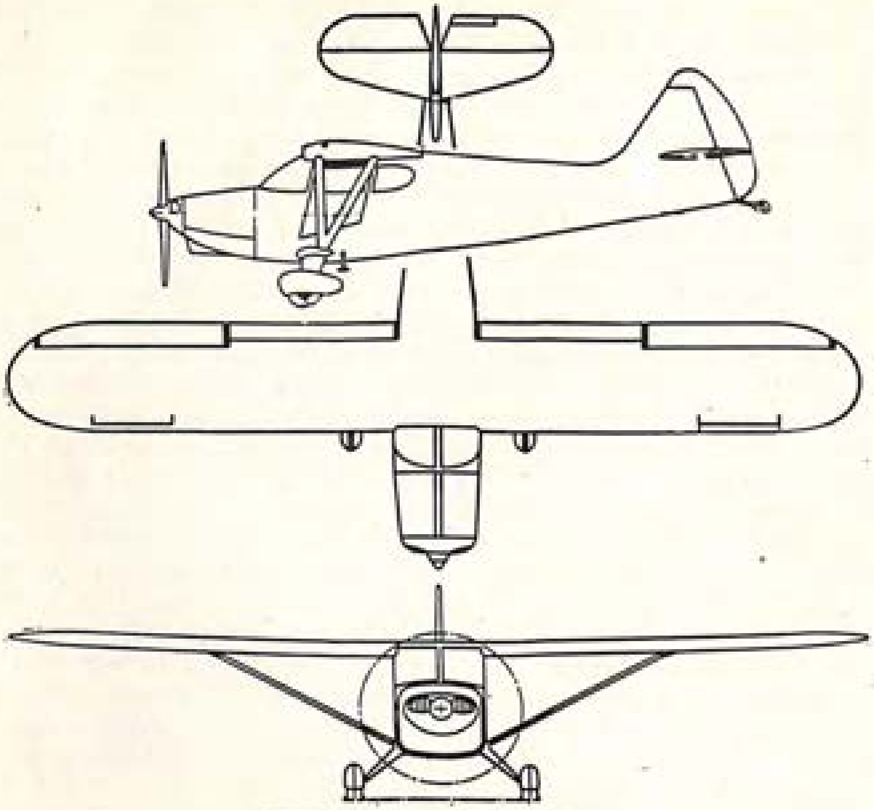
Flint, made their way into an almost hidden valley to bring out the survivors of a crashed transport. In another of a long series of spectacular emergency rescues late in November, during a violent "northeaster," local authorities called the Sikorsky plant at Bridgeport for emergency help. A tanker barge was grounded and breaking up on Penfield Reef. Because of the treacherous shoal water, rescue vessels could not get to the stricken boat. A Sikorsky R-5, carrying Capt. Jackson E. Beighle, and Sikorsky Pilot D. D. Viner, was able to remove the two bargemen from their perilous position. The Coast Guard's specially developed rescue hoist was employed in both rescues.

When floating repair bases were sent to the Pacific theater, largely for B-29 maintenance before adequate shore bases could be established, each of the ships had a landing deck from which Sikorsky R-4s operated for ship-to-shore transportation of personnel and repair parts. In all, the more than 400 Sikorsky helicopters produced on military contract before V-J Day, had spent 35,000 hours in the air. By the beginning of 1946, approximately 375 pilots had been checked out to fly Sikorsky type helicopters. Of these, the Army had given instruction to 180 at Chanute Field, Freeman Field, Sheppard Field, Wright Field and overseas. The Coast Guard had trained 25 British pilots, 25 Navy pilots and 100 of its own personnel at Floyd Bennett Field, and the balance were qualified by Sikorsky Aircraft.

Southern Aircraft Division, Portable Products Corporation, Garland, Texas, was developing a roadable plane with demountable wings, designed to let the operator land on an airport and then drive the fuselage home and store it in his garage.

Stinson Division of Consolidated Vultee Corporation is covered in the story on that company's activities on page 314.

The Taylorcraft Division, Detroit Aircraft Products, Inc., Alliance, O., formerly Taylorcraft Aviation Corporation, resumed production of light personal planes after V-J Day, including the postwar Taylorcraft BC12D deluxe and standard. It was essentially of the same design as the prewar model B with considerably improved equipment and parts designed to increase strength and durability, give better flight characteristics and add to the comfort of pilot and passenger. The fuel tanks were enlarged, providing 24 gallons, giving a longer cruising range. The Standard BC12D had a wing span of 36 ft., length 22 ft. It was powered by a Continental 65 h.p. 4 cyl. aircooled engine, and had a cruising speed of 95 m.p.h. The new Taylorcrafts had one-piece Plexiglas windshields, and in the deluxe model a portable radio receiver with battery and antenna. Both models had full-position lights and a dome light, and a dual wheel-control system. A specially designed three-piece stamped metal rib was installed in the wings which were assembled in vertical jigs. A new method of rib-stitching, with crimped wire instead of the old needle and thread system, reduced the time of wing construction by



STINSON 4-PLACE VOYAGER

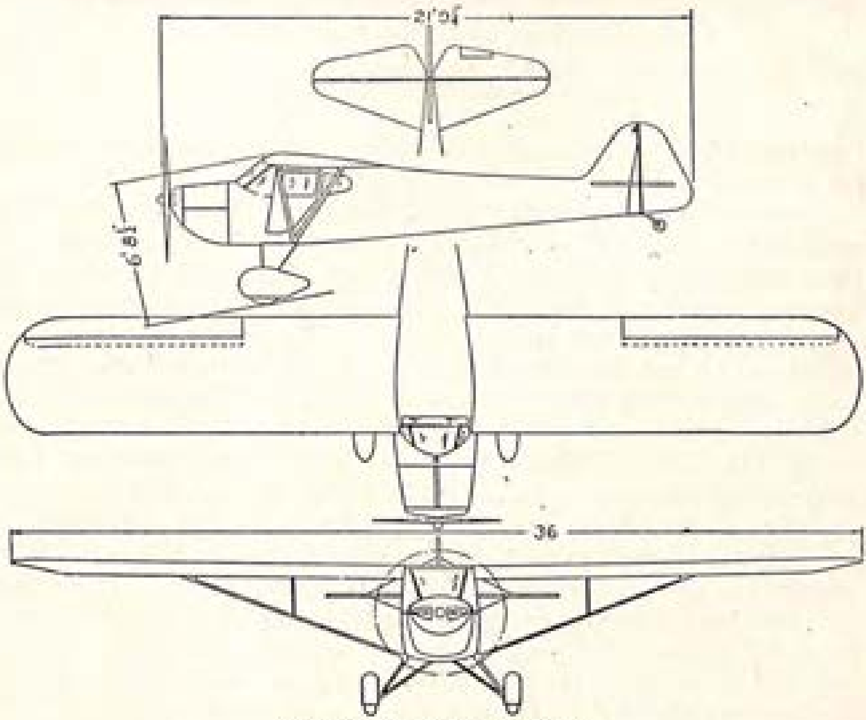
more than 60 per cent. The first postwar Taylorcraft was delivered 14 days after V-J Day.

Months before the end of the war, the company had completed its contracts for the L-2 series Taylorcraft liaison-observation planes for the Army Air Forces and a highly restricted radar-controlled buzz bomb glider project for the Navy. It had been operating at top speed, in a greatly enlarged plant, on several vital war contracts, the largest of which was the fabrication of all control surfaces for the Douglas A-26 Invader attack bomber. Other projects included wing sections for PBY flying boats, Curtiss Commando ailerons, parts for Sikorsky helicopters and some smaller subcontracts. The Taylorcraft plant was the only factory in the country making A-26 control surfaces. As the war drew to an end the company completed plans for resumption of civilian plane production and made remarkable progress in reconverting its plant from military to civilian activities.

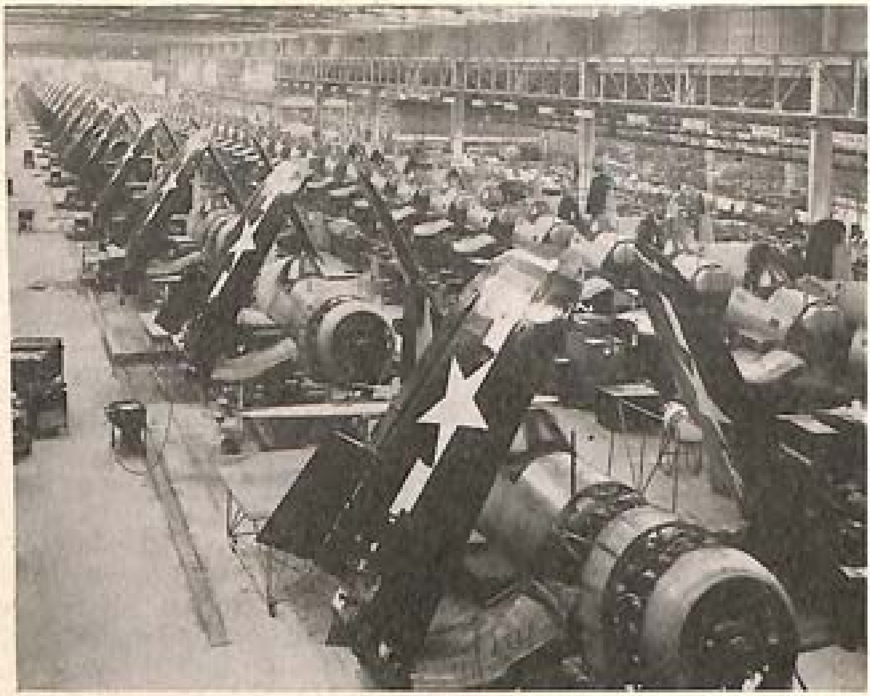
The new Taylorcraft management decided, in view of the tremendous civilian demand that had accumulated, to concentrate its full manufacturing capacity on production of the two-place side-by-side

65 h.p. Taylorcraft personal plane. Actual production of the Model 15, 4-place family plane which had been introduced in December, 1944, was postponed until a new addition to the plant could be completed early in 1946. Plans of the company included construction of new assembly jigs, conveyor systems wherever practicable, new methods of wing construction and other improvements in manufacturing technique to facilitate the production of 30 planes or more a day. Early in 1946, with few of the plans in effect, a daily output of eight to 10 airplanes was being realized.

Chance Vought Aircraft Division of United Aircraft Corporation, Stratford, Conn., had built 6,600 Corsair fighters and was turning out the new Corsair F4U-4 at a rate of approximately 300 a month when Japan capitulated on August 14, 1945. At that time, thirteen Corsairs were moving from the final assembly line each working day, or one every 82 minutes, and the plant was capable of stepping that figure up to 16 a day. Of the 6,600 Corsairs produced by the Chance Vought division from June, 1942, through August 14, 1945, 4,699 were F4U-1s and 1,901 were F4U-4s. Added to this total were more than 3,000 Corsairs built by the Goodyear Aircraft Corporation under the designation of FG-1, and more than 750 turned out by the Brewster Aeronautical Corporation under the designation of F3A-1.




TAYLORCRAFT MODEL B



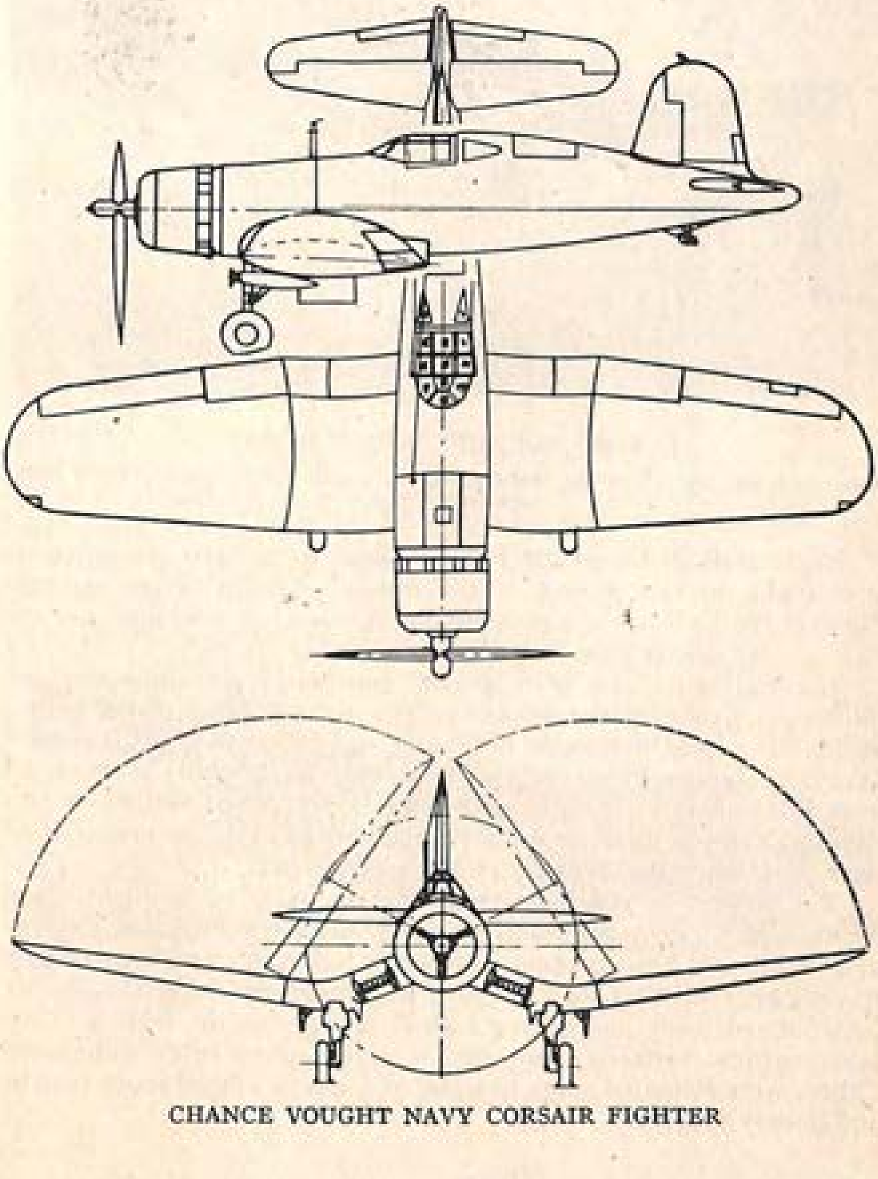
VOUGHT CORSAIR ASSEMBLY

More than 6,000 Navy Corsair fighters flowed from the assembly lines at the Chance Vought plant in Stratford, Conn.

Goodyear continued to produce Corsairs until the end of the war, but the Brewster contract was terminated by the Navy in 1944.

Chance Vought Aircraft reduced time for production and lowered costs during the first six months of 1945, and was continuing the same trend up to V-J Day. The last F4U-4 turned out on V-J Day required only 3,350 manhours to build, as compared with 92,500 manhours needed to build the first F4U-1. The output of Vought airplanes, which had amounted to only 72 aircraft in 1939, had reached a grand total of more than 10,000 by V-J Day, most of these being the hard-hitting Corsairs. In the peak year of 1944, the team of Chance Vought Aircraft, its subcontractors and its licensees, turned out more than 32 million pounds of aircraft, 85 times the 1939 figure.

Pride of the Chance Vought division was its F4U-4 Corsair. A marked improvement over the earlier Corsair models, which had good records for performance and dependability, the F4U-4 utilized fully the increased horsepower made available by Pratt & Whitney's R-2800-C engine. The new Corsair had increased speed, rate of climb and ceiling—three of the four basic criteria for air combat. Like its predecessor, the F4U-1, it had the fourth requirement—excellent maneuverability. The new engine was rated at 2,100 h.p., but in combat emergencies, that power could be increased substantially by means of water injection. The F4U-4 was the first carrier airplane to take advantage of this engine's high horsepower. In addition, a weight-saving program contributed to the improvement in performance. So successful were the efforts of Vought engineers in this direction that, despite a heavier engine and propeller and increased armament provisions, the total weight of the F4U-4 was only slightly above that of the F4U-1. A drag clean-up program also had added speed to the new Corsair without use of greater horsepower.



CHANCE VOUGHT NAVY CORSAIR FIGHTER

U. S. Navy photo

VOUGHT CORSAIRS IN THE PACIFIC

Bomb-carrying Navy Corsairs warming up at a mid-Pacific airstrip for a strike against the Japs.

Flight tests disclosed the F4U-4s speed to be over 450 m.p.h. in level flight, making it one of the fastest propeller-driven aircraft. Climb of the F4U-4 was increased almost 1,000 feet a minute over the F4U-1. Its ceiling also was raised.

The F4U-4 had the same general appearance and dimensions as the F4U-1, retaining the distinctive inverted gull-wing of the earlier model. The most noticeable difference was the four-blade Hamilton Standard Hydromatic propeller which replaced the three-blade model in earlier Corsairs. The engine cowling was different, too, having an elliptical shape with an air intake in the bottom arc. The engine cowl flaps were larger and fewer than those on the F4U-1.

The cockpit in which one man had to navigate, dogfight, drop bombs, shoot rockets and machine guns, and control a 2,100 h.p. engine could well have become so complicated as to reduce materially the efficiency of the pilot. To meet this situation, Vought engineers incorporated many simplifying cockpit changes in the F4U-4. Certain controls, formerly manually operated, were made automatic. Others were relocated so as to come to the pilot's hand more readily and in easy sequence.

The Waco Aircraft Company, Troy, O., in 1945 continued both glider production and its design and development, together with engineering service to other companies holding prime contracts for the production of various Waco glider models. Production in the Waco plant was confined to the CG-15A and an experimental contract for these models equipped with two 300 h.p. Jacobs 7-cyl. radial engines, rated at 325 h.p. for take-off. The performance of this combination as cargo equipment proved quite satisfactory, but the military demand for it, of course, ceased on V-J Day. Waco production contracts were terminated as of that day and experimental and engineering contracts terminated at various intervals between August and the year's end. Owing to the extent of the military engineering work in progress, no postwar development on personal airplanes was started until after the war. Waco planned to announce its new models in the late Summer or early Fall of 1946.

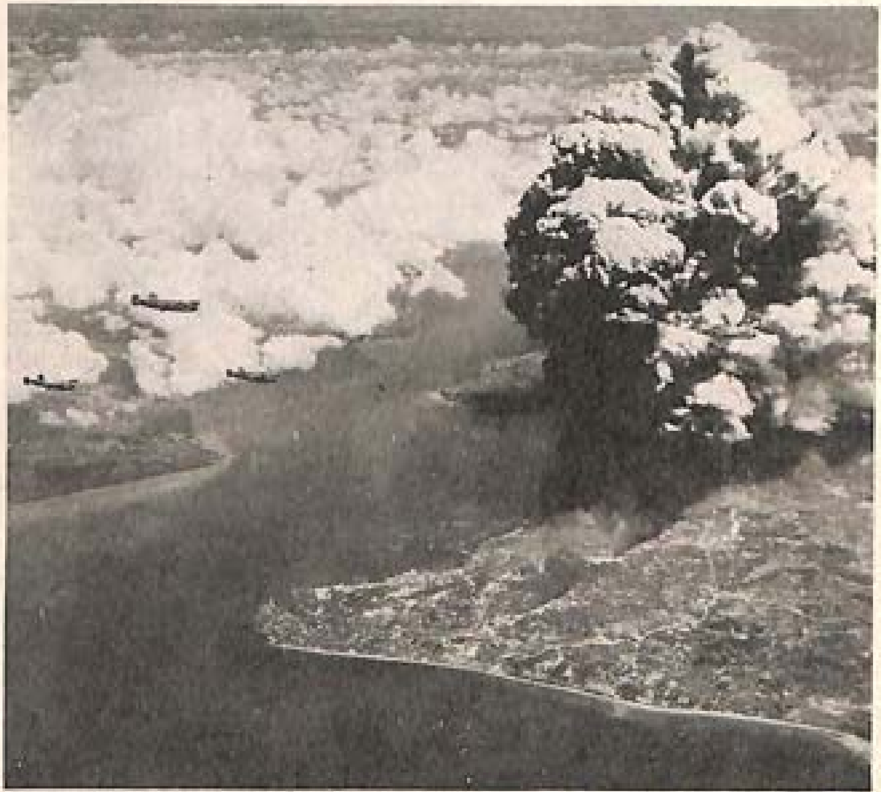
Over the entire war period and excluding its production of UPF-7 secondary trainers and VKS-7F 4-place cabin cross country trainers for the Civilian Pilot Training Program, later known as War Training Service, Waco's war effort encompassed the design of four troop and cargo-carrying gliders, the CG-3A, CG-4A, CG-13A and CG-15A, and holding production contracts on the CG-4A and CG-15A only. At various times as many as 16 other contractors held prime contracts for the production of all these models excepting the CG-15A, and Waco supplied the engineering service to these contractors to the extent that the gliders so produced were on an interchangeable basis so that components or spares could be used on any glider regardless of its source of manufacture. The company likewise supplied a great many Waco-designed parts incorporated in these models to the other manufacturers working on the program. In addi-

THE WACO CG-13 SUPERGLIDER

It could carry 42 fully equipped troops.

tion to the glider program, Waco acted as subcontractors to Republic Aviation Corporation for P-47 motor mounts; Curtiss-Wright for control columns, P-40 rudder pedals and fuel tank shells for bullet proofing.

Waco planned to reenter the personal airplane field, distributing its planes in the same manner as prior to the war, through a network of distributors and dealers holding exclusive sales and service contracts in the territory allotted to them. In the intervening period, service parts for Waco prewar models were being produced and depleted service stocks replenished. The company was engaged in general overhaul of owners' airplanes and, likewise, producing parts for other aircraft manufacturers in the personal airplane field.



U. S. Army Air Forces photo

OUR AIR FORCES HIT JAP OIL SUPPLIES

The Liberators of our Thirteenth Air Force hurl the fourth of their heavy raids against the enemy's principal oil refineries in Balikpapan, Borneo.

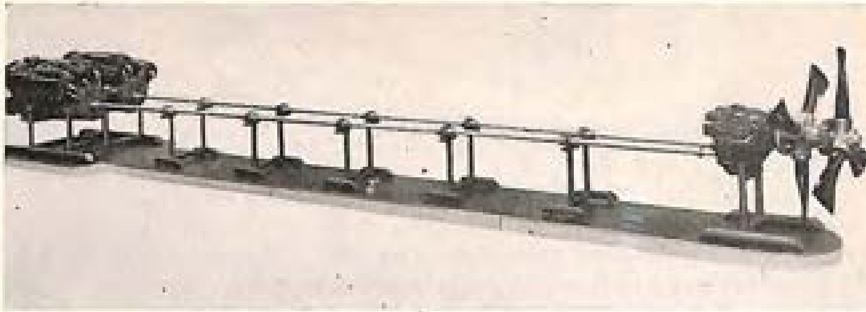
## CHAPTER XI

### AIRCRAFT POWER PLANTS

Development of Lighter and More Powerful Engines—New Reciprocating Engines Designed to Improve Aerodynamic Surfaces—New Pusher and Tractor Drives—Propellers for Greater Power and Performance—Progress in Gas Turbine and Turbo-Jet Power Plants—Greater Speeds and Loads Obtained by Combinations of Reciprocating and Jet Units—War Production of Engines and Propellers Speeded Victory.

AVIATION entered the postwar era with revolutionary developments under way in the power plants for aircraft and guided missiles. The conventional internal combustion reciprocating engines had been improved steadily throughout the war, in reliability and in power. Early in 1946 radial aircooled engines were being installed with more than 3,600 horsepower ratings. Jet propulsion was a development of the war, both here and abroad. Jet fighters first were used by the Germans in actual combat, but they could stay in the air only about 45 minutes, and their effectiveness was curtailed by their short range and lack of maneuverability. The Americans and the British developed jet power plants and they were installed in production fighters during the last months of the war. Jet propulsion in many forms was in the development programs for all high speed aircraft as was development of rockets for various kinds of aircraft power. Gen. H. H. Arnold summed up the situation in his final report before he retired as Commanding General of the Army Air Forces, as follows: "Original research in rockets for the AAF was for the purpose of assisting take-off with heavy loads on short landing strips and as a short-duration speed boost to achieve high emergency performance in combat. Among new uses for rockets are winged missiles for extreme range; guided anti-aircraft missiles; launching supersonic, long-range pilotless, or manned aircraft; and deceleration devices for aircraft with high landing speeds.

"Jet propulsion is in its infancy despite the fact that this war has evolved six distinct methods of utilizing atmospheric oxygen for propulsion, such as (1) motor-jet—or reciprocating engine plus ducted fan, (2) turboprop—a gas turbine plus propeller, (3) turbofan—a gas turbine plus ducted fan, (4) turbojet—a gas turbine plus jet, (5) ramjet—a continuous jet with compression by aerodynamic ram, and (6) pulsojet—or intermittent jet. These new and strange sounding



ALLISON POWER PLANT IN THE XB-42

The two Allison V-1710 engines in the fuselage of the Douglas experimental Army bomber are connected with the counter-rotating pusher propellers in the tail by 30 feet of extension shafting for each engine.

words will be familiar ones in our speech in the near future, and right now they carry more meaning for Americans than any other six words I know."

Allison Division of General Motors Corporation, Indianapolis, Ind., with its wartime program concluded in 1945, concentrated on a peacetime application of its V-1710 and V-3420 engines. Its war record showed production of more than 70,000 engines and 1,000,000 steel-backed bearings. Allison had reached its war stride early and had stayed to the finish. The 1,090 h.p. V-1710C engines that had powered the P-40s with the AVG in China and the British Tommies in Africa had given way to 1,150 h.p. V-1710E engines in the P-63 and 1,500 h.p. V-1710F engines powering P-38s. At the end of the war, a new jet propulsion engine designed by the General Electric Company was being produced in quantities that made Allison the world's largest builder of jet engines. These engines powered the Lockheed P-80 Shooting Star primarily, although a few were built for the combination reciprocating engine-jet assist Ryan Fireball. After termination of hostilities, Allison took over the entire production program for P-80 engines.

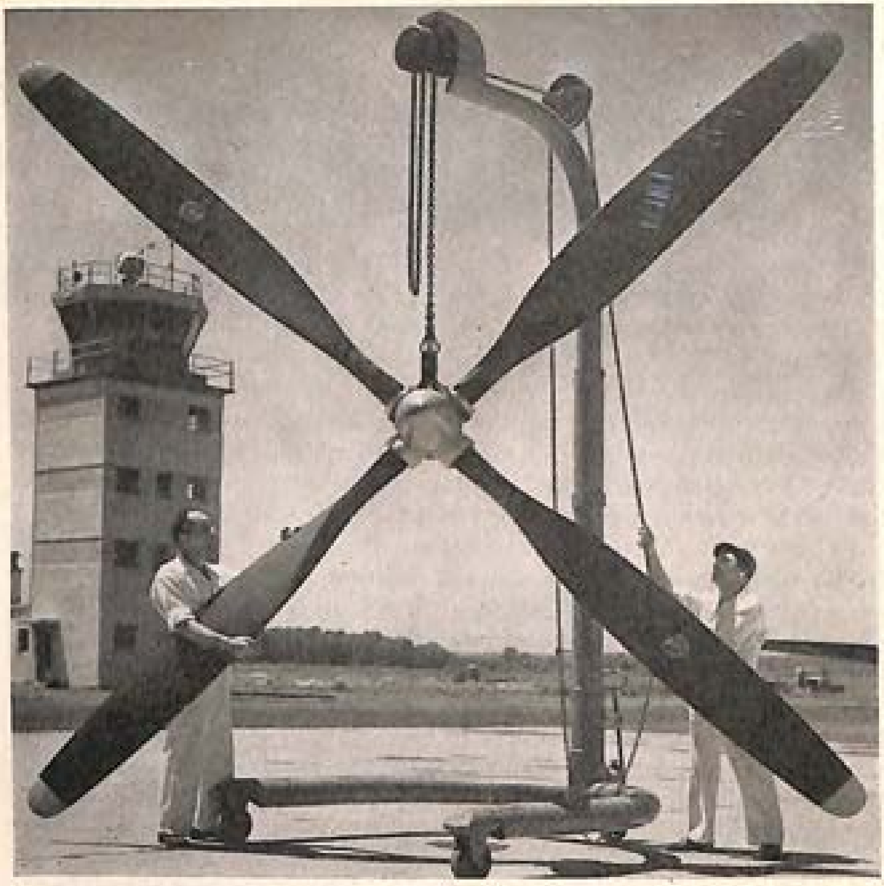
Two other engine installations were announced, one actual and one projected but both having substantial peacetime implications. The long secret Douglas XB-42 bomber was unveiled, to reveal its twin Allison installation with 30 ft. of extension shafting to counter-rotating propellers in the tail. Dubbed the Mixmaster, it immediately made aviation history by flying from Long Beach, Calif., to Washington, D. C., in 5 hrs. 17 min. 34 sec., at an average speed of 432 m.p.h.

Douglas promptly claimed this inter-city speed record as ample vindication for its claims of greatly increased speed and economy through placement of engines inside the fuselage, thus leaving the wings clean and unobstructed. At about the same time, Douglas introduced to the nation's airlines a commercial airliner on the same buried-engine, extension shaft principle. Calling it the successor to the DC-3, Douglas said the Allison-powered DC-8 would reduce by almost half the per-passenger-mile operating cost of the DC-3. It had counter-rotating propellers and up to 48 passenger capacity. The prototype model was scheduled to fly in 1946 and be available in quantities during 1947. In the XB-42 were Allison V-1710E engines with a 1,820 h.p. take-off rating using water injection and a 1,100 h.p. military rating. A new V-1710G engine was to power the DC-8 with ratings of 1,600 take-off and 1,000 normal up to 19,000 ft. Both models used Allison wartime experience in extension shafting and outboard reduction gearing achieved through installations on the P-39 and P-63. Allison also made another appearance in the large plane field during 1945 when four 24-cyl. V-3420 engines took aloft a special version of the B-29, the Boeing XB-39. In preliminary tests it demonstrated improved performance in speed, range and fuel economy. Other commercial and military installations in the larger plane field were under active consideration early in 1946.

The Curtiss-Wright Corporation, Propeller Division, Caldwell, N. J., was in production on a variety of new propellers, some of them designed to power the gigantic airliners and bombers scheduled to take the air in 1946. At the same time the Division had under way an intensive research and development program for even newer propellers to meet the demands of a rapidly expanding market for American aircraft. The last year of the war had brought to a close a remarkable record of design and production for the Propeller Division. During the conflict Curtiss-Wright had produced approximately 150,000 air screws. From January 1, 1940, until the beginning of 1946, Curtiss propellers had provided thrust for United Nations aircraft equal to 250 million horsepower, comparable to that of three million motor cars.

During the four months after the war, the Propeller Division closed and disposed of war-created manufacturing facilities at Beaver, Pa., and Indianapolis, Ind., and then had begun consolidation of manufacturing equipment from its Clifton, N. J., plant with that at Caldwell, N. J., where future production was being concentrated. During this same period the number of employees dropped to 2,435 from a wartime peak of 17,500. One of the Propeller Division's outstanding military roles was played in the final days of the war when 18 ft. 2 in. Curtiss Electric propellers with hollow steel blades were provided especially for the Boeing B-29 Superfortresses which carried the atomic bombs to Hiroshima and Nagasaki. These aircraft, in an emergency, could have been landed with their deadly weapon in less distance than usually is required by a single-engine fighter, the extra margin of safety having been afforded by the reversible feature of the propellers.

Reversible propellers, also an outstanding feature on the Consoli-



GIANT CURTISS ELECTRIC PROPELLER

Designed for huge air transports, this Curtiss Electric propeller is the largest ever to fly in this country—19 ft. 1 in. diameter. The light weight of hollow-steel for the blades made it possible to construct propellers of such large diameters needed to harness efficiently the tremendous horsepower of large aircraft engines.

dated B-32 which made its appearance in the closing days of the war, were developed by the Propeller Division to provide aircraft with an auxiliary braking system by making it possible to reverse completely the angle of the propeller blades and create a reverse thrust once the plane was on the ground, thereby greatly reducing the landing roll. Some of the outstanding military aircraft for which the Propeller Division designed and produced propellers during 1945 were the Ryan FR-1 Fireball, marking the first installation of an engine-driven propeller combined with a turbo-jet power unit on a production aircraft; the Curtiss SC-1 and SC-2 Seahawk scout planes; the Curtiss XP-55 Ascender, a highly maneuverable pusher-type experimental fighter; and the Douglas XB-42, featuring a dual rotation pusher-type propeller, unique in that its fore and aft units were 30 feet apart. In the commercial aircraft field Curtiss Electric propellers were produced or scheduled for installation on the Douglas DC-7 Skymaster, the Douglas DC-6, the Lockheed Model 49 Constellation; and the Douglas DC-8, a commercial version of the XB-42.

The Duramold Division of Fairchild Engine and Airplane Corporation moved from New York during 1945 to a large and modern plant in Jamestown, N. Y., and produced various molded items for aircraft. Among the parts made by the Duramold process were ferry fuel tanks for the Douglas A-26 Invader, and a unique type of knockdown plastic tank for the Lockheed P-80 Shooting Star, which could be assembled on the field in a very few minutes; also numerous types of radar housings fabricated of Fiberglas and low density material, utilizing sandwich construction. New types of high strength-to-weight ratio flooring for aircraft were developed. Duramold continued research into improved structural material, better and more lasting finishes, and more efficient methods of fabrication, utilizing electronic processing for heat curing of plastic laminates and structural assemblies. After V-J Day, production continued on certain aircraft parts and radomes, and a large part of the plant was reconverted into production of radio cabinets and lightweight molded boats, utilizing the Duramold process, and electronic methods in the fabrication of these items. Production was started on metal and plastic-faced plywood for use in aircraft, trucks and building construction.

Hamilton Standard Propellers Division, United Aircraft Corporation, East Hartford, Conn., with its four licensees completed more than a half-million controllable or hydromatic type propellers for war purposes and by V-J Day had shipped two million duralumin blades. The branch plants at Norwich, Conn., and Westerly, R. I., continued in operation until V-J Day, turning out controllable-counterweight propellers for trainer planes and hydromatic propellers and parts for bombers and fighters. By early June, 1945, both had swung over to a 40-hour week, while the home plant at East Hartford remained on its full wartime working schedule until the end of hostilities with Japan. Production of hydromatic and controllable-counterweight propellers by the division's three plants totalled 18,620 for 1945 up to the end of August, reflecting the reduction in military contracts following the collapse of Germany and shorter working hours at both branch plants. By the end of 1945, production was stabilized at prewar levels.

With the closing of the war plants at Norwich and Westerly, Hamilton Standard reconverted to a peacetime program. A number of propeller types produced by the branch plants or licensees during the war were returned to East Hartford, together with essential branch plant machinery. Top supervisory personnel, who had been shifted from East Hartford when the branches were opened, also returned to be absorbed into the home plant personnel force.

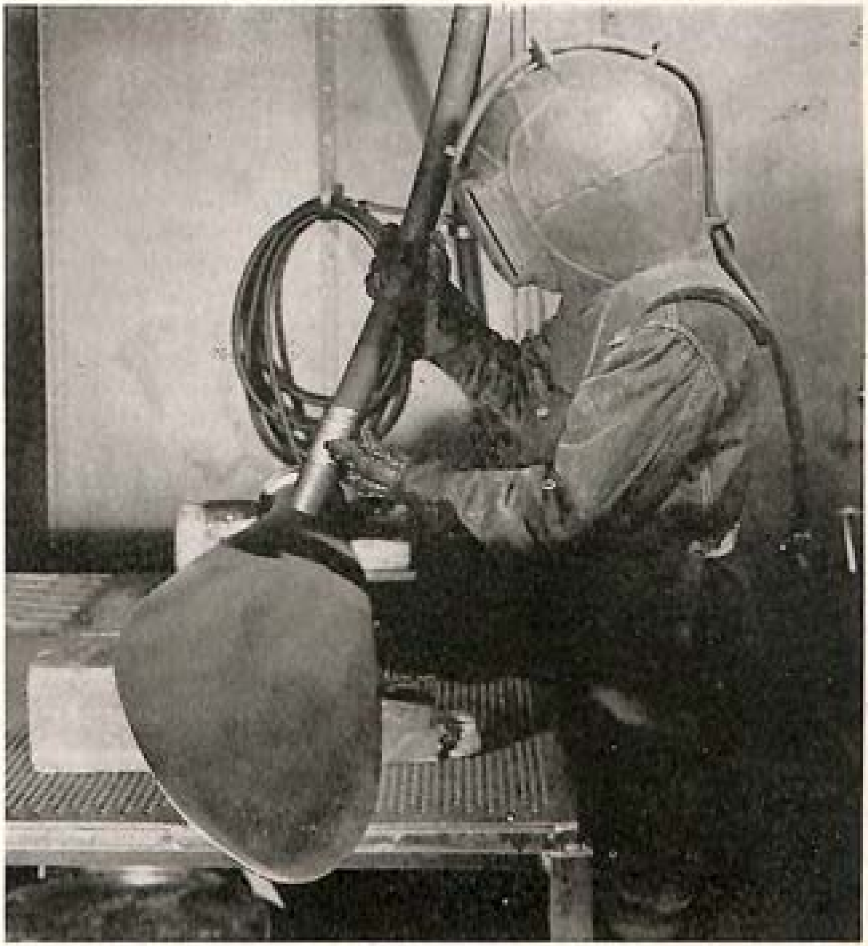
The division's four licensees, Nash-Kelvinator at Lansing, Mich., Frigidaire at Dayton, O., Remington-Rand at Johnson City, N. Y., and Canadian Propellers, Ltd., at Montreal, ceased building propellers on V-J Day. From the time the first licensees started in mid-1941 until their propeller-building activities ceased August 15, 1945, they had contributed a total of 304,097 propellers. During the 1939-45 war period, Hamilton Standard and its own plants produced 242,105 propellers. Of that total, 113,139 rolled from the East Hartford plant, 90,721 from Westerly and 38,026 from Norwich.

Early in June, 1945, the Norwich plant, youngest of the three, received its fifth Army-Navy E award for excellence in production. The East Hartford and Westerly plants were awarded their sixth in August, placing them among the six aviation plants to achieve that number of awards. Other awards conferred on the division included a certificate of service presented by the Army Air Forces to the division's propeller training school conducted at the Westerly plant, which processed more than 3,000 Army technicians.

At the end of the war, Hamilton Standard propellers were standard equipment on the North American P-51 Mustang, Chance Vought F4U-4 Corsair, Grumman F6-F Hellcat and F7-F Tigercat, Douglas A-26 Invader, Grumman TBF Avenger, North American B-25 Mitchell, Lockheed PV-2 Ventura, Consolidated-Vultee PBY Catalina, Boeing B-17 Flying Fortress, Boeing B-29 Superfortress, Consolidated Vultee B-24 Liberator and PB4Y-2 Privateer, Douglas C-47 Skytrain, C-53 Skytrooper and C-54 Skymaster, Noorduyn Norseman, Lockheed C-69 Constellation, Fairchild C-82 Packet, Beech UC-45 Expeditor, North American AT-6 Texan, Beech AT-7 Navigator and Consolidated AT-19 Reliant. Hamilton Standard-equipped aircraft broke several records for cross-country and long-distance flights during 1945.

Early in 1946, Hamilton Standard was in limited production on the super-hydromatic propeller and was preparing to produce a new line of hydromatic propellers. The new hydromatics included many refinements and modernizations, such as reverse thrust, which wartime experience had indicated to be desirable. Some models included the company's new hollow-steel blade, lightest of its type in the world, and the blade vibration absorber, which effected reductions of up to 66 per cent of the vibrations set up in propeller blades by engine excitation. All the new hydromatic types, with the exception of smaller models for smaller aircraft, incorporated reversing, which was built into the propeller by extending the blade angle pitch range to 120 degrees. Reverse thrust enabled large aircraft to land on smaller airfields and also resulted in safer landings on ice-covered runways. When used in conjunction with mechanical brakes, hydromatic reversing reduced landing lengths by one-third.

Taken off the secret list was Hamilton Standard's automatic synchronizer, a development for synchronizing the propellers of multi-engine aircraft. Used in conjunction with the company's new electric governor head and standard propeller governor, the synchronizer eliminated tiresome, uneven beat of unsynchronized propellers, and relieved the aircraft crew of some of its duties.



AT HAMILTON STANDARD PROPELLER PLANT

This "Deep-sea diver" is at work on dry land, in a room devoted to experimental shot-blasting at the Hamilton Standard Propellers plant of United Aircraft Corporation, East Hartford, Conn. Thousands of tiny pellets are expelled from the hose in his hand under pressures of up to 85 pounds, their impact against the propeller blade on his work-bench strengthening the surface of the metal by increasing stress resistance. A rubber apron, heavy work clothes, and a rubber diver-type helmet are required to protect him from the pellets, which ricochet from the blade and walls like an intense hailstorm. Water-cooled air for breathing purposes is pumped into the helmet through a hose connected to the outside atmosphere.

Some of the outstanding new aircraft using or about to use Hamilton Standard hydromatic propellers included the Douglas DC-6 and DC-4M, Martin Models 202 and 303, Boeing 377 Stratocruiser, Consolidated Vultee Model 240, Fairchild C-82 Packet, Hughes Hercules, Beech D-18S and D-17, Grumman G-73 Mallard, Spartan Model 12A, Douglas A-26 Invader, Chance Vought F4U-4 Corsair, Grumman F7F Tigercat, Lockheed P2V Neptune and PV2-4 Harpoon, Hughes XF-11, Lockheed C-69 Constellation, and Model 49 Constellation and Noorduyn Norseman.

Jacobs Aircraft Engine Company, Pottstown, Pa., a division of Republic Industries, Inc., had completed or terminated its war contracts on engines and parts and during the last year of the conflict production was concentrated on rockets. Up to November, 1945, Jacobs delivered 160,000 5-in. rockets to the U. S. Navy. Reconversion late in 1945 was directed to production of the Jacobs new model engine, the R-755A, and spare parts for older Jacobs models in use throughout the world. The company delivered during the war a total of 32,200 engines and replacement engine parts equivalent to about 7,000 engines. This production included 20,300 models R-755-9, R-755-7 and R-915-7, all of Jacobs design and rated from 225 to 330 h.p. The replacement parts also produced for those models were equivalent to about 4,342 engines. In another plant Jacobs produced and delivered 11,614 and 2,658 equivalent in parts of Pratt & Whitney models R-985 and R-1340 manufactured under license.

Limited quantities of the Jacobs L-4MB (R-755-9) and L-6MB (R-915-7) were produced in 1945. The L-4MB model was a 7-cyl. radial, aircooled engine, rated at 245 h.p. at 2,200 rpm for take-off. Displacement was 757 cu. in. Bore and stroke were 5¼ and 5 in. respectively. The L-6MB model also was a 7-cyl. radial, aircooled aircraft engine, rated at 330 h.p. at 2,200 rpm for take-off. Displacement was 914 cu. in. Bore and stroke were both 5½ in.

The Jacobs R-755A model, which was a further development of the L-4MB engine, completed its CAA Type Test. This model, which had the same displacement as the L-4MB engine, was rated at 300 BHP at 2,200 rpm for both take-off and maximum continuous power. Compression ratio was increased from 5.4:1 for the L-4MB to 6:1 for the R-755A. The engine featured dependable, economical performance at low weight (505 lbs.). Specific fuel consumption at cruising was 0.45 lbs. per BHP/hr.

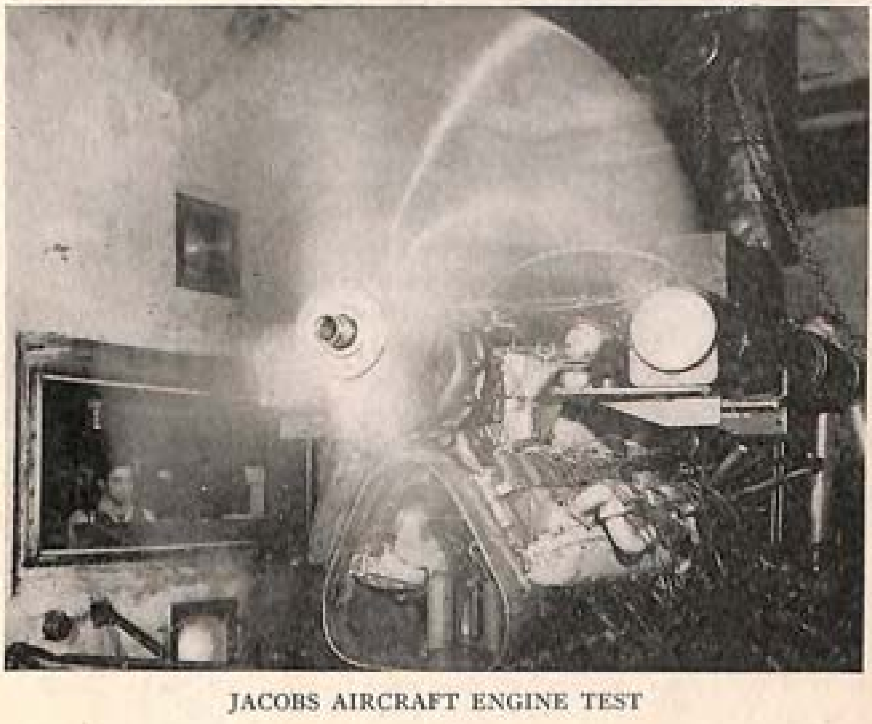
Jacobs also was working on the improvement of other 7-cyl. radial aircraft engines, and on the development of 4-cyl. flat, 100 h.p., and 6-cyl. flat, 165 h.p. liquid cooled engines for the postwar commercial market.

Menasco Manufacturing Company, Burbank, Calif., acquired from Lockheed Aircraft Corporation the manufacturing rights to a series of gas turbine power plants which had been in process of development at Menasco for more than two years. At the same time, Menasco obtained the services of the entire Lockheed gas turbine engineering staff, headed by Nathan C. Price. The gas turbine program, which was under way, visualized gas turbine power plants for the largest military and commercial aircraft down to the smallest private planes. During 1945, and continuing on into the postwar era, Menasco produced large numbers of small, two-cylinder, 22 h.p. gasoline engines for the radio-controlled target planes.

Service tests on the Menasco 15 h.p. Diesel engine still were under way. During the war, Menasco's plant area increased from 74,500 sq. ft. to 212,500 sq. ft.

Pratt & Whitney Aircraft Division of United Aircraft Corporation, East Hartford, Conn., and its licensees produced 363,619 Pratt & Whitney aircraft engines during the war period, and early in 1946 had reconverted all manufacturing to the home plant at East Hartford where it was in heavy production on six basic models, among them the new 28 cyl. Wasp Major R-4360 in three versions. One, the TSB3-G, had a take-off rating of 3,500 h.p. with water injection and 3,250 h.p. without it, while the VSB11-G Wasp Major was a single stage, variable speed engine with a take-off rating of 3,000 h.p. Pratt & Whitney also was working on the development of gas turbine power units.

The Wasp Major was capable of delivering more than 3,650 h.p.



JACOBS AIRCRAFT ENGINE TEST

and early in 1946 was the most powerful engine on production lines. Company engineers believed that its power output did not represent its ultimate possibilities. They pointed out that the smaller, 18-cyl. 2,800-cu. in. Double Wasp had delivered, in combat operations, well in excess of 2,800 h.p. The Wasp Major had a piston displacement of 4,360 cu. in. Its 28 cylinders were arranged in four rows of seven cylinders, each, giving the engine a frontal area no greater than that of the 18-cyl. Double Wasp, a two-row radial engine with a basic rating of 2,100 h.p. Indeed, the new engine was only one inch larger in diameter than the original Wasp, which in 1925 delivered 410 h.p. A helical arrangement of the new cylinders about the crankcase of the Wasp Major projected each individual cylinder into the air stream and gave the big engine better cooling characteristics than most one and two cylinder engines.

The engine had a dry weight of 3,405 lbs. a bore of 5.75 in. and stroke of 6 in. Its cylinders had forged aluminum heads with deep-cut cooling fins and integral valve mechanism housing, screwed and shrunk on a forged steel cylinder barrel. Forged aluminum sleeves in which deep-cut cooling fins had been machined (muffs), were shrunk on over the walls of the cylinder barrel. Each cylinder had one inlet and one exhaust valve, the inlet seating on a bronze insert and the exhaust on a steel insert, both of which were shrunk into the head. The cylinders were arranged helically around the crankcase, and pressure baffles were provided for individual cylinders and for each bank of four. All cylinders were completely interchangeable. The forged aluminum pistons were of the full skirt type. Each was fitted with three compression rings, one dual oil control ring and one oil scraper ring. The top compression ring was chromium plated on the face which bore against the cylinder wall. The rod assembly for each row of seven cylinders consisted of master rod with detachable cap, two-piece lead-silver bearing, and six "I"-section articulated or link rods. Each link rod had a bronze bushing at the piston end and rode on a silvered knuckle pin. The one-piece crankshaft was forged steel. It had four throws and was supported in the crankcase by five, steel-backed, lead-silver main bearings. The weights of the reciprocating parts connected to the crankpin were counterbalanced by fixed and bifilar counterweights.

The propeller shaft of the Wasp Major was supported at the crankshaft end by a plain lead-bronze bearing and at the propeller end by a roller bearing to carry radial loads and a deep-groove ball bearing which absorbed engine thrust. The power section crankcase was made up of five sections, all except the front and rear sections being interchangeable. The parts for the power section were machined from aluminum forgings, and were held together with through bolts. All other crankcase sections were magnesium castings. Attached to the front of the power section by studs were the magneto section, which mounted seven interchangeable magnetos, and the nose section, which housed the planetary reduction gearing and the torquemeter, and had provision for full feathering or other controllable propellers. Attached to the rear of the power section by studs was the supercharger housing enclosing the supercharger drives and impeller. Behind the supercharger housing, also attached with studs, was the rear section. On this was mounted a down-draft, pressure-type carburetor. The rear section housed the accessory drive mechanism and provided mounting pads for the radial mounting of all accessories to permit greater accessibility for servicing. Nothing was mounted on the rear of the engine. Rocker boxes were a part of the cylinder head, extending fore and aft. Rocker arms with plain bearings were actuated by enclosed push rods. Shelf-mounted cams, intake track in front and exhaust track in rear, served each row of cylinders, and were driven by spur reduction gears from the crankshaft at one-sixth crankshaft speed. The induction system included a Stromberg, four-barrel,

PRATT & WHITNEY WASP MAJOR ENGINE ASSEMBLY pressure-type carburetor, with automatic mixture control, idle cutoff, primer tubing and distributor; from which metered fuel was carried through internal passages and was thrown centrifugally through small holes between the impeller blades to mix with the combustion air. The fuel-air mixture, after passing through the diffuser to the blower rim, was carried to the cylinders through seven intake pipes, one for each bank of four cylinders.

There were two basic types of supercharger in unrestricted engines —a single-stage, single-speed supercharger suitable for use with an exhaust driven turbo-supercharger, and a single-stage, hydraulically driven variable speed supercharger. The two-piece impeller assembly consisted of a machined impeller, the straight blades of which were blended with the curved entrance blades of an inducer. The ignition system included seven Scintilla shielded magnetos, each with an integral distributor, operating at one-half crankshaft speed. Through a short "whip-type" harness each magneto provided dual ignition for the bank of four cylinders directly behind it. Forced feed lubrication was provided by a gear-type oil pump to all parts of the engine. The planetary reduction gears were of Pratt & Whitney Aircraft design and were spur gears with optional ratios of .381 or .425. All accessories were mounted radially on the periphery of the rear section. All accessory drive gears were driven by a bevel gear revolving at crankshaft speed.

Development of the Wasp Major engine was accelerated and encouraged by experimental and production contracts from both Army and Navy. Because of the urgency of military demands and the wartime telescoping of engineering activity, less than five years elapsed from the time the project was authorized late in 1940 until its public announcement in November, 1945. The first engine was run in April, 1941. The Wasp Major first powered an airplane in flight in May, 1942, and completed its 150-hour qualification test in December, 1944. The design was subjected to more than 20,000 hours of full scale development running, exclusive of test running of component engine parts, flight tests and operation by Government agencies and airplane contractors.

Immediately following the surrender of Japan the war production program was stopped, and the licensees, Ford, Buick, Chevrolet, Nash-Kelvinator, Jacobs and Continental ceased the manufacture of all Pratt & Whitney engines, as did Pratt & Whitney Aircraft of Missouri, a Government-owned plant at Kansas City, managed by personnel from the parent company. Pratt & Whitney Aircraft and its licensees had produced with spare parts, 603,814,700 horsepower in engines, of which Pratt & Whitney had turned out 37.8 per cent.

The schedules after V-J Day necessitated rearrangement of manufacturing operations centering in East Hartford. During the war numerous departments had been moved to Government-owned plants in Willimantic and Southington, Conn., and East Longmeadow, Mass., and to company-leased plants in Hartford and Buckland. Before the end of 1945, the activities at the Hartford and Buckland locations had been returned to East Hartford and plans were well advanced for vacating the factories in Willimantic and East Longmeadow. Plans for the future use of the Southington plant were not announced, but indications were that the manufacture of cylinders and baffles might continue there for a longer period of time. To make room for the departments being returned to East Hartford, much Government-owned equipment was removed from the main plant. The reconversion program was completed by Spring. While manufacturing activities were curtailed after the surrender of Japan, there was no let-up in the experimental and development program. These activities were being carried on at the highest level in the company's history. The Pratt & Whitney Aircraft development program covered all major phases of the aircraft power plant field, including developments of gas turbine types as well as advanced models and designs of reciprocating engines.

Expansion of facilities included new production test houses to accommodate the Wasp Major, and the installation engineering laboratory building. This building housed refrigerated, high-altitude chambers for fuel and oil systems and for complete power plant installations, together with electronics, fuel system, oil system, air flow, vibration and flight instrument shops and laboratories. The United Aircraft Corporation wind tunnel, with interchangeable 8 ft. and 18 ft. throats and air speeds up to 600 miles an hour, was put in operation.

After V-J Day, production lines were set up for the manufacture of six basic engine types. These included the 450 h.p. R-985 Wasp Junior, the 600 h.p. R-1340 Wasp and the 1,200 h.p. R-1830 Twin Wasp as well as improved models of the 1,450 h.p. R-2000 Twin Wasp, the 2,100 h.p. (2,400 h.p. with water injection) R-2800 Double Wasp and the Wasp Major.

Among the new military aircraft powered with Pratt & Whitney aircraft engines were the Martin PBM-5 Mariner with two R-2800-C Double Wasps; the Grumman F7F Tigercat with two R-2800-C Double Wasps; the Grumman F8F Bearcat with one R-2800-C Double Wasp; the Vought F4U Corsair with one R-2800-C Double Wasp; the Consolidated-Vultee PB4Y-2 Privateer with four R-1830 Twin Wasps; the Goodyear F2G Corsair with one R-4360 Wasp Major; the Boeing XF8B with one R-4360 Wasp Major; the Republic XF-12 with four R-4360 Wasp Majors; and the Douglas C-74 Globemaster with four R-4360 Wasp Majors, the Martin BTM Mauler with one R-4360 Wasp Major; the Lockheed PV2-4 Harpoon with two R-2800-C Double Wasps; the Consolidated-Vultee XB-36 with six R-4360 Wasp Majors; the Boeing B-50 Superfortress, with four R-4360 Wasp Majors; and the Douglas XC-112 with four R-2800-C Double Wasps, and commercial transports including the Boeing Model 377 Stratocruiser with four R-4360 Wasp Majors; the Republic Rainbow with four R-4360 Wasp Majors; the Douglas DC-4 Skymaster with four R-2000-D13 Twin Wasps; and the DC-6 Skymaster with four R-2800-CA Double Wasps; the Martin Model 202 (and 303) with two R-2800-CA Double Wasps; and the Consolidated-Vultee Model 240 with two R-2800-CA Double Wasps.

Private and executive type airplanes using single-row Pratt & Whitney aircraft engines included the Beech Model D-18S with two R-985 Wasp Juniors; the Beech Model D-17 with one Wasp Junior, the Grumman Model G-73 Mallard with two R-1340 Wasps; and the Spartan Model 12A with one Wasp Junior. A number of helicopters were being developed around the company's single-row engines which had been adapted to operate with the crankshaft in the vertical plane, including the Bell Model 42 and the Sikorsky Model S-51, each powered with one Wasp Junior.

Ranger Aircraft Engines Division of the Fairchild Engine and Airplane Corporation, Farmingdale, N. Y., which had manufactured thousands of its 6 and 12-cyl. series of inverted, inline, aircooled engines for the air forces of the United Nations, continued to devote its extensive manufacturing facilities to war production right through V-J Day. Production of its own engines was discontinued earlier when a quantity sufficient to carry on the military training program had been completed, but Ranger had shifted its facilities to the manufacture of combat plane components and other urgently needed equipment. Production of this type of materiel was increased early in 1945.

Manufacture of Andover auxiliary power units for the B-29 and other large bombers was continued at a high rate of production until midsummer. Component parts for Packard-built Rolls-Royce Merlin engines used in the P-51 Mustang were manufactured in quantity sufficient for the entire production of these engines until the war's end. A large order from the Navy for 5-in. rocket motors also was completed. Production of radar castings under subcontract for Western Electric was continued until Summer, and Ranger manufactured some similar parts again in the Fall. The war's end brought a halt to much of the subcontract work, including the production of miscellaneous detail parts, such as magazine cover cases, front plates and camera adapters, for Fairchild Camera & Instrument Corporation, on which work just had reached the quantity production stage.

The end of the war brought no halt, however, to Ranger's research program. Work on several developmental contracts for the Army and Navy continued throughout the year. In addition, Ranger began overhauling surplus Ranger Six engines. It sold these engines—factory-rebuilt and factory-guaranteed—as agent for the R.F.C. The first of them went into Grumman Widgeons. This engine rebuilding program was stepped up during the latter half of 1945 so that Ranger 6-cyl. inverted, inline, aircooled engines were available for civilian use soon after hostilities ceased. A general consolidation of activities followed V-J Day, and Ranger gradually moved its manufacturing facilities under one roof at the main plant in Farmingdale.

The Warner Aircraft Corporation, Detroit, Mich., continued production of the R-550-3 and R-500-7 aircooled radial engines for use in aircraft purchased by the Army Air Forces. Production also was continued on Warner hydraulic brake control units for military aircraft at the Detroit and Grand Rapids plants.

Westinghouse Electric Corporation, Pittsburgh, Pa., started designing an axial flow jet propulsion engine in January, 1942, on orders from the Navy. The Westinghouse 19A jet engine was ready for test 14 months later. By the middle of 1944, other models had been produced, including the 19B and 9.5A engines. The company had under way several secret projects for the Navy. They were described by R. P. Kroon, chief engineer on the project, as follows: "The 19B engine is good for 1,400 h.p. at modern plane speeds. A conventional aircraft powerplant of the same horsepower has more than twice the diameter of this jet engine. It weighs only half as much as a corresponding piston engine. Contrary to the rocket, which carries its own oxygen for combustion, the jet engine brings in its air from the outside. Air is pumped in by a compressor. The air is heated by burning liquid fuel in it. A portion of the energy of the hot combustion products, which have been expanded to several times their original volume, is used to drive a turbine, the sole purpose of which is to supply power to keep the compressor going. The remaining horsepower is not delivered to a shaft, but appears in the form of a high velocity jet. It is reaction of this jet that propels the aircraft.

"It is possible to take more power out of the turbine than is needed to drive the compressor, and this surplus power can then be used to drive a propeller. Such an arrangement, in which only a small part (20 per cent) of the energy remains in the jet, is known as a gas turbine propeller drive. Contrary to the present day piston engine, the jet engine really has only one moving element, as the compressor, the combustion chamber and the turbine are arranged in line. This is one reason for the streamlined appearance. Another reason for the small diameter is that the axial flow type of compressor has been selected. Contrary to the centrifugal compressor, which utilizes centrifugal force to pump up the medium, and which requires large diameter, the axial flow compressor is like a fan with many, many blades, that pushes the air backward towards the combustion chamber. In this six stage compressor the rotating blades revolve at a top speed at 18,000 rpm; that is, 300 times a second. At 18,000 rpm the compressor swallows an enormous quantity of air (50 ton/hr.) which it delivers to the combustion chamber. The combustion chamber is something like a perforated wastepaper basket, and the compressed air enters the burner baskets through these perforations. Fuel is sprayed in through a row of atomizing spray nozzles. A spark is used for ignition, but as soon as the flame has started, the ignition can be cut off because the combustion is continuous. There is no dilly dallying in the burner; the air particles spend only 1/100 of a second in the combustion chamber. The rate of combustion is so intensive that in a given space 1,000 times as much heat is released as in a conventional power plant boiler. Brought to temperature up to 1,500 degrees F., the combustion products then enter the turbine where they give off a good deal of their energy to drive the compressor. The tips of the turbine blades move at 800 m.p.h. They are going around so fast that the centrifugal pull on each turbine blade is 50,000 times its own weight.

"As the air enters the engine, it first performs an important little chore in cooling the lubricating oil. The aluminum oil cooler is located where it is subject to cooling air independent of whether the airplane is flying or on the ground. After going through the turbine, the gases then enter the exhaust nozzle. From here the jet exhausts as a 1,200 m.p.h. gale.

"The exhaust nozzle is one in which the area and thereby the velocity of the jet can be varied by a movable tail piece. The accessory drive comprises those accessories which serve the engine proper, and they consist of an electric starter to bring the engine up to the speed at which it can maintain itself, a fuel pump to deliver fuel to the combustion chamber, an oil pump to circulate the oil to the bearings and to the coil cooler which is mounted in front of the engine where air cooling is available at all times, an overspeed control to prevent the engine from 'running away,' an electric tachometer to give a visual indication of rpm to the pilot.

"Then there are the accessories which serve the airplane, and these consist of a generator to provide electric current, a hydraulic pump to furnish high pressure oil to serve wing flaps and landing gear, or a vacuum pump to operate the aircraft instruments.

"The 9.5A engine, the little brother of the 19B, has many of the same Westinghouse family features. Its top speed is 34,000 rpm, 567 revolutions per second. It was originally designed to power an American buzzless bomb, but appears promising in general to drive small planes, and, in later modified form, as a small mechanical drive turbine to drive helicopters, cabin superchargers and electric generators."

Wright Aeronautical Corporation, Paterson, N. J., in 1945 produced more than 16,000 Wright engines, developing over 32 million horsepower, for such aircraft as the Boeing B-29, the Lockheed Constellation, Curtiss Helldiver, Grumman Wildcat and North American Mitchell. At the same time, Wright Aeronautical, while maintaining war production at peak levels, developed a new 7-cyl.

engine for trainers, light transports and executive planes, increased the power output of the Cyclone 9 and Cyclone 18, which had served all branches of the armed forces; and further, continued development work on gas turbines leading to thousands of horsepower.

From Pearl Harbor to V-J Day, a total of 202,160 Wright engines were produced. Plants of Wright Aeronautical Corporation turned out 120,651 engines of all types and models, while from 1942 through 1945, Studebaker produced 63,789 Wright 9-cyl. Cyclones, and Dodge Chicago produced 17,720 Wright 18-cyl. Cyclones in 1944-45.

Peak production of Cyclone 18's was maintained until the defeat of Japan. Of the 7,700 of that type shipped in 1945 by Wright, a majority came from the Wood-Ridge, N. J., plant, but the Cincinnati plant retooled in 1945 and began production of the engine while continuing to turn out Cyclone 14's. The company's plants in the Paterson, N. J., area manufactured a slightly more powerful version for Navy experimental planes as well as advanced models of the Cyclone 9 for Navy fighters and scout bombers. Soon after the Japanese surrender, nine foreign and domestic airlines purchased a large number of Lockheed Constellation transports, powered by 2,200 h.p. Cyclone 18's for use in transcontinental and transoceanic flights. Later models, to be delivered early in 1946, were powered by 2,500 h.p. Cyclone 18's which increased speed and range far beyond that which enabled a Constellation to set the Burbank-Washington transport airplane record of six hours 58 minutes.

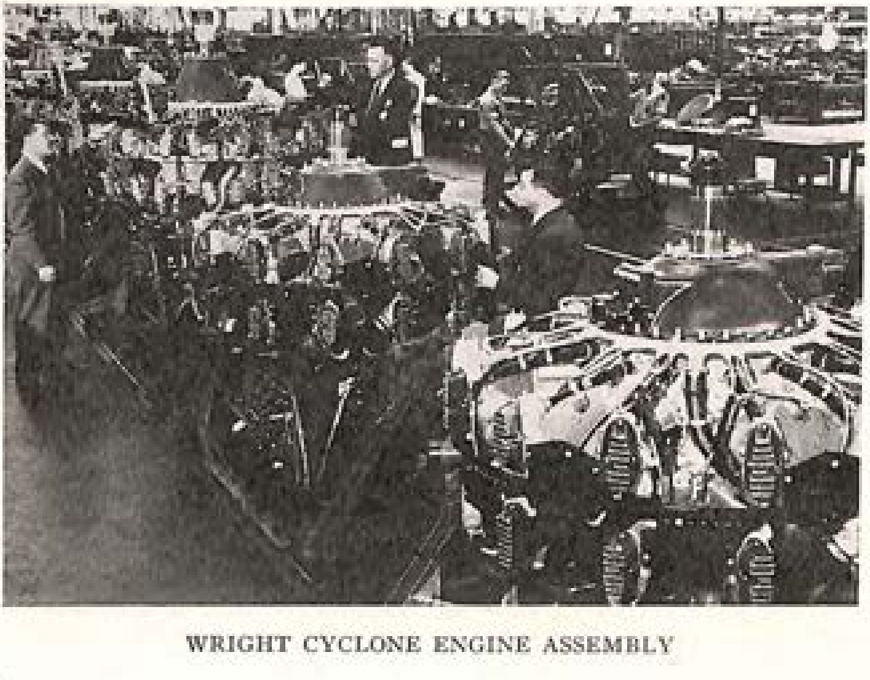
Late in 1945, the Cyclone 9 was increased to 1,425 h.p. The Cyclone 9 had powered 80 per cent of the nation's prewar and wartime commercial transports. With a ratio of one horsepower to each .95 lb. of weight, the latest Cyclone 9 was the most powerful aircooled engine per lb. of weight in production early in 1946. The Cyclone 7, "baby" of the series, was introduced early in 1945 for use on light transports. Produced in two models, with single or two-speed supercharging, the Cyclone 7 operated on low octane fuel, and had many parts interchangeable with other models for easier maintenance.

Another development for improved air travel made by Wright Aeronautical was the introduction of a Wright-designed turbosupercharger which used engine exhaust gases to enable planes to "breathe" in the thin air of high altitudes where passenger transports could travel over the weather for smooth, uninterrupted flights. In working on the development of the turbosupercharger, Wright engineers also gained added knowledge of heat-resistant metals which they put to use in developing the gas turbine power plant.

During 1945 Wright steadily increased production of Cyclone 18's equipped with fuel injection. This method of gasoline metering, which fed fuel directly into the combustion chamber, ensured an even fuel distribution and cut down detonation or "knocking", eliminating the dreaded icing of inlet manifolds and other parts.

On the scientific side, Kenneth Campbell, Wright Aeronautical research engineer, was awarded both the Wright Brothers and the Manly medals by the SAE for a paper on engine cooling fans, adjudged the best technical paper of the year. Wright engineers also developed a high altitude ignition tester which simulated atmospheric and temperature conditions of high altitudes for testing and development of improved ignition systems. Built of transparent plastic, the test chamber was one of the world's largest laboratory bell jars.

New military aircraft powered by Wright Cyclone engines included the Consolidated B-32, powered by four Cyclone 18's like those in the B-29. The Curtiss SC-1 Seahawk, powered by a Cyclone 9, took part in a pre-invasion attack on Borneo as its military debut. The Ryan FR-1 Fireball fighter, the first to combine jet and reciprocating power in one airplane, used a 1,350 h.p. Cyclone 9 for take-offs, landings and normal flight, relying on the jet to give added speed and climb during combat maneuvers. Cyclone engines in Col. Irvine's B-29 "Dream Boat" helped establish the world's long distance record in a flight from Guam to Washington—8,198 miles. Col. Irvine and "Dream Boat" also hold the Hartford-Seattle and the Seattle-Los Angeles record, and flew from Los Angeles to New York in 5 hrs. 28 min., to break the transcontinental record at that time. A Boeing C-97 transport, cargo and passenger version of the B-29, powered by four Cyclone 18's, set a record from Seattle to Washington, D. C., of 6 hrs. 3 min. and 50 sec. early in 1945.



WRIGHT CYCLONE ENGINE ASSEMBLY

## CHAPTER XII

### NEW AVIATION ACCESSORIES

Huge Production of Accessories Helped to Win the War—New Developments for Giant Aircraft and Private Planes—New Electronic Devices—New Aids to Navigation—Simplified Controls—Improved Fuels and Materials—Reconversion of the Industry to Postwar Programs.

NOWHERE in the realm of aeronautics was greater progress made during the war than in the vast field of accessories design and production. From cable controls and spark plugs to the practical application of gyroscopic and electronic science which supplied good bombsights and radar, the manufacturers of accessories kept pace with the demands made upon them for new things which contributed to the remarkable efficiency of our air force operations. Nearly all the new wartime accessories had peacetime applications in postwar air transport and private flying. They were vitally important factors in the maintenance of our air power in all its branches.

Aeronautical Services, Inc., Washington, D. C., was organized in October, 1945, and contracts were made with several of the major airlines for instrument approach procedure charts, route charts for instrument flight, airport surveys and related items. Other contracts were in production. A loose-leaf flight manual showing approach information at principal airports was being produced for one of the airlines. It superseded the popular prewar manual published by Range Data, Inc., the sole rights to this publication having been obtained by Aeronautical Services. The revised manual was to be ready for general distribution by the spring of 1946, providing complete coverage for the United States, Alaska and certain foreign areas. Aeronautical Services was an authorized agent for Government charts, manuals and other publications. It also maintained a "chart subscription service," under which subscribers automatically received current charts as soon as they became available. Navigation computers and other accessories also were carried in stock. A staff of expert engineers and cartographers was available as consultants, and for the production of special charts, as well as design and production of computers and other special devices for use in air navigation.

Airadio, Inc., Stamford, Conn., throughout the war devoted its facilities exclusively to the production of over $17,000,000 worth of radar and other electronics equipment for the armed forces. It was one of the largest producers for the Navy which awarded the company its Certificate of Achievement. Airadio was especially distinguished in the design and development of super-high and ultra-high frequency radar and electronic test equipment.

Many of the instruments developed for military use could be used to advantage in the peacetime electronic field. The SGE signal generator, developed for the Navy, proved indispensable on far-flung battlefronts, as well as in laboratories throughout the country for the development, testing and maintenance of radar equipment. The instrument was built in quantity production, and so precise was its operation that Westinghouse asked Airadio to build a modified oscillator for use as the local oscillator in a new type of very high frequency super-heterodyne receiver. The SGF signal generator, a companion unit, was a long line oscillator of ingenious design and was of particular interest because it covered the range of frequencies used by the television and FM stations throughout the country. It proved invaluable in the design and maintenance of both FM and television transmitting and receiving equipment.

With peacetime aviation on the threshold of a new era, Airadio 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, interphone 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 3¾ in x 5 11/32 in. x 5 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 headphone volume to several outlets simultaneously were features of the design.

Al-Fin Corporation, a subsidiary of Fairchild Engine and Airplane Corporation, at Jamaica, N. Y., continued to develop its process of chemically bonding pure aluminum to steel or other ferrous metals.

The process, used extensively in construction of cylinder barrels for the Ranger SGV-770 12-cyl. engine, resulted in more horsepower per pound of weight. The Al-Fin process of bonding aluminum and steel into an integral whole offered advantages in innumerable industrial applications where highly efficient heat transmission with saving of weight was desirable. It also proved useful in structural applications where thermal problems were not involved. Products which involved use of the Al-Fin process included aluminum-muffed and finned aircraft-engine cylinder barrels, steel-hubbed aluminum gears, aluminum-lined steel-backed preformed sleeve bearings, aluminum-muffed and finned heat exchangers, and aluminum-coated exhaust systems.

Edwin D. Allmendinger, New York, announced a line of tools for which he was export distributor. They included the Royal clipper metal cutter designed to eliminate cumbersome sheet metal snipping and save time in cutting light metals up to .040 in., plywood, plastics or cardboard. It could cut inside a sheet with a quarter inch hole for a starting point. Another tool was the C-B manual metal shrinker designed to do in minutes a job formerly requiring hours. It was manually operated and portable, and had a 45-1 leverage. Angles up to an inch wide could be worked to a radius as small as three inches. The tool would shrink metal of .016 to .051 in. Another tool, the C-B drill saver, permitted the operator to continue to use a drill after it had been broken by slipping the broken end into the drill saver, chucking up and continuing the job without loss of time or drill. The drill was held from turning in the holder by two dimples which rode in

THE ROYAL CLIPPER METAL CUTTER

the drill flutes, while a slotted end, compressed by the grip of the drill chuck, added gripping power. That tool was made in 52 sizes to fit from one sixteenth in. to No. 10 drills. Another tool was the C-B rivet cutter which could be gripped in a vise or mounted on a work bench, a rivet inserted and cut smoothly to the desired length. Still another manual tool was the C-B metal crimper for inside or outside curves, or upsetting or crimping the edges of metal. It was adjusted easily, and could be installed permanently. The C-B joggling block was another tool to form a joggle or an offset in a few minutes merely by inserting the angle into the block, tightening side plates, dropping into a vise and tightening.

The Aluminum Company of America, Pittsburgh, Pa., during the war supplied more than four and one half billion pounds of aluminum for the aircraft industry. The war years brought many new developments in fabricating methods, and new aluminum alloys. Noteworthy among the new alloys was Alcoa's Alloy 75S, made available in sheet, extrusions, forgings, rod and bar. The Aluminum Company of America offered a wide range of sheet aluminum alloys with mechanical properties ideally suited to aircraft primary and secondary applications. Many of these alloys were available as Alclad sheet, a form which proved so corrosion resistant throughout the years. Alclad 75S-T sheet, having a typical tensile strength of 77,000 lbs. psi. was fast approaching the status of the standard high strength sheet alloy for new aircraft design. While the bulk of production in aircraft sheet had been Alclad 24S, Alcoa also offered heat treatable alloys 61S, 24S, 75S, Alclad 14S and Alclad 75S. For extruded shapes requiring extra high strength (wing spars and fuselage primary structure being typical), Alcoa Alloy 75S was utilized to a very great extent. This alloy in extruded form had a tensile strength of 88,000 lbs. per sq. in. Stepped extrusions, which reduced machining to a minimum, were available. Through the development of increasingly larger hammers and presses, aluminum forgings of much larger sizes were possible. Aluminum forgings provided very high strength per unit of weight and their use resulted in great weight savings so essential in aircraft. Alcoa Alloy 75S forgings, recently made available, were proving of great interest to aircraft designers. The new aluminum fabricating methods and new alloys developed during the war were available to the builders of commercial and personal aircraft. Alcoa's engineers were ready to assist on the use of aluminum in new and unfamiliar aircraft designs and fabricating procedures.

American Tube Bending Company, New Haven, Conn., used its entire manufacturing facilities up to V-J Day in producing war materials, of which approximately 95 per cent were for the aircraft industry. The company's greatly increased productive capacity included equipment for bending, swaging, expanding, flanging and beading of round oval and square tubing in all metals. Gas and electric welding, as well as gas and induction brazing, played important roles in producing large scale quantities of finished assemblies. Heat treating and various finishing processes were added to the list of activities. The skills developed and experience gained during the war years improved the company's peacetime work materially. More than 50 per cent of its entire production still was devoted to the aircraft industry, including exhaust collector work in the light plane class, and experimental work for the engine manufacturers in both the large and small engine categories.

S. Appel & Company, New York, pioneers in specialized aviation uniforms and other clothing, had designed a variety of uniforms for use in airline operations.

The B. G. Corporation, New York, continued to supply the military services and engine manufacturers with aircraft spark plugs in quantity up to the end of the war. The B. G. Model RB19R ceramic spark plug was increasingly in demand for use in commercial operations, where very satisfactory results were reported. The RB-19R spark plug incorporated precious metal electrodes as well as a resistor in series with the spark gap, both of which contributed to extended service-free operation. This plug was currently approved for many of the high-output engines where its excellent anti-fouling characteristics were an advantage for idling and low-power running. Other ceramic spark plug models were in final stages of testing and were to cover a full range for all aircraft engines. A new D. C. Ignition Harness Test Set was developed and put in production for the field.

Charles H. Babb Company, New York and Los Angeles, a long established international aircraft sales and supply organization, was planning for a sharp increase in business volume. Commercial sales for the first few months of 1946 were at the best peacetime levels in the company's history. In line with heightened activity the company acquired a hangar at Newark Airport for servicing and reconditioning planes. Warehouses of the company were moved from Mineola, Long Island, to Newark, where storerooms, sales and service were available. Babb supplied a complete aircraft service at Newark, including motor overhauls, reconditioning and reconverting. The company also provided the public with storage facilities for private planes. During 1945 Babb erected a new warehouse and sales room on Airways Avenue, Glendale, Calif., fronting on Grand Central Airport.

Bendix Products Division of Bendix Aviation Corporation, South Bend, Ind., during the 1,347 days between Pearl Harbor and V-J Day, delivered to the armed forces of the United Nations $441,800,000 worth of military and naval equipment. It represented an output of nearly 14 million units by Bendix and its subcontractors, and an average of 10,000 units each working day. This equipment ranged from automotive carburetors and brakes to aircraft carburetors and brake and wheel combinations; from universal joints powering thousands of jeeps and multiple-drive vehicles to hydraulic power steering controls for giant trucks and armored cars; from vacuum power control units to massive aircraft landing gear struts and complex electrically powered gun turrets developed by Bendix engineers in cooperation with the Army Air Forces.

Some of the most dramatic of these products, resulting directly from years of engineering activity in the South Bend plant, lay in the field of fuel-metering or fuel feeding equipment for aircraft engines. Revolutionary developments in carburetion and fuel feed systems developed by Bendix played a key role in establishing and maintaining the superiority of allied air power over that of Germany and Japan.

For a decade before the war, Bendix invested more than six million dollars in research on various products at its South Bend plant. Much of that research money was used to build up research facilities devoted exclusively to fuel-metering developments, which later were to help make it possible for huge transports and multi-engine bombers to fly at ceilings over 35,000 feet and carry huge bomb and cargo loads at speeds over 300 miles an hour. As airplanes flew higher and faster, carried bigger pay loads and widened their cruising radii, fuel equipment by Bendix-Stromberg assumed increasing importance as the heart of aircraft power plants. When war came, Bendix engineers were ready to toss at the enemy an ingenious blow in the form of the Stromberg injection carburetor, perfected in 1937 and available immediately to the Army and Navy. Working in close cooperation with the services and with designers and builders of aircraft engines, Bendix-Stromberg engineers specialized in developing fuel systems designed to meet operating requirements of various engine designs.

This continuous development and constant improvement of fuel-feeding devices and controls built up in the South Bend plant what is believed to be the world's largest engineering laboratory devoted exclusively to aircraft fuel-metering research. From that laboratory emerged not only the injection carburetor but also an improved direct fuel injection system which gave American air power the first system of this type with fully automatic master control of fuel-air ratios.

Test facilities included a battery of "air boxes" for testing fuel-metering performance under high altitude air pressures up to 40,000 feet, refrigerated air boxes, which manufactured frigid temperatures as low as —70 degrees and engine test houses to check performance of fuel-equipment designs on actual aircraft engines. Direct fuel injection systems were checked in test stands which measured delivery of fuel quantities to individual engine cylinders. High speed movie cameras were used to check characteristics of fuel spray deliveries, and light ray optical measuring devices were used to check vital dimensions of fuel pump plungers to a millionth of an inch. In addition, the Stromberg engineering department had in operation extensive facilities to deal with fuel research problems involved in jet propulsion engines, gas-turbine propeller engines and ram-jet missiles. These included a complete jet-engine test stand and equipment to test performance of jet-engine burners at simulated high altitudes.

A huge job taken on by Bendix was development and production of electrically power-driven gun turrets. These were perfected at South Bend and put into production in the form of top turrets which equipped the North American B-25 bombers and chin turrets which protected the forward approaches on the Boeing Flying Fortresses.

The Bendix semi-automatic gun charging system made its contribution to air success in that remotely located guns which failed to fire in combat could be fired instantly by merely actuating a valve placed at the gunners' fingertips. Thousands of those units were manufactured during the war.

Serving its products and helping the armed forces to keep them functioning at top speed was an army of Bendix field service men on duty at every important fighting front. Stromberg fuel equipment experts were on hand at key air bases and on flat tops to check the performance of carburetors and direct fuel injection, and they reported back suggestions which contributed to constant improvement and efficiency.

With regard to Bendix aircraft products, which were major production items during the war, definite plans awaited future requirements of the Army and Navy air forces and reorganization of the transport and commercial aircraft industry along peacetime operating lines. The Bendix Products division, through continuance of its longstanding research and development program, planned to be in a position to make substantial contributions to the expected progress in commercial aviation, as well as in private flying.

Boston Insulated Wire & Cable Company, Boston, Mass., while continuing the manufacture of the standard types of aircraft wires and cables, produced many specialty and developmental types used in aircraft. In an effort to reduce the weight and size of lighting and power cables, a new type under the brand name "Radex" was brought out to replace the conventional lacquered braid covering with a film of tough yet flexible plastic which had unusual qualities for withstanding temperature and pressure changes. Also to reduce weight, power cables using pure aluminum conductor were manufactured for the larger feeder circuits with weight savings amounting to 22 per cent based on the equivalent carrying capacity of copper. A further weight saving was accomplished by the application of aluminum shielding braids in place of copper in open wiring systems. This saved an additional 20 per cent in the No. 18 gauge and about 10 per cent in the No. 6 gauge. High temperature coaxial cables for antennae lead-ins and other radar applications were important developments. COX-5F-22 was a flexible armored coaxial cable ⅞ in. in diameter, capable of withstanding temperatures up to 250 degrees C., with a capacity of only 8uuf per ft. and correspondingly low losses at ultra high frequency. Special matched fittings were developed to make sure that no moisture could penetrate into the cable when connected directly to an antenna or radiator.

Breeze Corporations, Newark, N. J., produced more than 8,000 different items in great volume for the Army, Navy, Signal Corps and Ordnance Department up to V-J Day. Having operated for twenty years in close cooperation with leading aircraft and engine manufacturers on development of numerous advanced aviation products, the company took long technological strides during the war and emerged with a strong organization to meet the rapidly changing postwar problems of the industry. In the radio ignition and secondary shielding field, Breeze met the trend with a flexible spark plug lead assembly greatly improved in shielding qualities and mechanical strength. In the secondary shielding field, Breeze designed improved end fittings and improved conduits, all in the interest of safer and better electrical systems in aircraft.

Typical of its noteworthy war developments was the Breeze Monobloc connector. It met urgent requirements of aircraft engineers and designers for a connector to eliminate many of the shortcomings of connectors designed before and during the war. 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 had contributed greatly to the deterioration of contacts at the point of soldering. The crimping method also insured uniformity of attachment to connector contacts as it eliminated the human element involved in soldering jobs. By the use of insertable contacts, cables could be attached to the contacts on assembly benches and then installed into the finished equipment, eliminating the need for soldering the wires or cables to the connectors at the point of installation. In designing this connector, Breeze engineers excluded many of the component parts characteristic of standard aircraft connectors, eliminating the possibility of mal-function due to flashover, condensation, erroneous assembly or breakage.

In the mechanical control field, Breeze improved the design of its actuator mechanisms used in the trim tab control systems, and developed many new mechanical drives used in a wide variety of applications, such as tachometer installations and radio control devices. Breeze also developed an electrically driven cowl flap mechanism for uniform opening and closing of cooling vents; and in the engine accessory field, Breeze concluded development and testing of a cylinder head temperature bulb.

The company's developments in aircraft armor plate for higher degree of protection and faster manufacture were among the war's more interesting aeronautical accomplishments. Armor plate production for aircraft continued after V-J Day, and experiments in this field still were carried on by the company. Among miscellaneous products, Breeze continued to produce flexible conduit in all varieties, internal tie rods and cartridge engine starters.

Champion Spark Plug Company, Toledo, O., prior to termination of war contracts, manufactured and delivered tremendous quantities of aircraft spark plugs to the Government air services and to aircraft engine manufacturers. During 1945, major airlines adopted Champion aircraft spark plugs for their use. While a very intensive engineering development program was carried on all through the year, after V-J Day special emphasis was placed on developments both of spark plugs and spark plug reconditioning methods and equipment to meet the requirements of the airlines. Several improvements in spark plug design were worked out, and they were expected to be available during 1946.

Chandler-Evans Corporation, West Hartford, Conn., consolidated all its activities in a large new plant in West Hartford, and was in an expanding production program on aircraft carburetors, fuel and water pumps and fuel controls for high output engines of both reciprocating and turbine types. At the same time, the company continued engineering and research into new uses for dehydrating equipment for shipment, storage and other fields. Chandler-Evans developed and produced the carburetor for the Pratt & Whitney R-4360 engine.

Chandler-Evans manufactured in its war plant at Wallingford, Conn., more than a hundred million Protek-Plugs used for protection of engines and instruments in shipment and storage. More than 380,000 fuel pumps and 80,000 water regulators for all types of engines were manufactured in the war plant at Meriden, Conn. More than 100,000 carburetors were made for Wright Cyclones in the B-29, B-32, C-69 and C-97 planes and also for Pratt & Whitney engines on the B-24 and C-87 planes.

Chicago Aerial Survey Company, Chicago, Ill., developed specialized photographic equipment which was used to great advantage during the war by both the Army and the Navy. The Sonne continuous strip camera was developed by the company for low altitude aerial reconnaissance. Studied on continuous uninterrupted strips in a special stereoscopic viewer, the large scale photographs, impossible to obtain by conventional aerial photography, revealed intimate details of enemy plans and operations. Photographs could be obtained at extremely low altitudes with this camera mounted in fast fighter planes because the moving film was synchronized to the movement of the ground image, effectively stopping motion in the photograph. Sharp clear photographs could be obtained at 100 feet of altitude at top jet airplane speeds with this revolutionary camera. Stereoscopic photos were obtained by means of a double lens system.

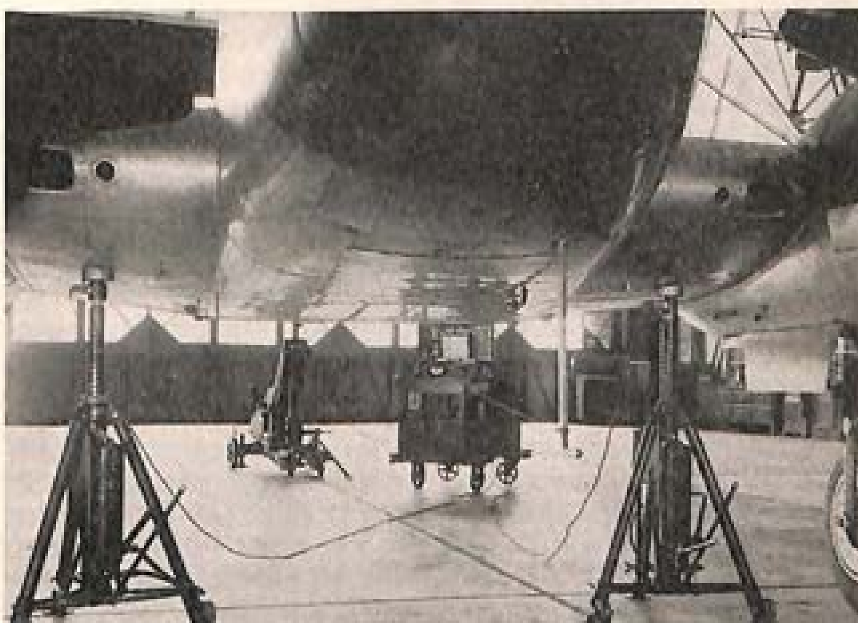
During the war the Navy developed a method of stereoscopically measuring water depths with Sonne strip photography. A measuring comparator was developed by the company so that parallax measurements necessary for this work could be made conveniently and quickly. This method of water depth measurement was used effectively in providing depth information on assault beaches during the latter phases of the amphibious war against Japan. Both the Army and Navy made good use of the extremely large photographic scale obtained at low altitude by swift fighter planes traveling at top speed. These low altitude missions proved to be relatively safe for combat operations because the photo plane flashed over and disappeared before enemy gunners could man their weapons. Commercially the camera was particularly adapted to photographing linear subjects such as railroads, highways and pipelines. A stabilization device was in the process of development, to allow strip photography at any flight altitude. An automatic continuous printer also was developed for the Army and the Navy which, in addition to printing the Sonne film, proved to be extremely valuable in quick printing of standard aerial roll film in large quantities.

The Cleveland Pneumatic Tool Company, Cleveland, O., manufacturer of aerols (air-oil shock absorbing landing gear units), Cleco pneumatic tools, rock drills and equipment for the mining and construction industries, and shock absorbing equipment (Cle-Air spring control unit) for military and commercial trucks and buses, had its large production schedule curtailed sharply immediately after V-J Day. Principal design facilities then were concentrated on landing gear for commercial transports, which in many cases were converted military models. Unable during the war to devote much time to engineering its landing gear units for small commercial and private airplanes, the company delegated a large part of its staff to develop its aerols for that fast-growing market.

Commercial Plastics Company, Chicago, Ill., developed a unique plastic clip-support which was used successfully by the Army and the Navy under all conditions and further, earned an enviable reputation in the aircraft and electrical industries. The clip-support was made from a special formula of ethyl cellulose which originally was produced for army canteens. As a clip to hold electrical wiring and cabling it had many unique and exclusive features. Its tensile and impact strength was excellent. It was light in weight and had good dimensional stability under a wide range of atmospheric conditions. Its rolled edges prevented short circuiting by cutting of braided insulation caused by vibration. It did not sweat as easily as metal clips and prevented rotting insulation of the wires. The clip-support was available in many stock sizes to fit practically any electrical wiring need, or it could be obtained in special construction to meet a particular requirement.

The Cox and Stevens Aircraft Corporation, Mineola, N. Y., continued production of specialized computing devices and its aircraft electric weighing kit. The weighing equipment constituted the major production item and the weighing cell itself was perfected in a variety of capacities ranging from 5,000 to 300,000 pounds each, all with the guaranteed basic accuracy of 1/10 of one per cent of applied load. More than 500 weighing kits were shipped to the AAF and Navy stations all over the world in 1945, and all types of military aircraft were weighed with the weighing cells. The fact that the weighing kit could be carried easily by one man and thus brought to an airplane at any place in a hangar saved much time otherwise spent in moving aircraft around to bring the airplane to the scales. By means of the portable kit, weighing equipment was available to stations that might otherwise have been without scales, and it assisted, along with the Cox and Stevens load adjuster, to insure weight and balance control of our military aircraft.

The weighing method was simple. The weighing cells were mounted on jacks and the jacks then raised until the entire weight of the airplane was supported on the cells. An interesting device was developed in connection with the weighing cell to simplify the weigh-



COX & STEVENS WEIGHING KITS

These aircraft electric weighing cells were mounted on jacks and the jacks then were raised until weight of the plane was supported on the cells.

ing of tail wheel type aircraft. A special adapter was designed for use with any one of the cells in the weighing kit. This adapter, which enclosed the cell, was attached to any hoist and the tail wheel weight then was secured by suspension rather than by the jacking method used on the main wheels.

Cox and Stevens planned to continue manufacture of weighing equipment, and with that end in view developed many other special adaptations of the device outside the aircraft field. However, for commercial aviation the company perfected equipment making it possible to read actual weights to within one or two pounds. The high capacity cells for experimental work in connection with the new, large airplanes, because of their comparatively small size and ease of operation, proved extremely successful. An interesting adaptation of the weighing cell was the measurement of the thrust of jet engines. Preliminary tests showed the weighing cells to be well adapted to installation in motor mounts and test stands for securing that essential data.

Although basically an engineering organization, Cox and Stevens had increased manufacturing activities until they represented 98 per cent of the dollar volume of the business. The ratio was expected to continue, although engineering services were available, particularly in weighing services and the preparation of approved loading schedules for privately owned aircraft.

Crescent Insulated Wire & Cable Company, Trenton, N. J., operated by the same family since 1881, had been developing and manufacturing insulated wire since the invention of the incandescent lamp. During the war Crescent met the exacting specifications of all the armed services and maintained scheduled production despite frequent changes in specifications caused by substitution of available materials as ordered by the Government or changes dictated by requirements which came to light in actual combat. Every length of wire had to surpass the applicable specifications requirements. All operations, starting with wire drawing, mixing of insulating compounds, spooling of cotton, rolling and galvanizing of steel strip, to the finished goods, were performed in one large integrated plant.

Durham Aircraft Service, Inc., Flushing, N. Y., and Detroit, Mich., which started business late in 1944, locating "hard to find" hydraulic valves and fittings, had expanded its organization to 80 personnel early in 1946, and was serving as distributor for a number of manufacturers as well as agent for the disposal of surplus war equipment throughout the United States and abroad. Durham service shops and warehouses were maintained in several areas.

Eclipse-Pioneer Division of Bendix Aviation Corporation, Teterboro, N. J., was in production on a variety of new devices for postwar aviation, besides maintaining its long-established regular line of accessories and flight and navigation instruments. Continued development of accessories for jet propulsion aircraft was in progress. Starters were available for turbo-jet engines having a single stage planetary gear train, a multiple disc clutch and automatic engaging and disengaging jaw mechanism, weighing approximately 27 lbs. For conventional aviation engines, light weight starters were being produced that weighed 20 lbs., less than those of previous design. They were direct-cranking electric starters, concentric in design, and consisting of a heavy duty electric motor, planetary gear trains in series, a friction disc clutch and automatic engagement and disengagement jaw mechanism, for engines up to 3,000 h.p. In addition, aircraft generators were developed, capable of producing up to 400 amperes at generator speed range of from 3,500 to 8,500 rpm, sufficient to provide current for operating all the electrical components of large modern air transports. D.C. generators, engine driven, were redesigned to give maximum performance with minimum weight. In recognition of the importance of operating valves and control equipment in attaining effective ice removal with new types of inflatable de-icers, Eclipse-Pioneer developed the electronic control for the previously developed Manifold Solenoid de-icing system. Offering distinct advantages over previous systems, it was widely accepted by the Army and Navy as well as several airline operators for use on large transport airplanes. Electrically operated actuators were redesigned to provide improved operating characteristics, longer service life and reduced weight. These actuators were used for electrically operated doors, lowering and raising retractable landing gears, operating wing flaps and tail wheels, and were furnished to various airplane manufacturers. Automatic engine controls,—the result of considerable engineering attention, were predominant in the further development of automatic devices with dependable performance.

Another outstanding Eclipse development was the motor driven, dry air-pump. It was equipped with an explosion-proof motor, required no lubrication, and was designed to provide air pressure or suction for operation of instruments, camera, noxious gas detector and radio harness pressurization. It provided a theoretical airflow of 4.1 CFM at 10,000 rpm and was driven by an integral .2 bhp. 27.5 volt d.c. motor. Rated capacity was .018 lb./min. air flow at 11.1" Hg. abs. inlet pressure, maintaining 31" Hg. abs. discharge pressure. Maximum operating characteristics were current draw 15 amperes, pressure differential 20" Hg., discharge temperature 300°F., minimum flow .01 lb./min. The construction was such that oil filters, separators or accumulators were eliminated, and air free of oil contamination was provided. This eliminated explosion hazard in applications where electrical discharges were prevalent. The pump required no lubrication and could be mounted near its supplementary equipment or in inaccessible places. The pump was of the rotary single-vane type; vane held against the rotor by pressure exerted through dual helical springs. The fins of the rotor housing dissipated heat rapidly. An automatic electrical overload protector was incorporated in the structure and provisions were included for wiring connections through electrical connector fitting AN 3102-16-11P. It weighed 4¾ lbs., and was 8 21/32 in. long and 3 17/32 in. diameter.

Several outstanding accomplishments in the instrument field also were recorded by Eclipse-Pioneer. The Pioneer Automatic Pilot was developed to meet the requirements of airline operators for precision automatic flight control of modern transport aircraft. The Automatic Pilot was accepted as standard equipment by the majority of the major airline operators in the United States and Canada. Incorporating specific features, developed as a result of a complete survey of airlines and C.A.B. specifications in respect to control characteristics, maintenance facility and safety provisions, the Pioneer Automatic Pilot provided, 1—proportional control, 2—coordinated turn control, 3—constant pressure altitude control, 4—automatic synchronization, 5—all electric operation, including 3 phase, 400 cycle, flight gyros and electric servos, 6—pitch trim indication, 7—magnetic azimuth control by means of the flux gate compass with multiple repeater indication, 8—reconnectible mechanical disconnect system for servo emergency control, 9—demountable servos, 10—airline type controller, 11—electrical fail-safe provisions (they were such that failure of a component in a signal circuit caused that channel to become inoperative and allowed the corresponding control surface to return to neutral), 12—simplified wiring and minimum number of individual units, 13—complete interchangeability of units, 14—availability of standard AN size flight instruments.

The Pioneer Pilot consisted of the following units: 1—Gyro stabilized flux gate compass transmitter, a completely sealed unit of small size for rigid mounting in the optimum magnetic field location in the aircraft. An important feature was a self-contained, cycling caging mechanism, remotely operated by push button. 2—Master direction indicator, incorporating convenient mechanical cam type compensator as well as the repeater transmitter. 3—Rotatable dial repeater indicator. Two of these units could be used in addition to the master direction indicator for remote indication of magnetic azimuth. 4—Amplifier and signal generator unit. In one compact assembly the signal gyros and the amplifier network were incorporated for the complete auto-pilot system, including vertical gyro for pitch and roll signal, rate gyro for azimuth rate signal generation, constant pressure altitude control unit, gyro caging relay, adapter control for follow-up ratio adjustment of the particular type of aircraft, pitch trim indicator tie-in, flux gate and servo amplifier system.

The amplifier and signal generator, designed for installation in a standard aircraft radio relay rack, provided maximum serviceability and ready maintenance. It resulted in the major reduction of weight and complexity of external wiring as compared with earlier automatic pilot systems. The constant pressure altitude control unit would maintain satisfactorily a given altitude up to 30,000 ft. It was so designed as to prevent the aircraft's assuming any extreme pitch attitude in maintaining altitude when subjected to severe vertical drafts. This unit was mounted within the case of the amplifier and signal generator unit and provided a change of one degree pitch altitude for every 30 ft. change of altitude. A switch was provided for this control so that upon reaching the desired altitude, the unit could be switched into the automatic pilot circuit. The match ratio adjustments were such as to provide the proper ratios to three axes as well as rate in the automatic pilot circuit, and was accompanied by four potentiometers. These potentiometers were located in the amplifier and signal generator unit to be accessible when it was mounted in a plane. A coded lock type cover-plate made it impossible to have incorrect potentiometer settings for a given type of ship. A quick disconnect was provided for this unit to facilitate rapid insertion and removal of the entire amplifier rack from the plane.

A fifth unit in the automatic pilot was a standard servo No. 2, entirely electric in operation. It consisted essentially of a 2-phase induction motor controlled by a coupling autosyn unit and driving the servo output shaft through a reduction gear train. The servo was automatically positioned in synchronization. An electrically operated clutch was incorporated for engaging or disengaging the servo to the aircraft control system. It was designed to provide a torque output of approximately 50 foot pounds and a revolution of 3 rpm. The combined weight of each servo, plus mounting bracket and mechanical disconnect was approximately 13 lbs., and the amount of pull necessary to disconnect the mechanical disconnect under load was about 10 lbs.

The reconnectible disconnect was used in conjunction with the servo 2 to provide emergency mechanical disconnect and reconnect of the servo to the control system. The individual mounting bracket permitted the servo to be separated readily from the disconnect and the control system without disturbing the control system rigging. Positive operation under all icing conditions also was provided.

The controller of the automatic pilot incorporated airline type turn control for coordinated turn, trim indices and pitch and bank trim control. The trim control provided maximum sensitivity required for procedure flight control. Included in the turn control grip was a momentary switch for disconnecting the compass signal when making fine course adjustments. A separately mounted clutch switch provided electrical control of the servo clutches to engage or disengage the automatic pilot from the aircraft control systems. A pitch trim indicator provided continual visual indication of the trim adjustment of the automatic pilot on the pitch axis.

Provision was made so that with simple external wiring changes,

ECLIPSE-PIONEER INSTRUMENT PANEL
A complete unit for small planes.

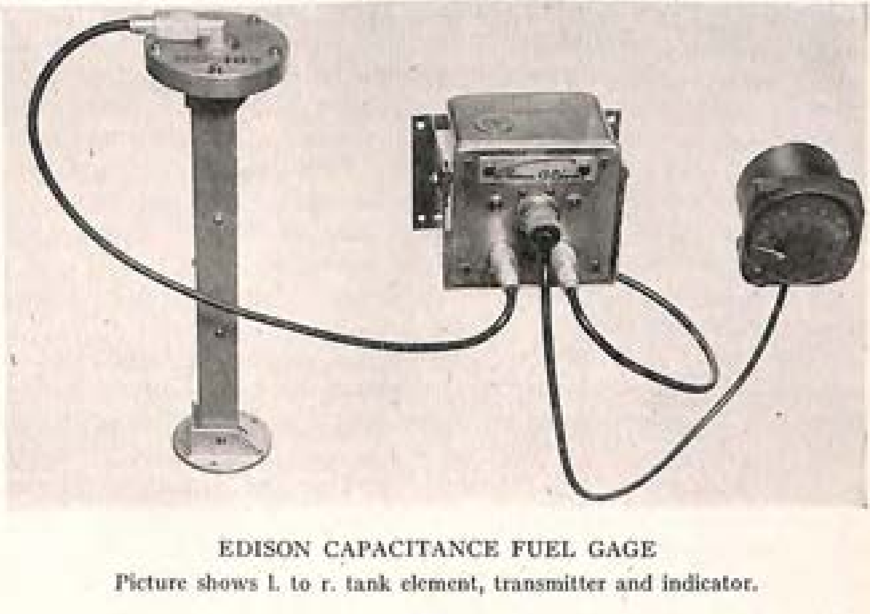
it was possible to use the flux gate compass section of the automatic pilot without the total current drain of 350 V.A. In this case, the flux gate compass system's current requirement was only 50 V.A. total. Hence an added safety feature was made possible.

The Pioneer Air Position Indicator was a valuable instrument for long-range aircraft. Mounted at the navigator's station, it provided visual indication of longitude and latitude, and by means of a numbered counter, air mileage was readily obtainable. The navigator, by entering his wind correction, could determine the position of his airplane in flight, in longitude and latitude.

Pioneer flight control instrument panels were developed for the owner of small, private aircraft in particular, and were designed to conform with the airplane's interior scheme. Completely self-contained, these panels embraced a single packaged unit, containing the basic flight instruments, including an altimeter, air speed indicator, tachometer, fuel level, oil pressure, oil temperature gauges, bank indicator and ammeter. All instruments were arranged compactly in the panel to provide instantaneous reading. The panels were mounted by means of four screws, plus, of course, the wiring and connections necessary for the instruments. Furnishing instruments in a small and compact panel eliminated the necessity of stocking individual instruments at a repair base, and simplified the maintenance problem in that the whole panel could be removed easily and a replacement installed while the individual instrument was being serviced. Additional instruments, such as manifold pressure, turn and bank, rate of climb indicators and clocks could be supplied readily in special auxiliary panels for cross-country and night flight. Similarly, any combination of instruments could be furnished in the basic panel as desired. The panel was adopted as standard equipment by several private plane manufacturers.

Thomas A. Edison, Incorporated, West Orange, N. J., continued to expand the activity of its Instrument Division in the aeronautical field. Production of electrical thermometer indicators and of engine gage units incorporating electrical temperature indication and vented fuel pressure indication was continued for the Army and Navy and for commercial planes. Two basic Edison instrument designs were applied to various unusual instrumentation problems. They were the moving magnet ratio meter in which hair springs were eliminated, and the differential pressure gage in which the response element was a simple capsule contained within a pressure chamber, the motion of the capsule being transmitted through the wall of the chamber by a unique motion seal.

The Edison aircraft engine fire detection system went into volume production. In this system, thermocouple units were placed at suitable locations in the power and accessory sections. Flame or hot gases striking these thermocouples generated currents which directly operated a sensitive relay, causing the alarm to operate. Tests indicated that the system responded to fire within one to five seconds after its



EDISON CAPACITANCE FUEL GAGE
Picture shows l. to r. tank element, transmitter and indicator.

outbreak, and was not damaged by the fire. Thus it indicated when the fire was extinguished, and was ready to detect any recurrence of fire.

Edison also was granted an exclusive license in the aeronautical field under patents of John E. Lindberg, Jr., on a capacitance type of liquid quantity gage, suitable for fuel, oil and hydraulic fluid tanks. Service tests were made and indicated for the average four-engine installation a total weight of less than 20 lbs. per plane, and an overall measurement error of less than five per cent. Production designs were completed, and quantity manufacture was to commence early in 1946. The Edison line of thermostatic switches and thermal timing relays found numerous aeronautical applications. Their distinctive construction, in which the contacting mechanism was completely sealed in glass and operates in vacuum or arc quenching gas, gave them a high current breaking capacity for their small size and light weight, with their capacity independent of altitude.

Edo Aircraft Corporation, College Point, N. Y., was in production on a backlog of orders for light plane floats for private aircraft, with plans for production of larger models in 1946. During the war Edo had produced 95 per cent of the dollar volume of all Army and Navy floats. Besides on schedule delivery of floats, the company built assemblies for 19 different types of aircraft, and its production record earned for Edo the second E award.

Naval aircraft equipped with Edo-designed and produced floats included the SB2U3, OS2U, SO3C, F4F, SB2C, the Martin Mars (wing tip floats), SC-1. Army ships included the L-1A, L-4, L-5, Ryan, Northrop, C-47-A, C-64, C-47 and AT-7. Two important engineering developments included Edo construction of the world's largest amphibious floats for the Douglas C-47 transport. This project was a direct result of prewar commercial development of amphibious gear for light planes. The other important design and construction project was the float gear for the Curtiss SC-1 Seahawk which included the unique innovation of internal bomb bays in the main float. Edo also produced subassemblies at the rate of 500 per month for the Grumman F6F Hellcat. Edo also was working on a major engineering development project for the Navy.

The Eisemann Corporation, Brooklyn, N. Y., had a line of magnetos for light aircraft.

The G & O Manufacturing Company, New Haven, Conn., had an expanding postwar program of production on its line of oil coolers which had been developed for Army and Navy aircraft during the war.

Gabb Manufacturing Company, East Hartford, Conn., introduced an entirely new and different kind of timing tool known as the Time-Rite. Unlike other methods of engine timing, the Time-Rite determined timing positions of the piston by direct measurement of piston travel. Top center indicators, timing discs and crankshaft pointers were eliminated, and faster, more accurate timing resulted. The Time-Rite could be used in practically all the current American aircraft engines, and its use was approved by the manufacturers and the Services. It was in use by several branches of the Services, the engine manufacturers, airlines and smaller operators.

The B. F. Goodrich Company, Akron, O., was a wartime producer of essential items for the armed forces. Principal products included bullet-sealing fuel cells and non-sealing fuel cells; de-icers; tires and tubes; brake expander tubes; all types of aircraft hose; life rafts; oxygen equipment, anti-exposure suits and many other aeronautical accessories. The transition to peacetime production was prompt. Few reconversion problems were involved because major items were continued largely as before, for civilian use. Goodrich engineers, with new production techniques and ideas evolved from war activities made possible a number of new developments. Airplane tires in new (Type 7) high pressure sizes and constructions to meet increasing load-carrying demands were developed, with special emphasis on the use of nylon to accomplish this. At the same time, splendid cooperation from airlines helped to forward the development of the company's new Rotovane tire, designed to provide rotation of the tire before the plane lands. New developments in de-icers provided a lighter, smoother shoe. A new Type 12 de-icer using a manifold tube arrangement combined lighter weight with cleaner ice removal, and showed up favorably on flight tests under icing conditions. Company engineers worked closely with the Eclipse company toward development of the new solenoid valve unit for de-icer operation. The Goodrich Rivnut, which long served as a nutplate for de-icer attachment, was found useful for many other fastening applications in aircraft. Originally available only in aluminum, development work made possible Rivnuts of brass, steel and stainless steel.

Announcement was made of a new pressure-sealing zipper with a precision-molded rubber lip, to seal gases and liquids from zero pressures to pressures up to the strength of the zipper itself. The pressure-sealing zipper was used as an aileron gap seal, as a seal for pressure cabin units, for camera cases, waterproof clothing and other equipment. Avtrim, a plasticized polyvinyl chloride applied to fabric, metal or plastic board, was introduced for use in airplane interiors. Also added to the Goodrich accessories line was Avtex, a plastic made of thermo-setting resins in both laminated or molded forms. For several years, this material was used successfully in fabricating trim tabs, larger control sections and structural parts. A new synthetic rubber cement, Plastilock, was used effectively in securing a good metal-to-metal bond. As an indication of its strength, Plastilock 500 used for metal-to-metal bonding had a shear strength of 3,250 lbs. per square inch, and tensile strengths reached 4,000 lbs. per square inch. The

New Products Department, staffed with sales engineers equipped to work with aircraft designers, found solutions to many problems where rubber, synthetics and plastics could be the answers. Adaptation of a Flexlock joint to airplane plumbing lines and similar uses was a typical example of the dozens of applications already proved or in experimental stages of development.

Grimes Manufacturing Company, Urbana, O., designers and manufacturers of aviation lighting equipment, introduced several new types of lights for aviation service. An electrically retractable landing light of explosion-proof design was intended for transport and private aircraft as well as for Army and Navy planes. Several models were available with sealed reflector lamps in two sizes and various wattage ratings. A plug-in type simplified landing light was developed for low-cost installation in small airplanes. Various new interior and instrument lights were developed for the latest models of transport and private aircraft. Grimes expanded activities to include design and manufacture of lights for small airports. Contact, boundary, obstruction, and glide-path lights as well as beacons were being developed for low-cost operation at small fields.

The Hilliard Corporation, Elmira, N. Y., developed a new line of Hilco oil filters and purifiers for the Army and Navy. The Hilco Flite filters were installed on several Army and Navy aircraft. A Hilco portable filter was developed for the Navy and it was installed at Naval air stations. The company also developed a completely integrated line of Hilco oil equipment designed to solve many maintenance problems and provide more hours between engine overhauls.

International Flare Signal Division of The Kilgore Manufacturing Company, Westerville, O., throughout the war carried on development work for the Army and Navy, and supplied the Services and civil operators with a complete line of landing flares and signaling equipment for all types of planes. The company was developing a new line of distress signals.

Jardur Aviation Company, New York, produced their Jardur-Warner air navigational plotter, a compact precision instrument for students and private and commercial pilots. The company also imported from Switzerland, for sale in the United States, the Jardur Bezelmeter aviation waterproof chronographs and wrist watches.

Koehler Aircraft Products Company, Dayton, O., which had developed valves for American combat planes during the war, in close collaboration with AAF experts at Wright Field, designed and produced new and modernized valves and other accessories for postwar aircraft. For example, the advanced K1700 drain valve, particularly designed for use in lighter, smaller airplanes, was ready. The design of this valve made slow, uncertain thumb-screw adjustment unnecessary, and safety wiring had been eliminated. It was but one of the many Koehler wartime proved valves and accessories that could be adapted to civilian planes advantageously. Koehler engineers devoted much of their time to solving the special problems of aircraft manufacturers. All the Koehler regular valve products were in production, including poppet type oil drain valves, fuel drain valves, line shut-off valves, electric solenoid valves and fuel selector valves, plus several important additions, including a new fuel strainer.

Kollsman Instrument Division of Square D Company, Elmhurst, N. Y., continued large scale production activities of its standard aircraft instruments, at the same time concentrating engineering and development on new instrumentation problems posed by industry progress, particularly in the fields of high speed flight, high altitude pressurized cabin operations, jet propulsion and helicopters. Important new instrument developments were made by Kollsman in each of those fields, including further development and initial quantity production of the Mach airspeed indicator, a unit which gave the pilot a continuous accurate indication of his relationship to the critical speed or point at which he would enter the shock wave pattern. The instrument was developed to solve automatically the problems involved in the relationship of airplane design and constantly changing air density, and was particularly important to high speed fighters and jet-propelled aircraft.

In the field of high altitude operations, considerable development work was done on a pressure pack for the Lockheed Constellation and the necessary instrumentation for it. The pressurizing system was designed to maintain cabin pressure at normal passenger comfort levels for flights up to approximately 20,000 feet and partial pressurization above that altitude. Another feature of the system was controlled rate of pressure change, so that ascents and descents of the aircraft could be made at fairly rapid rates while still holding cabin pressure changes within the 400 to 500 feet per minute rate.

Two new tachometer developments were necessitated by requirements of jet engines and helicopters. A new tachometer with a range of 10,000 rpm was developed for the jet requirements, while helicopters received a new unit indicating the relationship of the engine speed to that of the rotor to indicate any slippage in the gearing system.

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.

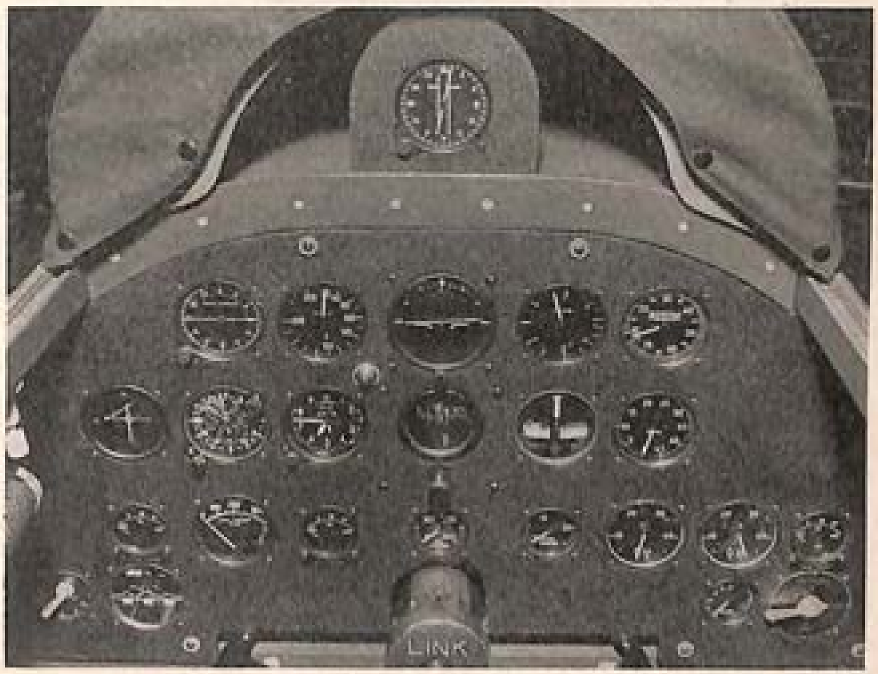
Leach Relay Co., Los Angeles, Calif., pioneer West Coast relay manufacturer, for the last 30 years, devoted its war-expanded facilities to producing both the old and new types of equipment needed to meet the ever-increasing requirements of the electronic era. Arriving too late for actual combat, a light weight (1,225 lbs.) heavy duty relay (200 amps.—capable of handling 1,200 amps. inrush—29 VDC) was designated by the Army and Navy as Relay No. AN-3370-1, and by the AAF as the B-10. More recently this relay was approved for use on military craft in variable frequency alternator circuits where it was required to handle 70 amperes at 115 VDC, 400 to 1,000 cycle alternating current, at a power factor of 95 per cent across the contacts. This relay found many new applications in modern transports, cargo planes and the new high-flying stratosphere aircraft. Others in the new series included the B-4A, B-8A, B-12 (rated 200 amps.); the B-11 (rated 50 amps.); the B-16 (single pole double throw rated 50 amps. on the normally open contacts and 25 amps. on the normally closed contacts). To the light personal plane industry Leach offered a light weight solenoid type relay, weight 8½ oz., having special alloy contacts capable of carrying 100 amps. at 12 volts direct current or 75 amps. at 24 volts direct current.

The Leece-Neville Company, Cleveland, O., completed its wartime commitments for Army Air Force generators, regulators, relays and motors, and followed this with the 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.

Link Aviation Devices, Inc., Binghamton, N. Y., had a fine war record for production of a number of devices which proved invaluable in the training of Army and Navy pilots. In addition to the famous Link instrument flying trainer, which trained pilots in instrument flying procedures while on the ground, the company also developed the Link crew navigation trainer for instruction of operational flight crews, the Link radar trainer by which pilots practiced interception procedures, the Link automatic pilot trainer used to instruct pilots and mechanics in operation and maintenance of automatic pilots, as well as many other significant training aids.

Best known of the Link devices was the Instrument Flying Trainer which was used by nearly 500,000 airmen in bringing American air power against the enemy. This trainer, the only item of training equipment to stay with a pilot throughout his entire professional career, consisted of a fuselage and instructor's desk, and contained all controls, switches and instruments necessary to simulate flight in an actual aircraft. Latest of these instrument trainers was the Model F, developed in 1945 and being produced by the Link firm for the AAF postwar training program. It contained 21 flight instruments and a complete set of controls, including trim tabs, landing gear, and wing flap controls, cowl flaps, carburetor heat control and oil cooler shutters. Instrument indications were accurately responsive to changes in flight attitude, power setting, air speed, altitude, rough air and air temperature, characteristics combined with air loading on rudder, elevator, and aileron controls to duplicate the conditions of actual flight with remarkable fidelity.

The Link crew navigation trainer, described by the AAF as a "marvel of American ingenuity," provided a navigator, radio operator, and pilot—individually and as a team, with working conditions similar to those in the air. It was a reproduction of a bomber fuselage housed in a 45 foot silo-like building. Above the fuselage was a celestial dome, a reproduction of approximately 380 stars of the Northern Hemisphere. Beneath the silo in front of the fuselage was a large screen, upon which a picture of the ground was projected from below. This picture of the terrain traveled along the screen according to the direction and speed of the simulated aircraft in flight. Night-time




NEW LINK INSTRUMENT FLYING TRAINER PANEL problems using the celestial dome, and daytime problems using the screen could be rehearsed in complete detail in the crew navigation trainer without risk of life or property. A modification of the crew navigation trainer was the celestial navigation class trainer which contained all the navigational features of the crew trainer but did not include fuselage, projection screen or terrain mechanism. Instead, six student navigators worked in individual booths under the star-studded celestial dome, each utilizing an observation platform. Consisting of a flying unit similar to the instrument trainer, a remote indicating cabinet, and a large instructor's table, the Link radar trainer provided a pilot with the same type of radar equipment used in actual aircraft. Figures appearing on an indicator scope in the pilot's cockpit were utilized to guide his "fighter" toward a simulated "enemy" aircraft many miles away. The course of the "plane" was controlled by an instructor at a table, and its position picked up by simulated radar, was reported on the pilot's scope. The constantly changing relationship of the pilot plane to the target was solved through the establishment mechanically, electrically, and electronically, of a spherical triangulation which provided accurate indications on the scope.

In the Link automatic pilot trainer, all types of automatic pilot equipment were installed on instrument trainers to provide a quick and efficient method of learning how to maintain the electro-hydraulic apparatus. It was found that since the controls and responses on a Link were identical with those encountered on standard aircraft, the training for mechanics could be made shorter and more effective. Also produced by the Link firm were the Link map reading trainer, in which a moving photograph of the ground was projected on a screen before a class, thus enabling navigation students to work out problems by seeing the ground over which they were flying. Other instruments were the Link aviation marine sextant and Link test collinator.

In prospect for early production was the Link pre-flight trainer which was being designed for use in school classrooms and for pre-flight training of laymen who "want to learn to fly." This low-priced trainer would assist beginners in understanding the functions and operations of aircraft, and it was being developed in response to a large number of requests relative to the adaptation of Link instrument flying trainers to classroom use.

The Liquidometer Corporation, Long Island City, N. Y., supplied practically all the principal aircraft manufacturers with remote indicating aircraft tank quantity gauges for installation on trainers, fighters, bombers, cargo, transport, utility and other types of airplane. These gauges were used to indicate quantity of fuel, oil, de-icer fluid, windshield alcohol, water and other liquids contained in tanks. After V-J Day when most of its war contracts were cancelled, the company completed readjustment of its facilities for peacetime business and disposed of war-expanded plants and equipment. The manufacturing and engineering facilities which remained after the adjustments, comprised considerable expansion over that available before the war. The company also carried on its regular continuous experimental program which resulted in many new designs and manufacturing improvements.

Lodwick Aircraft Industries, Inc., Lakeland, Fla., was established by Albert I. Lodwick to serve as a modification center, reconversion base and overhaul and maintenance depot for both airline transports and personal aircraft. The company also served as distributor for aircraft equipment; and its facilities were available for reconverting Army transport planes for purchasers in Latin America.

Macwhyte Company, Kenosha, Wis., was in production on its well-known line of "Hi-Fatigue" aircraft cables which were made of galvanized and stainless steel fabricated to reduce constructional stretch and increase fatigue resisting properties. At the same time Macwhyte "Safe Lock" swaged cable terminals were produced in eye ends, fork ends, stud ends, turnbuckle ends and numerous special types. They were supplied both loose and attached to aircraft cable. The "Hi-Fatigue" cable assemblies were used on primary controls of planes for operating ailerons, rudders and elevators, and for motor controls, bomb release controls and retractable undercarriages. The cable with terminals attached was made in lengths to specifications.

Macwhyte aircraft wire rope slings were manufactured for use with the airplane itself and for use in the production, handling and shipping of aircraft. On the aircraft, slings were used mainly for hoisting and lowering airplanes. These slings were made light weight and flexible and were built into the aircraft by the manufacturer so that, by means of a crane, it could be lifted quickly and safely on board ships, aircraft carriers, and otherwise handled. Macwhyte slings also were in constant use as auxiliary crane equipment in the production, handling and shipping of aircraft material. They harnessed such loads as boxes of vital material that had to be unloaded and transported overhead in the factory, packs of steel, motors, tires, pontoons and machinery. Wherever there were cranes to hoist and carry heavy loads, slings had to be there to handle these loads. In addition to manufacturing aircraft cable, assemblies, swaged cable terminals and a general line of wire ropes of many sizes, grades and constructions, Macwhyte also produced tie rods for internal and external bracing of aircraft. These were made of cadmium plated carbon steel and corrosion resisting steel. Macwhyte wire ropes had many uses other than that required by the aircraft industry, such as crane ropes, shovel ropes, hoisting lines, and draglines; wire rope for passenger and freight types of elevators, and for ship rigging, hoisting and towing.

The Glenn L. Martin Company, Baltimore, Md., announced three important developments in fields allied to aircraft production. One was a new elastic plastic, Marvinol resin, a polyvinyl type which experiments showed suitable for manufacturing such items as multicolored wire insulation, "rubber" sheeting, shoes and soles, food packages, umbrellas, raincoats, upholstery materials and many other items. Plans of the Martin Company included marketing it in white powder form to manufacturers of these products, the material to be produced in a new $1,500,000 plant to be erected at an undisclosed location. Another Martin development was a new feather-weight construction material, made of a "honeycomb" of cloth or paper sandwiched between and firmly bonded to thin sheets of aluminum, stainless steel, wood veneer or plastic. The new, waterproof sheets were designed to be structurally stronger than other materials of the same weight being manufactured. A third Martin development was a new process by which wood, metals, cloth, leather, plastics or almost any other surface could be made usable for photographic reproduction. Basis of the new process was an emulsion which could be spread on many kinds of materials, sensitizing them for photographic print use. Savings for reproducing drawings and charts for production purposes proved large, and the system was used widely during the war in the aircraft and other industries. Added to these were more than two hundred other outstanding developments and processes made during the year in Martin plants and laboratories to speed production and save valuable materials and man hours.

Menasco Manufacturing Company, Burbank, Calif., produced landing gear struts for P-51 Mustangs, P-47 Thunderbolts, P-38 Lightnings and other military aircraft. In addition, Menasco manufactured glycol heaters, shimmy dampers, hydraulic pressure accumulators and gas ejector valves for naval guns. Total value of wartime production was slightly over forty-two million dollars. In July, 1945, Menasco acquired the assets of the Malabar Machine Company, manufacturers of nationally accepted hydraulic jacks for aviation, railroad, industrial and automotive use. After V-J Day, the two companies were merged physically and sales and production efforts were coordinated to market the Malabar equipment on a large scale. The line of Malabar jacks included fixed-height, variable-height and multistage models; wing, tail and axle jacks for every type of airplane.

Menasco also continued production of aircraft landing gear, making struts for the Lockheed P-80 Shooting Star, North American P-82 and the Douglas BT2D. Development work was conducted on one of the largest sets of struts ever built, intended for a gigantic military transport on the secret list.

The exclusive Menasco Uniweld process was developed and proven for three years. During 1945, its successful application to the fabrication of landing gear struts was recognized when Army Air Forces approval was obtained for the first time in the history of welding. Uniweld was an automatic method of producing pressure welds which could not be distinguished from the parent metal in strength, appearance, weight or micro-analysis. Uniwelded assemblies averaged about 20 per cent less weight than designs based upon conventional forms of assembly—bolts and nuts, screws, rivets and arc-welding.

Mercury Aircraft Inc., Hammondsport, N. Y., continued to supply parts and accessories to other manufacturers, but broadened its scope to cover other fields outside aviation as well. Chief among its new products were aluminum school buses, which embodied the latest technique and processes developed in building aircraft, with a great reduction in dead weight and in operation and maintenance costs. Other production included articles fabricated from aluminum, utilizing the same equipment as was used during the war—applying aircraft technique to industrial products.

The Norma-Hoffmann Bearings Corporation, Stamford, Conn., produced ball, roller and thrust bearings for airframes, power plants, instruments and accessories both in standard types, as well as in many special designs to meet the needs of the aircraft industry. Many of these bearing types were made for peacetime production. The company extended its line of extra light ball and roller bearings, bearings for instrument applications requiring extremely low torque, corrosion resistant bearings and bearings having built-in seals for protection against dust and moisture. Research and development departments cooperated with Government agencies in development of new bearings and bearing lubricants and in writing specifications to cover them.

Pioneer Parachute Company, Manchester, Conn., which since its organization in 1938, had become one of the world's largest producers of parachutes, developed a new type of parachute harness, named the "Quick-Fit," which could be adjusted on any wearer, regardless of size or weight, in just three seconds. It superseded the older type harness which required separate adjustments. The new harness was simple to put on; chest and leg straps were snapped on in the usual way, then a tug at leg and chest straps automatically drew the entire harness to a perfect fit. The harness was loosened as easily by a simple tug at the chest and leg strap fittings. Therefore, it could be kept loose for comfort during flight and tightened immediately in an emergency. The parachute could be put on or removed by the wearer while sitting inside a plane, another Pioneer development. The Pioneer P3-B was a thin, soft, flexible chute especially designed to be used with the new harness. Pioneer also developed a new and larger chute testing tower.

The John A. Roebling's Sons Company, Aircord Division, Trenton, N. J., continued to supply at peak production its aircord, swaging terminals, control assemblies, including its Lock-Clad control assemblies, and aircraft and engine slings for prime aircraft manufacturers, their subcontractors and the Government. Most of the aircord control assemblies were of galvanized carbon steel, although stainless steel aircord was supplied to the limit of availability, particularly on Navy contracts. In addition to the Lock-Clad control assemblies, which afforded decreased stretch characteristics and greater sensitivity of control, special control cable designed to maintain uniform loading conditions under wide ranges of temperature was supplied for certain airplanes. Improvements in manufacturing processes were developed to produce aircord having materially decreased permanent stretch characteristics, and these improvements were incorporated in regular production.

SKF Industries, Inc., Philadelphia, Pa., had a war record of millions of aircraft bearings. This vast production was accompanied by many scientific improvements in the bearings and in production technique, all of which SKF was making available to industry. Among the principal SKF bearing types produced for both military and commercial aircraft requirements were cylindrical roller bearings for crankshaft locations, and deep groove separable type ball bearings to carry the propeller thrust. Progressive improvements and refinements in both design and manufacture were made in order to keep pace with the continuous demand for improved engine power and performance. In addition, many bearings of all types were manufactured in ever increasing quantities for use on auxiliary parts and accessories, rocker arms, superchargers, generators and starters. Production of miniature precision bearings was stepped up to meet the demand for use in gyro compasses, automatic pilots, speed and directional indicators, fire control mechanisms and the bomb sight. Balls and rollers were held to size within 25-millionths of an inch, while dimensions of races were controlled within 10-thousandths of an inch. The surface finish of raceways was improved until it was being measured in 3-millionths of one inch. With the end of the war, attention was focused on the development of suitable SKF bearings to meet the elevated temperatures and high rotative speeds encountered in aircraft gas turbines and jet propulsion units. The techniques and production facilities developed during the war were concentrated toward offering the optimum selection of ball and roller bearings for postwar aviation.

Scintilla Magneto Division of Bendix Aviation Corporation, Sidney, N. Y., during the war produced nearly three million units to meet the ever increasing demand of the Army and Navy for ignition and fuel injection equipment destined for tank, automotive, industrial and aircraft engines, which required production of extraordinary quantities of magnetos, battery ignition units, radio shielding harnesses, switches, spark plugs, electrical connectors, mouldings, fuel injection pumps and nozzle holders, with their service repair tools, and in addition many millions of spare parts. Personnel at the Sidney plant increased from a December, 1941, total of 3,900 to 8,600 in February, 1943, an increase of about 120 per cent. During January, 1942, 81,831 pieces of Bendix-Scintilla equipment were produced and twenty-one months later, in September, 1943, 134,381 units were shipped for use in the war.

Outstanding improvements in methods of tooling and manufacturing technique were accomplished, and real strides were made in perfecting both performance and durability of the ignition and fuel injec-

SCINTILLA'S ALTITUDE CHAMBER

It was used for testing Scintilla aircraft ignition equipment under simulated flight conditions.

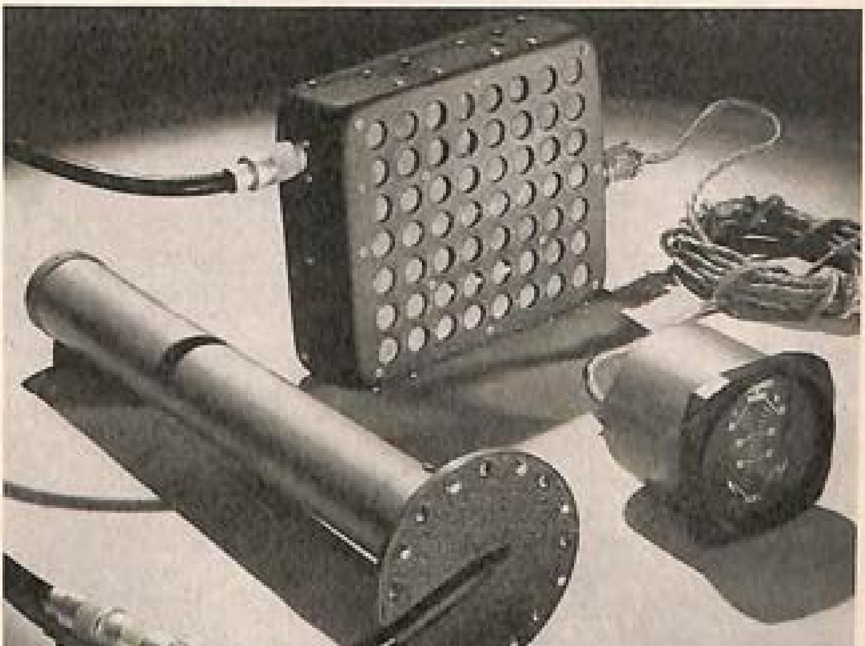
tion systems. Moulding of dielectric parts for all types of units was of special importance, and extensive research in better materials resulted in higher general performance, particularly at altitude. Electrical connectors to meet the insistent demand for explosion and waterproof electric wire joints were produced. Scintilla engineers designed and made available to production, new ignition devices that, even in the face of the pressure for production of standard types, found their way to engines powering combat aircraft. Low tension ignition systems that eliminated long circuits of high tension current was one of the outstanding achievements of the Scintilla engineers, and incorporation of changes in production units to meet the ever increasing horsepower earned for the company the repeated commendation of the armed forces. Suppression of interference with radio and combating of ignition effects upon radar were top ranking projects which were accomplished successfully by Scintilla's research, engineering and production.

New and improved designs for aircraft, industrial and automotive engine ignition and fuel injection were in Scintilla's postwar program. Moulding of plastics for general use and dielectric materials for insulation were to be made available. Fine ceramics of high heat-resistant value and mechanical strength were among the products planned by Scintilla. Electrical connectors, comprising the newly developed Scinflex dielectric inserts, were in demand where the connections had to be definitely positive. Ignition equipment for all types and sizes of industrial, aircraft and marine engines were well along toward production. Scintilla received the E award three times.

Scott Aviation Corporation, Lancaster, N. Y., had a war record of production for the Services including thousands of portable oxygen breathing units, and at the same time vast quantities of subcontract parts for aircraft, including tail wheels, hydraulic master brake cylinders, AN-A-17 aluminum alloy castings and special parts. During 1945, as war conditions permitted, efforts were made in the design and sales promotion of new and old products, to preclude a damaging slump on V-J Day. As a result, practically every major manufacturer of personal aircraft designated one or more items of Scott manufacture as standard equipment. Typical of this equipment were tail and nose wheel assemblies, hydraulic master brake cylinders and parking brake valves, control wheels, rudder and toe pedals, co-pilot rudder pedals, fuel gauges, pressure gauges, temperature gauges, ammeters, free air thermometers and aviation chemicals. Portable oxygen breathing equipment was supplied for the air transport industry. The company designed and produced a new type of breathing apparatus, the Scott "Air-Pak," for use by fire and police departments, industrial concerns having breathing hazards, and for complete lung protection in any condition of noxious atmosphere, and even for underwater use. This was a direct outgrowth of tremendous experience in the manufacture of oxygen breathing equipment for the AAF.

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, which registered these changes on the instrument panel. There were no moving parts in the Simmonds Pacitor gauge and, once installed,



THE SIMMONDS PACITOR GAUGE

For gauging aircraft fuel, it improved accuracy of fuel measurements to within 3 per cent.

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.

The Simmonds 4L light duty push-pull control met a need for a light-weight precision control to transmit mechanical motion from a convenient point of application to a remote point of operation. It was designed especially for use on light and medium weight aircraft and for industrial applications where the greater strength of the Nos. 5 and 7 push-pull control sizes was not required. The 4L light duty control consisted of a sliding member made of phosphor bronze bearing rings swaged on steel cable. This linkage moved in either a rigid or flexible casing, and was capable of operating loads up to 20 lbs. Like the 5 and the 7 push-pull controls, the light duty control was pre-assembled ready for immediate installation. It could be used with the Simmonds Radian unit and other fittings, and was waterproofed when required.

Continuing its engineering program in development of automatic engine controls, the Simmonds Type SA-9 automatic engine control was produced for the Packard Rolls-Royce Merlin engine in the P-51H Mustang to coordinate automatically spark and manifold pressure and to operate the water injection switch. Engineering work began on the application of the automatic engine control, in conjunction with the development of other automatic devices, to multi-engine aircraft and the non-conventional engines developed during the war.

The Simmonds Capsule, a diaphragm type pressure-sensitive bellows, which had been developed and manufactured by Simmonds for use in the automatic engine controls and other products, was made available to the field for applications which required an engineered diaphragm type bellows of great strength and sensitivity. The Simmonds hydraulic fuses, the quantity measuring type and the return flow type, were developed and produced as devices to protect aircraft hydraulic systems against break or leakage in hydraulic lines.

Sinclair Refining Company, New York, expanded facilities for production of aviation and all-purpose high octane gasoline for military purposes. Sinclair aviation gasolines were supplied in large quantities to our Army and Navy air forces and other Allied nations for maximum performance in all types of aircraft. These fuels and components were produced in nine Sinclair refineries. Critical laboratory analysis and engine testing controls were maintained to assure the highest standard of quality and uniformity. Sinclair also continued its research and development program on aircraft engine oils and lubricants suitable for the higher output engines on the larger type of airplanes in both military and commercial service. Particular attention was given to development of lubricants providing full protection under great extremes and variations of temperatures.

Skydyne, Inc., Port Jervis, N. Y., since 1938 had pioneered sandwich construction for airplane parts and airborne equipment. The experience gained by theoretical studies, experimental development and technical data assembled during the early stages of the war was put to good use manufacturing ailerons for the Army and Navy, helicopter tail cones and tail rotors, radar antennae and chests. The company also developed hard surface tabs that were materially stronger and considerably lighter than aluminum prototypes. In 1943 the company's facilities were greatly enlarged to cope with Signal Corps and Army Air Forces orders for parabolic antennae, moisture-proof and shock-proof chests housing airborne radar to be parachuted in combat areas, and for particular use in the difficult conditions existing in the Southwest Pacific. The chest walls were sandwich panels consisting of aluminum alloy faces and balsawood core. The company's manufacturing activities were temporarily halted on V-J Day, but the production for the Signal Corps and Army Air Forces soon was resumed. The development work on hard airplane control surfaces, helicopter cones and rotors was continued, and Skydyne's experience was being applied to various peacetime products such as airplane interiors, airborne containers, airliner flooring, chairs, tables, chests and radio cabinets. Basic research on the mechanical properties of sandwich panels was carried on into 1946. The wartime pressure for large-scale production of sandwich construction items brought about the rapid development of articles to withstand the ravages of extreme weather conditions, insects, fungus and rugged handling. These methods and the experience gained during the war years improved the quality and decreased the cost of post-war sandwich-type airplane parts and airborne equipment.

Socony-Vacuum Oil Company, New York, having contributed substantially to the war program in the production of improved petroleum products for the armed forces, was directing a large part of its production to commercial and private flying. One of the greatest advances in refining made during the war was the introduction by Socony-Vacuum of the Thermafor catalytic cracking (TCC) process for production of high octane aviation fuels. Socony's refineries were equipped with the TCC process, and were producing large quantities of these improved fuels for domestic and foreign commercial and private consumption. Socony research and development laboratories with their staff of over 800 petroleum specialists were devoting their efforts to the production of better products for aviation. Considerable progress had been made in aircraft safety fuels, and it had brought Socony to the point of commercial production. Socony engineers also were cooperating with aircraft and engine manufacturers in formulation of new products to meet requirements of new designs such as turbine and jet propulsion engines, and development work was being directed to improved aircraft engine oils. In addition, Socony-Vacuum produced a complete line of improved aircraft lubricants for all types of aircraft.

Solar Aircraft Company, San Diego, Calif., with plants in San Diego and Des Moines, Ia., had an amazing war production record, and its postwar activities included development of new products as Solar specialized in fabrication of articles from stainless steel and other heat and corrosion-resistant alloys. To its extensive production of manifolds for multi-motored and combat aircraft, Solar early in 1946 added a "triple unit" for use on the light planes for private owners. The unit combined an exhaust manifold with a muffler and heater, the latter supplying heat for both cabin and carburetor. Solar, one of the earliest companies to receive experimental contracts under the Services jet-engine development program, continued energetically in both production and experimental work on major parts for these engines. The postwar program included increasingly important development work in that field.

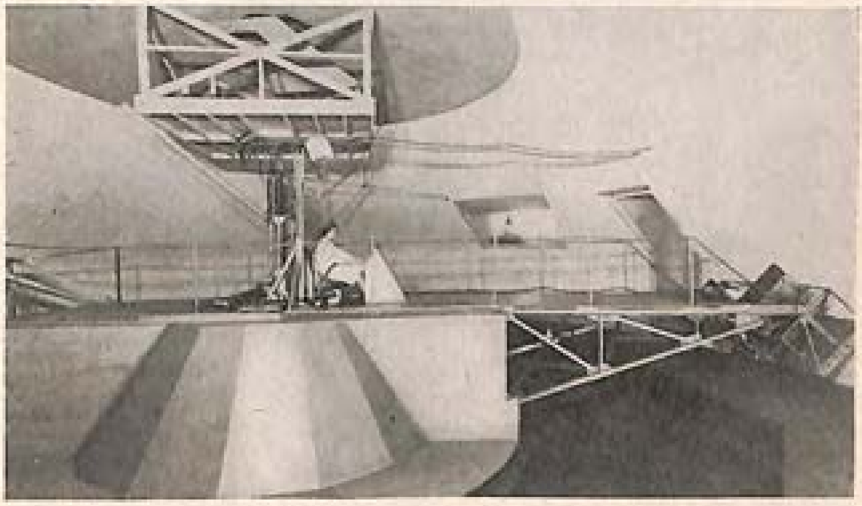
Late in 1945, the company started production at the plant of a subsidiary, Solar Precision Castings, Inc. which occupied part of its Des Moines plant, to make available to the industry a wide variety of precision casting products. Several engine manufacturers had conducted successful experiments in substituting these cast parts, which substantially reduced the machining required. While Solar was engaged in diversification of its activities and products, it retained its position in the exhaust manifold field, in which it had attained outstanding success. In addition to exhaust manifold components, Solar was making heat exchangers and a wide variety of parts where the use of heat and corrosion-resistant material was required. Solar also had substantial experimental contracts with the Navy in the aircraft field.

Spencer & Morris, Inc., Los Angeles and San Francisco, Calif., working in collaboration with Dr. D. R. Drury of the physiology department of the University of Southern California, developed for the air forces a huge machine to determine the ability of pilots to withstand accelerated high speeds and at the same time to check the effects of centrifugal force produced in the human body by fast plane maneuvers which often caused blackouts and other temporary conditions. The machine was named the "Human Centrifuge." It helped to solve many problems, and aided in perfecting an anti-blackout suit for flyers to prevent loss of physical control in power dives and other quick maneuvers. The suits contained special devices employing pneumatic pressure to maintain proper circulation in the body. By progressive and exhaustive tests, the effects on respiratory organs, heart action, blood pressure, pulse and visual reactions resulting from centrifugal force were recorded during "flights" in the machine.

Moreover, it was found that pilots could be prepared for their assignments in jet-propelled and other high speed aircraft by a progressive series of tests in the centrifuge. Where, at first, pilots "blacked out" at comparatively low "g's", indoctrination and training and higher and higher "g's" tended to improve their ability to resist the pull of gravity. Spencer & Morris experience over the years with impact loading, stress characteristics of fabricated steel, fatigue of metals and control of motion, assisted immeasurably on that project.

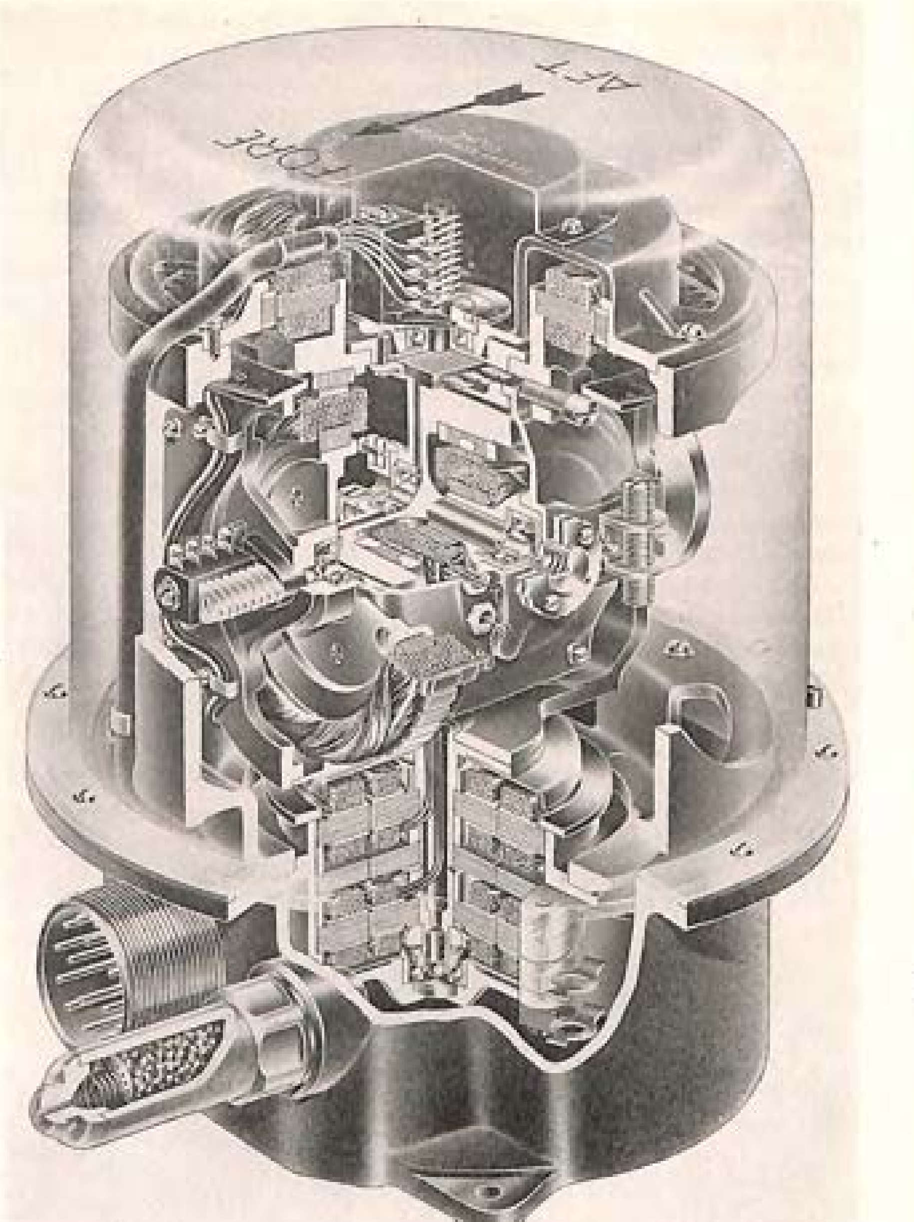
Spencer & Morris also produced many types of handling equipment, including the S&M tramrail system, which incorporated the company's especially designed trambeam, and was used in underslung cranes, monorail systems and transfer bridges.

Sperry Gyroscope Company, Inc., Great Neck, N. Y., introduced a completely new precision gyropilot—Model A-12. This automatic pilot provided all the desirable features which had been shown by 30 years experience to be necessary for reliable, accurate and convenient operation under all flight conditions. Continuous research in gyroscopic technique produced horizontal and vertical references possessing great accuracy. The development of signal systems kept pace, with the result that full advantage could be taken of the accuracy of the reference gyros. These signal systems not only sensed the slightest deviation of the aircraft from its reference, but also predicted, through the use of velocity components, the exact amount of control surface effort required to hold the aircraft in precise agreement with the reference gyros. Servo development produced mechanisms of sufficient



THE "HUMAN CENTRIFUGE"

Developed by Spencer & Morris and the University of Southern California, it helped to determine the physical ability of pilots to withstand sudden maneuvers at high speeds.

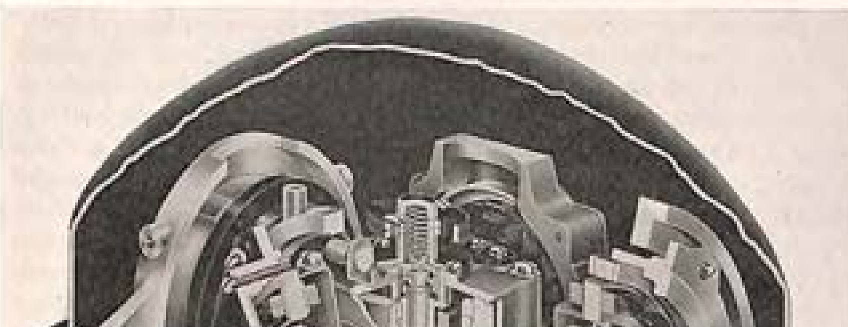



CUTAWAY VIEW OF THE SPERRY GYROSYN COMPASS CONTROL, A-12 GYROPILOT

This unit supplies the directional reference for flying the aircraft on a magnetic heading.

power and speed to utilize the no-lag system and control the aircraft in a deadbeat manner, even in the roughest air.

The Sperry A-12 gyropilot was tuned to the aircraft flight characteristics in such a way that the need for any manual sensitivity adjustment for the difference between rough air and smooth air was entirely eliminated. Directional control in the A-12 was derived from the deadbeat indications of the Model A-12 self-synchronizing gyrosyn compass. This meant that the airplane could be flown continuously on any magnetic heading without gyro drift, oscillation, or northerly turning error. Smooth, coordinated turns could be made from the pilot's pedestal controller, remote controllers, bombsight, runway localizer, camera viewfinder or radio aids. The ratio of turn in degrees per minute to the bank angle was automatically coordinated for all air speeds. No adjustments were required.. Automatic altitude



CUTAWAY VIEW OF SPERRY VERTICAL GYRO CONTROL, A-12 GYROPILOT

This unit supplies the gyro reference for controlling the aircraft about the pitch and roll axis.

control was built into the A-12, which could maintain the aircraft under normal air conditions within 20 feet of the desired pressure attitude both in straight flight and during turns.

The Sperry A-12 gyropilot also included automatic control of elevator trim, and provided for automatic approach control. Because of self-synchronization, the A-12 gyropilot was extremely simple to operate. The gyros were started when the aircraft's power switch was turned on, and synchronization was accomplished automatically in a few moments. All the maneuvers customary in normal flight could be made from the pilot's pedestal controller, while the aircraft was in automatic flight, with the touch of a finger. The A-12 gyropilot provided a choice of equipment to meet the requirements of various kinds of service. Instead of a pedestal controller, two flight controllers were available for those who preferred this type. There were also remote controllers by which the aircraft could be controlled through related equipment. As many as six compass repeaters could be operated from the compass repeater amplifier (optional equipment with the A-12 gyropilot). A flight repeater also could be operated. This instrument was an accessory to the A-12 which indicated the aircraft's magnetic heading from the gyrosyn compass control and the attitude of the aircraft in pitch and bank from the vertical gyro. All three of those vital indications were combined in one case. With automatic approach control accessory equipment, the A-12 gyropilot could approach an airport and land the plane automatically with signals received from a standard instrument landing system. When approaching an airport, this new automatic pilot picked up localizer radio signals. About five miles from the airport, the plane's receiver picked up signals from a glide path transmitter on the airport. These led the plane automatically down a precise beam sloping to a point exactly over the end of the airport runway. The human pilot then took over from the A-12 gyropilot and landed the plane.

In addition to the electrically-operated gyrosyn compass and attitude gyro, Sperry produced an air-operated attitude gyro. This new instrument retained all the features which made the electrically-operated attitude gyro outstanding in the flight instrument group, but it was designed especially for smaller aircraft where high altitude flying was not essential and where the power supply might be limited to a vacuum pump or a venturi tube. Although smaller in size, the air-operated instrument provided the same pattern indications as its predecessor and was used in the same manner. The instrument had no flight limitations, was universally mounted and provided continuous indications of attitude from any angular position of the airplane. Recovery from any awkward and hazardous flight position could be accomplished with speed and accuracy.

The gyrosyn compass, introduced during the preceding year, came into quantity production. In this important instrument Sperry engineers succeeded in combining the functions of a directional gyro and a magnetic compass. They produced an instrument that gave deadbeat directional indication of the magnetic North, without oscillation, northerly turning error or gyro drift. Two types were developed, one having a pointer moving over a fixed dial, the other having a rotating dial which could be read in reference to a fixed lubber line like a conventional compass.

Further progress was made with detonation indicating equipment for use both in flight operations and for test stand operation in the laboratory. An instrument which detected and evaluated detonation immediately, and gave instant warning of improper combustion, it allowed fuel mixture to be changed before damage was done. Pick-up units operating on the magnetostriction principle, weighing 0.27 lb. and only about two inches in length were developed. Manifolds for these pick-ups, adaptable to the principal models of both radial and inline engines were developed, and indicators were produced both of the incandescent and neon types. In addition, a knockometer, or portable testing equipment, providing meter readings was brought out. The knockometer, developed for both the engine manufacturer and the fuel refiner, was sensitive to "trace knock" and discriminated between fuels separated by a fraction of an octane number. The basic detonation indicating equipments were grouped conveniently to meet the requirements of the airline operator, the engine designer or research engineer and the fuel refiner.

Standard Oil Company of California, San Francisco, Calif., developed a complete line of high-grade gasoline and oil for commercial and private aircraft, and at the same time went into production on its Chevron jet fuel for jet-propelled engines.

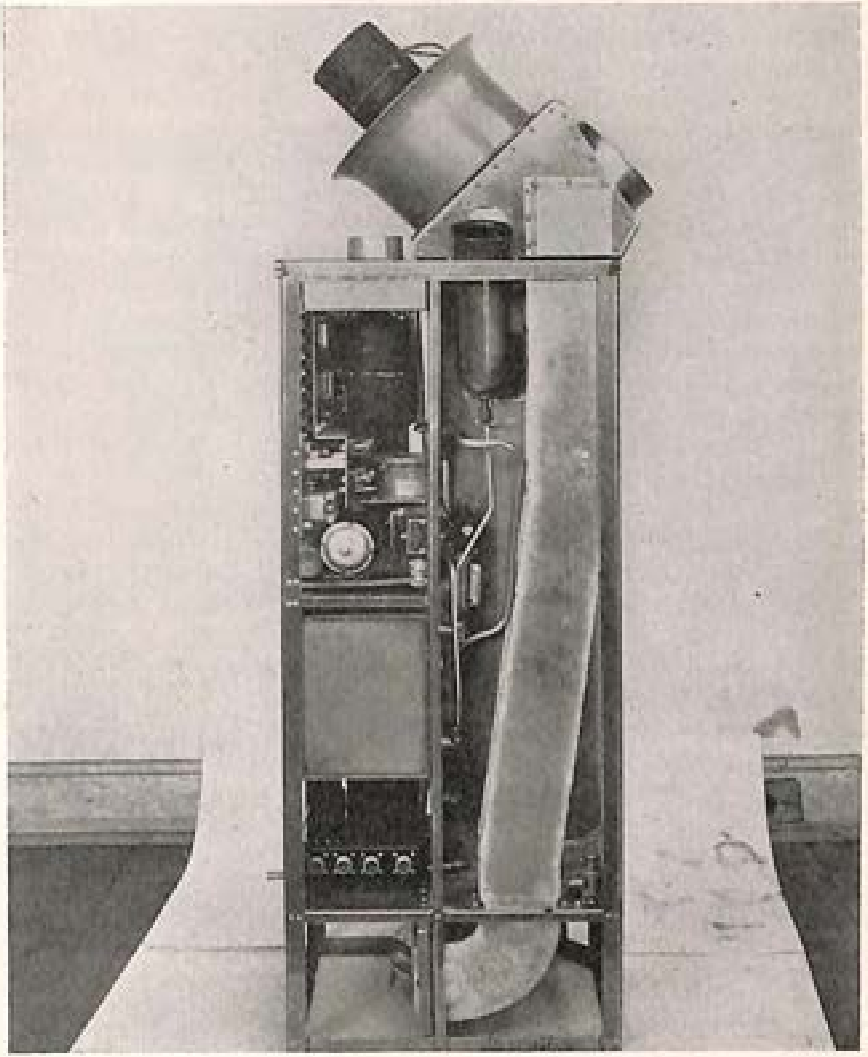
The Standard Oil Company of New Jersey, New York, N. Y., with its splendid war record in supplying large quantities of new fuels and oils for the armed forces, immediately after V-J Day expanded its service to its aviation dealers, a service which it had continued to render under its trade name Esso Marketeers even during the war years when private flying was laboring under heavy restrictions. Esso Marketeers backed the airport operators with bulletins on new product information and countless sales and merchandising aids. After the war, Esso Marketeers, through company representatives, developed a vast campaign to promote the services of the Esso dealers at airports and popularize private flying. Advertisements were used to encourage local interest in flying among the people in a particular airport operator's community. Esso also produced a booklet, Community Airports and Airparks, explaining the urgent need for them, and the booklets were distributed widely among civic leaders. Esso experts helped new airport operators in many different ways, planning fields, locating equipment and storing products for them.

Stratos Corporation, Babylon, N. Y., an affiliate of Fairchild

Engine and Airplane Corporation, developed their compact, lightweight, aircraft-cabin supercharger which was made available for installation in high-altitude military and commercial aircraft. Capable of being installed remotely from the aircraft's engines, this unit not only permitted inclusion of passenger comfort with the existing advantages of high-altitude long-range flight, but it also permitted rapid climbs and descents without the discomfort which once made shallow climbs and glides mandatory. A high-altitude single-stage supercharger for an entirely new high-performance aircraft engine also was brought to the last stages of development. Small turbines for cooling the cabins of military aircraft were under development and test, and research work was initiated on complete altitude pressurizing, ventilating and cooling systems for the cabins of several large airliners under construction by major airframe manufacturers. A high efficiency lightweight, compact, axial fan was designed especially for airborne ventilation systems of long-range airliners.

Superior Tube Company, Norristown, Pa., met fully in 1945 its principal war assignment by the United States Government, the production of aircraft engine valve push rods. The company not only supplied this product to Wright Aeronautical Corporation plants, but also to licensees. These large plants leaned heavily on Superior. In addition to that particular responsibility, the company also was loaded heavily with tubing for airframe use, as well as a large demand for fuel injection line stainless tubing. A new feature was aluminum tubing for aircraft controls. Superior also made considerable tubing used in instruments for other war industries, topped by large quantities of stainless tubing for hypodermic needles. Surgical instrument manufacturers called for various types of metal tubing. The heaviest of all demands was for nickel tubing for the radio tube manufacturers and others in the radar program. An additional temporarily used plant was secured and there parts were made from tubing produced in the main plants. Antennas for police cars and ships, designed several years prior to the outbreak of war, also became an important part of the output. Superior acquired by purchase early in 1946 another plant erected by the Government on the company's property, and in this additional facility only nickel tubing for the electronics industry was to be produced. The company already had acquired a total of 50 acres on the same tract where its plants were located.

Surface Combustion Corporation, Toledo, O., adapted its Janitrol aircraft heater with the "whirling flame", which was a wartime development for military planes of all types, to the heating of commercial airliners and other peacetime airplanes. This was done by incorporating into one package the heater with all controls and other accessories. For maintenance and servicing purposes, one package could be replaced by another in approximately 15 minutes. This quick-replacement feature eliminated the need of holding an airplane on the ground while maintenance work on heaters was in progress. The Janitrol aircraft heater package developed for the hundreds of DC-3's being converted to commercial airline service, for example, included a 100,000 Btu combustion-type heater which operated independently of the engines and provided heat on the ground while the airplane engines were not running; also a fuel pump, high voltage and dependable spark ignition system, ventilating and combustion air



SURFACE COMBUSTION'S AIRCRAFT HEATER

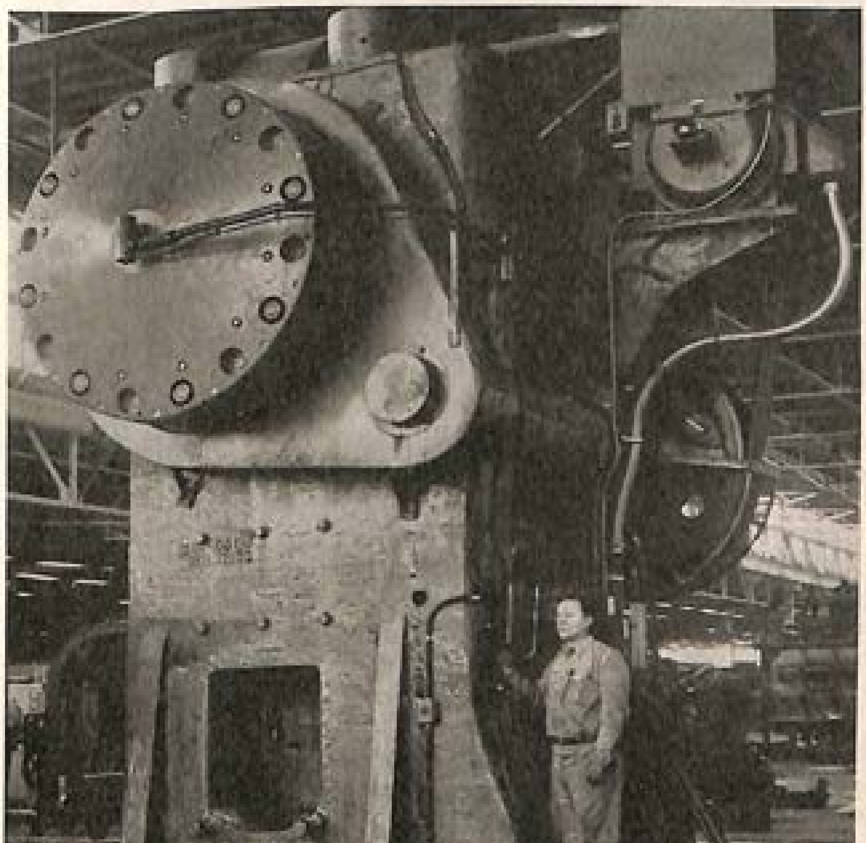
Janitrol aircraft heater package for the DC-3 with side panels removed. This view shows the compact arrangement of the heating package which includes all component parts for operation.

blowers, sensitive thermostatic temperature controls and other component parts. This complete package weighed but 100 lbs., which was 50 lbs. less than that of the former DC-3 heating plant, and it was enclosed by an aluminum alloy jacket 12 by 15 by 49 in. in size. The heating package was connected with DC-3 duct work so that the minimum amount of time was required to convert the airplane heating system for commercial flying. The package also was adaptable to many other types of airplanes. A majority of the postwar version passenger airplanes specified Janitrol aircraft heaters to increase passenger comfort and decrease weight of the planes. Different types of heaters were being developed for these new models. The new Douglas C-75 Globemaster was to have 14 Janitrol aircraft heaters for cabin and instrument heating and for hot wings. Douglas Skymasters originally were equipped with Janitrol heaters and the new DC-4 also was to be so equipped, as well as the new DC-6. Curtiss-Wright, which used Janitrol aircraft heaters in its C-46 Commando, continued to specify the heater for new versions of that plane. The Lockheed Constellation was heated with Janitrol equipment, and some versions used it for hot wings. Special units were to be made for Lockheed's new model 49 of the Constellation, to withstand the pressure in the plane's pressurized cabin. The 5-49 model of the Constellation was to use the heaters for hot wings as well as cabin heating.

The Texas Company, New York, had devoted the greater part of its research and production facilities to development and processing of fuels and lubricants necessary to sustain the highly diversified Allied aerial offensive. As authorities lifted security restrictions, Texaco revealed its part in producing and supplying special fuels and lubricants for use in the turbo-jet engines of jet-propelled fighter aircraft. Fuel for the jet-propelled fighter was announced as a very narrow petroleum "cut" between gasoline and kerosene. The Texaco lubricant for the turbo-jet engine met the requirements of extreme temperature range performing well at 90 degrees below zero F., and at 250 degrees above. The technique of jet-assisted take-offs, known as JATO, allowed greater bomb and payloads to be flown from phenomenally short take-off distances, utilizing Texaco solid fuels in the rocket units. Military needs and aviation progress were served further by the development and production of new low temperature Texaco greases with qualities of exceptional resistance to cold. Among the results was the more dependable operation of propeller hub mechanism and bomb bay doors on high-altitude missions.

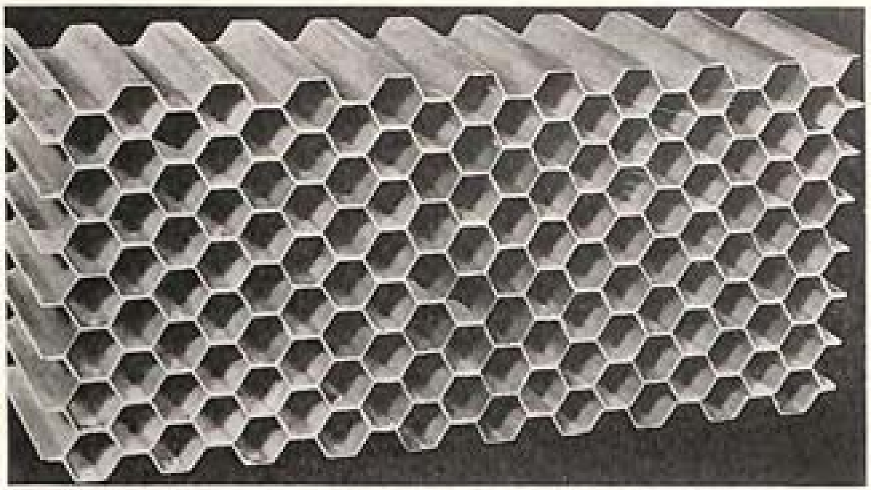
Sulphuric acid alkylation continued as a major process in the production of 100 octane aviation gasoline. The Texas Company played an important part in the development and improvement of this process, which produced an important component of super octane fuels. Much of the material for alkylation was produced by catalytic cracking and Texaco installed additional "cat cracking" equipment at strategically located refineries to meet the increased military demands during the final phases of the war. This modern equipment saved much time by permitting all the refining processes of 100 octane production to be completed at the same refining works.

Thompson Products, Inc., Cleveland, O., bought from the Government a plant in Euclid, O., where during the war, a subsidiary—Thompson Aircraft Products Co.—had produced 161 million dollars worth of sodium-cooled valves, fuel and fuel booster pumps, jet propulsion components and other hardened and ground aircraft parts. Total Thompson employment reached 21,114 during the war, more than 10,000 of whom were in the Euclid plant, which, located on a



COINING PRESS FOR JET ENGINE BLADES

This press, in the Euclid, Ohio, plant of Thompson Products, Inc., is used for forming jet turbine wheel and nozzle diaphragm blades. It weighs 350,000 pounds. Pressure on the work is 2,500 tons.



WELDWOOD HONEYCOMB CORE

**Manufactured by United States Plywood Corporation and developed jointly with The Glenn L. Martin Company, the core is a resin impregnated sandwich material made of cotton, linen, paper or Fiberglass which may be surfaced with wood veneers, plywood, aluminum alloys or plastic sheets.**

120-acre site, had a million sq. ft. of floor space. A nine million dollar reconversion program at the Cleveland and Euclid plants was nearing completion early in 1946. At Euclid four new manufacturing divisions included a valve and jet division for the production of aircraft and automotive valves and jet engine components, including turbine wheels and nozzle diaphragms; a parts and accessories division for hardened and ground aircraft and automotive parts, and aircraft accessories, such as fuel and fuel booster pumps; a light metals division, manufacturing pistons and other aluminum products; and a piston ring division. In Cleveland a special products division was set up to turn out piston pins, cylinder sleeves, water pumps, chassis bolts, cast iron pistons and other automotive parts, largely for the garage trades in the United States and 98 foreign countries.

The United States Plywood Corporation, New York, perfected Weldwood and Armorply Honeycomb, a new structural material of particular importance to the aircraft industry and developed jointly with The Glenn L. Martin Company. Honeycomb was a lightweight core material of cotton, linen, paper or Fiberglas impregnated with a phenolic resin, sandwiched between and permanently bonded to two facing materials or skins. The surface materials could be wood veneer, plywood, aluminum alloys, stainless steel or plastic sheets of any thickness. Characteristics of the new product were extremely light weight, the core weighing as little as four lbs. per cubic foot, combined with great strength, stiffness, stability under wide variations of temperature and humidity, and resistance to severe service conditions.

The company also completed development of a new low pressure laminate, Tempreg, which was machined easily and accurately into many intricate precision parts. Tiny lengths of Tempreg tubing were employed in the proximity fuse used in the atom bomb and heavy ordnance. Another product finding a wide range of uses was decorative Armorply, which combined the beauty of real wood and the workability of metal. Made of a thin veneer of wood bonded to steel, aluminum or copper, it possessed great dimensional stability and could be stamped, punched, drilled and formed as easily as its base metal, and could be bent either with or against the wood grain. Due to its versatility and beauty, decorative Armorply lent itself readily to interior panels, trim and decoration.

The United States Rubber Company, New York, in the Summer of 1941 produced the first nylon airplane tires, and this pioneering achievement resulted in military aircraft tires strong enough to make possible the high performance of jet-propelled planes. Ordinary tires could not stand up under the terrific impacts and higher pressures involved in high speed operations. The company's first proposal to the Army Air Forces in 1941 was to replace the then standard cotton tire carcass of eight plys with four plys of nylon, the idea being that it would save 30 per cent weight with no loss in strength. When the Army Air Forces received the company's proposal, they were not interested in saving weight while maintaining strength, but were enthusiastic over the possibility of securing a stronger tire with no increase in weight. The reason for this attitude was an acute condition which had arisen on some medium bombers, where the current cotton tires were failing prematurely and in such numbers as to ground planes for lack of tires. The result was that the U. S. Rubber Company received an order for 50 47-in. smooth contour non skid nylon tires. Never having made this size previously, it was necessary to start from scratch on the design of equipment, making dimensional compensations to allow for the greatly different stretch characteristics of nylon. The first tire was made early in October, 1941. It met the exacting AAF dimensions at all points, and the entire order was delivered.

The test planes on which those tires were placed, were dispersed to combat service after Pearl Harbor without any failure. Additional tires were made and placed on test. No carcass failures were experienced. In fact, their performance was so good that early in 1943, the industry was asked to procure the equipment and change a large list of sizes to nylon. The U. S. Rubber Company's experience with nylon was made available to all. All manufacturers were producing nylon tires in quantity by the Fall of 1943. Further improvements were made in the tire; and even with the replacement of rubber by synthetic, separation resistance was increased twofold.

The use of airplane nylon tires in combat areas reduced the percentage of tires removed for ruptures from over 15 per cent to 0.5.

The average motor car carried a load of 50 lbs. per lb. of tire weight. Nylon airplane tires could carry a load of more than 300 lbs. per lb. of tire weight. Nylon permitted the load actually carried by certain sizes to be tripled; and this contributed to the development of fast jet-propelled planes. The U. S. Rubber Company found that as many as six retreads could be applied to its nylon tires in military service without structural deficiency. The company was carrying on development work seeking to overcome the undesirable stretch characteristics of nylon and at the same time increase the limit of practical inflation pressures.

The United States Rubber Company was in production of flexible gasoline tanks for commercial and private planes—a development of its large war production of self-sealing fuel cells. A cell for the Beech D18S plane weighed only six lbs., yet it held 60 gallons of gasoline. The company's seamless liner development produced for the four-engine Douglas planes a lighter fuel tank with no laps or seams, thereby eliminating possible leaks. A nylon barrier or inner ply added strength to the tank.

Other developments by the U. S. Rubber Company of interest to aviation included plastic upholstery called Naugahyde. Over a million yards were made by the company for severe military applications. It was waterproof, could be flameproof, and was being made in a wide range of light and bright, clear decorative colors as well as darker tones. It was not affected by salt water, alcohol, gasoline, oils, greases, or most acids and alkalis. It could be cleaned with soap and water. It was easy to tailor, was very flexible, and could be formed easily around curves, corners and edges. In cargo compartments of airplanes, low pressure laminated V-board panels, produced by the company were being used because of their lighter weight, great strength and resiliency. The company planned to have available soon its Koylon rubber foam cushioning and mattresses, used before the war for airplane seating and as mattresses on sleeper planes. The company also produced ducts made of rubber, fabric and plastics for heating, ventilating and defrosting systems of airplanes. They were perfected early in the war in response to the Army's request for a light, highly flexible tube, to carry oxygen to the nostrils of horses which might be caught in enemy gas attacks. Later they were adapted to aircraft. The ducts, called Multiflex, were light and durable and easy to install. They could be twisted and turned around obstructions, saving installation time formerly required to cut and shape metal. They were repaired easily, and if accidentally crushed, they resumed normal shape as soon as pressure was released. They withstood temperatures up to 350 degrees F. and down to 70 degrees below zero. They were made out of glass and asbestos fabrics impregnated with synthetic rubber and plastics.

The Weatherhead Company, Cleveland, O., developed a complete line of ER aircraft fittings designed to solve the problems encountered by use of 3,000 lb. pressures for hydraulic aircraft systems. The fittings provided a sealing joint without flaring, threading, soldering or welding, and permitted use of high strength, weight-saving dural tubing and fittings in place of steel. Weatherhead developments in the field of jet propulsion included an automatic governor and fuel regulator for a Westinghouse assembly. Another was a double lever control valve for the I-40 jet engine and a single lever control valve for the I-16 jet engine. Also developed and produced were single drip valves, double drip valves, stop cocks, duplex check valves, oil scavenge pump check valves of the flapper type, and many types of tube assemblies with fittings solving other specialty jet problems. Automatic electrically operated servo cylinders and transfer valves also were designed and manufactured.

During the war, Weatherhead assumed the task of producing for the Army Air Forces the Cornelius type, small, 9-lb. air compressors of 280 parts to be used in the B-29 for snapping open and closing the big bomb bay doors. Experts in and out of the Services thought it would require six months to procure materials, tool up and get into production, but Weatherhead was making sizable shipments in 60 days. In that period, dies were made and 450 special precision tools were produced. By that achievement Weatherhead cut hundreds of pounds of extra weight as compared to former devices, and speeded up door opening and closing time from 40 seconds to less than two seconds, thereby making the Superfortress less vulnerable to enemy gunfire and saving the lives of our air force personnel.

The Weems System of Navigation, Annapolis, Md., developed and promoted many of the shorter and up-to-date methods and navigation instruments now in use, among them the Line of Position Book, the Star Altitude Curves, the Line of Position Tables, the Gold Medal Text Book "Air Navigation," the Mark II Plotter, Aircraft Computers of several types, skeleton navigation charts, so designed as to shorten and make easier the navigator's work, and the classroom models of navigation instruments designed to expedite class instruction. The last edition of the Star Altitude Curves for the Polar regions, recently published, introduced a new method of dead reckoning, commonly referred to as the "G" system. While this new system might not be adopted generally for use in the lower latitudes, it was essential in the Arctic regions. The first home study course in air navigation was a Weems publication. In 1935, resident courses were offered at Annapolis, Md. Branch schools were established, teaching the Weems System of streamlined navigation in various cities. The Service schools teaching navigation to the cadets adopted most of the ideas used in the WSN schools for presenting the subject in the most easily intelligible and quickly grasped manner. A recent book by Weems incorporated explanations of the very high frequency (VHF)

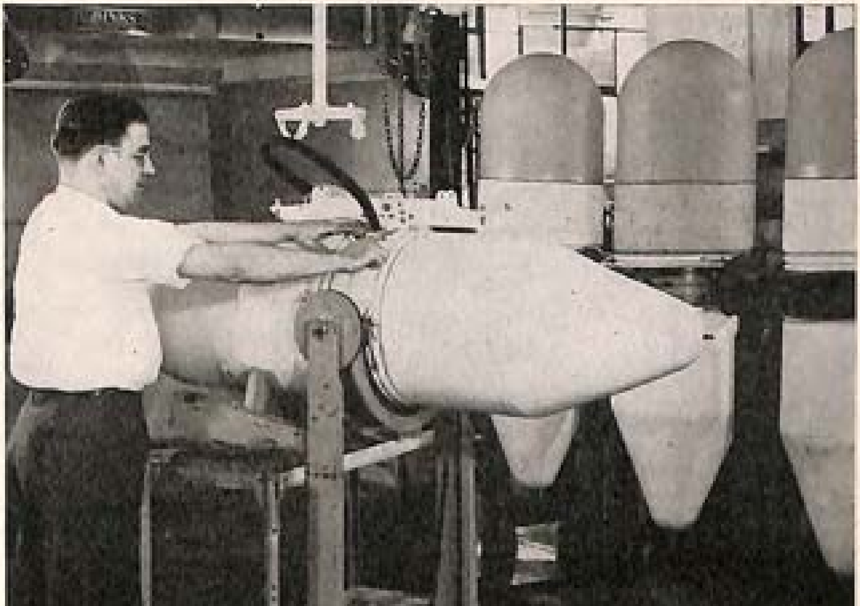
BUILDING RADAR EQUIPMENT

These intricate radars are being manufactured in the Hawthorne, Chicago, plant of the Western Electric Company which produced more than 56,000 during the war. They helped our airmen pinpoint targets through overcast or darkness.

aids to navigation, installed or to be installed by the Civil Aeronautics Administration, as well as explanations of the uses of radar and loran methods of navigation. Believing that navigation would be included in the curricula of most high schools and colleges, Weems developed many classroom teaching aids, including classroom models, blow-ups of the actual instruments, plotters, computers and compasses used by navigators. The AAF and many foreign air forces adopted these classroom models to facilitate training their navigators.

The Western Electric Company and Bell Telephone Laboratories, New York, as a team held its position as leading radar producer, and pioneer developer and supplier of airborne, two-way radio telephone communications for the armed forces during the war. This Bell System combination having devoted its full effort during the last five years to war projects, reverted to development and manufacture of telephone and commercial products for peacetime use. In the peacetime world, radio and radar redesigned were to be available for the convenience, safety and dependability of air transportation, including the maintenance of flight schedules even with low visibility. VHF radio equipment already was being sought by prominent commercial airlines for more dependable air communications. The latest model VHF radio equipment, the AN/ARC-1, designed by Bell and manufactured by Western Electric had been installed on every U. S. carrier-based plane during the war. The design of the AN/ARC-1 permitted operation of the equipment with 50 per cent of the crystals ordinarily used in conventionally designed equipment. Use of the same crystal for transmitting and receiving was an outstanding achievement. For a total of 10 transmitter and 10 receiver frequencies, plus a guard channel, only 12 crystals were required. The entire 10-frequency transmitter-receiver (weighing less than 47 lbs.) together with its power supply was housed in a standard rectangular ATR size box. Frequency selections were made by an automatic device, electrically operated. All connections except the antenna were made automatically when the unit was inserted into its mounting. By releasing two thumb screws at the front of the mounting, the set could be removed quickly. Easy to maintain and of proven dependable operation, this equipment required only simple resetting when changing to a new set of channel frequencies. It was statically and dynamically balanced on its mounting.

From March, 1944, through 1945, over 30,000 units of the ARC-1 had been manufactured. Other airborne communications equipment produced during the same period totaled over 625,000 radio receivers, and over 427,000 radio transmitters. Radar, the top electronic achievement of the war, had many of its problems solved even before the outbreak of the war by the Western Electric-Bell Laboratories combination. This was possible because radar contains many elements basic to telephone systems. Radar, thus made quickly available for



WESTERN ELECTRIC RADAR CASES

This type of radar equipment was attached to the wings of Navy carrier planes. The odd bomb-like plastic reduced wind resistance and protected equipment from the elements.

searching and bombing, was supplied to B-29's which battered Japan, to American Black Widow planes, to British Mosquitoes and others. Production of over 65 different types of radar for the Army and Navy totaled over 58,000 units of which over 46,000 were airborne. For the production of Naval airborne equipment, Western Electric was commended by the U. S. Navy Bureau of Ships: ". . . . Western Electric Company has been responsible for many of the great advances in radio, radar and communications of the war years. The Bureau wishes to commend the Western Electric Company for their outstanding performance on the AN/APS-4 aircraft radar contracts. The development and production of an entirely new type of lightweight radar equipment and the delivery, as scheduled, of approximately 15,000 sets over a period of 20 months from the time production quantities were first delivered, is a record that is equalled but a few times in our war effort. It is a record of which any manufacturer may be justly proud."

F. H. Woodruff & Sons, Milford, Conn., offered a complete advisory service on general soils stablization on airports. Beginning in 1930, Woodruff conducted extensive research in turf grasses and the stabilizing values of existing grass seed varieties throughout the United States. The result was that the company was prepared to offer grass seeds capable of wear resistance, soil binding and dust control.


THE P-51D MUSTANG FIGHTER

North American Aviation's late model of the Army Air Forces fast high-altitude fighter, with teardrop canopy giving the pilot 360-degree vision. It is powered by a Rolls Royce Merlin engine and a Hamilton Standard four-blade propeller.

# Flying Facts and Figures

## TONS OF BOMBS DROPPED BY U. S. ARMY AIR FORCES

Source: U. S. Army Air Forces Office of Statistical Control

| Year and Month | Total Tons | Theaters vs Germany | | | Theaters vs Japan | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Total Tons | European Theater | Mediterranean Theater | Total Tons | Pacific Ocean Areas | Far East Air Forces | China and India-Burma | Alaska | 20th Air Force |
| Grand Total... | 2,057,244 | 1,554,463 | 971,762 | 582,701 | 502,781 | 32,733 | 232,496 | 62,161 | 4,331 | 171,060 |
| *Annually* | | | | | | | | | | |
| 1941 (Dec.).. | 36 | — | — | — | 36 | — | 36 | — | — | — |
| 1942........ | 10,203 | 6,123 | 1,713 | 4,410 | 4,080 | 35 | 2,633 | 697 | 715 | — |
| 1943........ | 198,800 | 154,117 | 55,655 | 98,462 | 44,683 | 1,309 | 29,705 | 10,841 | 2,828 | — |
| 1944........ | 1,085,978 | 938,952 | 591,959 | 346,993 | 147,026 | 17,546 | 92,134 | 27,987 | 295 | 9,064 |
| 1945 (Jan.-Aug.) .. | 762,227 | 455,271 | 322,435 | 132,836 | 306,956 | 13,843 | 107,988 | 22,636 | 493 | 161,996 |
| *Monthly* | | | | | | | | | | |
| 1941 | | | | | | | | | | |
| Dec.......... | 36 | — | — | — | 36 | — | 36 | — | — | — |
| 1942 | | | | | | | | | | |
| Jan.......... | 20 | — | — | — | 20 | — | 20 | — | — | — |
| Feb.......... | 47 | — | — | — | 47 | — | 37 | 10 | — | — |
| Mar.......... | 68 | — | — | — | 68 | — | 46 | 22 | — | — |
| April........ | 128 | — | — | — | 128 | — | 95 | 28 | 5 | — |
| May.......... | 184 | — | — | — | 184 | — | 122 | 57 | 5 | — |
| June......... | 410 | 115 | — | 115 | 295 | 18 | 139 | 93 | 45 | — |
| July......... | 656 | 357 | — | 357 | 299 | — | 155 | 66 | 78 | — |
| Aug.......... | 958 | 549 | 135 | 414 | 409 | — | 250 | 48 | 111 | — |
| Sept......... | 1,156 | 697 | 215 | 482 | 459 | — | 279 | 63 | 117 | — |
| Oct.......... | 1,669 | 1,105 | 334 | 771 | 564 | — | 386 | 67 | 111 | — |
| Nov.......... | 2,559 | 1,807 | 612 | 1,195 | 752 | — | 547 | 98 | 107 | — |
| Dec.......... | 2,348 | 1,493 | 417 | 1,076 | 855 | 17 | 557 | 145 | 136 | — |
| 1943 | | | | | | | | | | |
| Jan.......... | 3,581 | 2,722 | 739 | 1,983 | 859 | 3 | 755 | 97 | 4 | — |
| Feb.......... | 3,571 | 2,424 | 705 | 1,719 | 1,147 | 12 | 591 | 421 | 123 | — |
| Mar.......... | 5,947 | 4,303 | 1,530 | 2,773 | 1,644 | — | 647 | 679 | 318 | — |
| April........ | 8,216 | 6,183 | 1,130 | 5,053 | 2,033 | 44 | 540 | 800 | 649 | — |
| May.......... | 12,329 | 9,985 | 2,688 | 7,297 | 2,344 | 15 | 710 | 1,170 | 449 | — |
| June......... | 12,909 | 11,064 | 2,468 | 8,596 | 1,845 | 4 | 1,015 | 542 | 284 | — |
| July......... | 22,253 | 18,212 | 4,366 | 13,846 | 4,041 | 40 | 2,708 | 879 | 414 | — |
| Aug.......... | 21,989 | 17,656 | 5,072 | 12,584 | 4,333 | — | 2,910 | 851 | 572 | — |
| Sept......... | 26,673 | 22,461 | 8,519 | 13,942 | 4,212 | 66 | 3,025 | 1,106 | 15 | — |
| Oct.......... | 18,653 | 13,640 | 6,015 | 7,625 | 5,013 | — | 3,269 | 1,744 | — | — |
| Nov.......... | 23,710 | 17,789 | 8,309 | 9,480 | 5,921 | 337 | 4,354 | 1,230 | — | — |
| Dec.......... | 38,969 | 27,678 | 14,114 | 13,564 | 11,291 | 788 | 9,181 | 1,322 | — | — |
| 1944 | | | | | | | | | | |
| Jan.......... | 40,997 | 33,112 | 14,015 | 19,097 | 7,885 | 1,041 | 6,067 | 777 | — | — |
| Feb.......... | 44,073 | 34,161 | 22,566 | 11,595 | 9,912 | 1,127 | 7,802 | 983 | — | — |
| Mar.......... | 56,234 | 43,979 | 26,539 | 17,440 | 12,255 | 1,150 | 9,444 | 1,648 | 13 | — |
| April........ | 81,933 | 68,396 | 38,540 | 29,856 | 13,537 | 1,911 | 9,595 | 2,002 | 29 | — |
| May.......... | 117,664 | 102,949 | 56,874 | 46,075 | 14,715 | 1,582 | 10,600 | 2,509 | 24 | — |
| June......... | 132,434 | 121,935 | 85,648 | 36,287 | 10,499 | 888 | 7,688 | 1,349 | 27 | 547 |
| July......... | 114,865 | 104,831 | 63,062 | 41,769 | 10,034 | 1,680 | 5,950 | 2,190 | 5 | 209 |
| Aug.......... | 117,504 | 108,046 | 67,766 | 40,280 | 9,458 | 1,730 | 5,025 | 2,408 | 43 | 252 |
| Sept......... | 94,309 | 81,460 | 52,175 | 29,285 | 12,849 | 1,404 | 8,203 | 2,669 | 52 | 521 |
| Oct.......... | 87,297 | 74,968 | 52,860 | 22,108 | 12,329 | 1,032 | 6,399 | 3,198 | 31 | 1,669 |
| Nov.......... | 93,133 | 78,108 | 51,413 | 26,695 | 15,025 | 1,416 | 7,443 | 3,910 | 51 | 2,205 |
| Dec.......... | 105,535 | 87,007 | 60,501 | 26,506 | 18,528 | 2,585 | 7,918 | 4,344 | 20 | 3,661 |
| 1945 | | | | | | | | | | |
| Jan.......... | 88,348 | 69,013 | 54,474 | 14,539 | 19,335 | 2,494 | 8,323 | 5,079 | 29 | 3,410 |
| Feb.......... | 136,928 | 113,009 | 80,348 | 32,661 | 23,919 | 2,158 | 12,543 | 5,165 | 33 | 4,020 |
| Mar.......... | 200,211 | 159,123 | 118,003 | 41,120 | 41,088 | 1,244 | 19,184 | 5,330 | 47 | 15,283 |
| April........ | 157,614 | 113,607 | 69,242 | 44,365 | 44,007 | 1,152 | 20,976 | 4,339 | 48 | 17,492 |
| May.......... | 47,699 | 519 | 368 | 151 | 47,180 | 996 | 20,355 | 1,446 | 98 | 24,285 |
| June......... | 50,893 | — | — | — | 50,893 | 603 | 17,075 | 568 | 105 | 32,542 |
| July......... | 53,665 | — | — | — | 53,665 | 3,359 | 6,577 | 547 | 91 | 43,091 |
| Aug.......... | 26,869 | — | — | — | 26,869 | 1,837 | 2,955 | 162 | 42 | 21,873 |

## TONS OF BOMBS DROPPED BY U. S. ARMY AIR FORCES HEAVY BOMBERS BY TYPE OF TARGET AND BY THEATER AGAINST GERMANY

Source: U. S. Army Air Forces Office of Statistical Control

| Type of Target | Grand Total Tons | 1942 (June-Dec.) | 1943 | 1944 | 1945 (Jan.-May) |
|---|---|---|---|---|---|
| | European and Mediterranean Theaters of Operations | | | | |
| Total | 1,096,794 | 4,964 | 97,937 | 683,605 | 310,288 |
| Marshalling Yards | 315,307 | 154 | 21,913 | 154,718 | 138,522 |
| Oil Installations | 126,191 | — | 238 | 99,391 | 26,562 |
| Airdromes and Airfields | 117,727 | 543 | 13,728 | 80,812 | 22,644 |
| Railroads, Roads and Bridges | 70,569 | — | 1,610 | 41,727 | 27,232 |
| Military Installations | 70,171 | — | 1,745 | 48,562 | 19,864 |
| Other Specific Industries | 70,136 | 78 | 8,588 | 44,722 | 16,738 |
| Aircraft Factories | 58,763 | 149 | 6,371 | 49,771 | 2,472 |
| Ground Cooperation | 57,106 | — | 36 | 37,720 | 19,350 |
| City Areas | 47,615 | — | 749 | 42,603 | 4,263 |
| Ship Yards, Sub Pens | 36,643 | 736 | 18,072 | 9,189 | 8,646 |
| Other Communications | 36,618 | — | 775 | 30,866 | 4,977 |
| Miscellaneous | 34,675 | 3,251 | 23,029 | 3,807 | 4,588 |
| Jettisoned and unidentified | 55,283 | 53 | 1,083 | 39,717 | 14,430 |
| | European Theater of Operations | | | | |
| Total | 714,719 | 1,713 | 47,452 | 446,165 | 219,389 |
| Marshalling Yards | 195,610 | 154 | 5,348 | 89,884 | 100,224 |
| Oil Installations | 68,110 | — | 238 | 52,622 | 15,250 |
| Airdromes and Airfields | 82,691 | 543 | 5,513 | 57,810 | 18,825 |
| Railroads, Roads and Bridges | 30,557 | — | — | 17,328 | 13,229 |
| Military Installations | 62,908 | — | 1,745 | 45,879 | 15,284 |
| Other Specific Industries | 53,492 | 78 | 7,030 | 32,658 | 13,726 |
| Aircraft Factories | 44,437 | 149 | 5,090 | 36,726 | 2,472 |
| Ground Cooperation | 36,958 | — | — | 25,647 | 11,311 |
| City Areas | 46,820 | — | — | 42,603 | 4,217 |
| Ship Yards, Sub Pens | 34,427 | 736 | 18,072 | 6,973 | 8,646 |
| Other Communications | 25,453 | — | — | 21,937 | 3,516 |
| Miscellaneous | 7,921 | — | 3,333 | — | 4,588 |
| Jettisoned and unidentified | 25,335 | 53 | 1,083 | 16,098 | 8,101 |
| | Mediterranean Theater of Operations | | | | |
| Total | 382,075 | 3,251 | 50,485 | 237,440 | 90,899 |
| Marshalling Yards | 119,697 | — | 16,565 | 64,834 | 38,298 |
| Oil Installations | 58,081 | — | — | 46,769 | 11,312 |
| Airdromes and Airfields | 35,036 | — | 8,215 | 23,002 | 3,819 |
| Railroads, Roads and Bridges | 40,012 | — | 1,610 | 24,399 | 14,003 |
| Military Installations | 7,263 | — | — | 2,683 | 4,580 |
| Other Specific Industries | 16,634 | — | 1,558 | 12,064 | 3,012 |
| Aircraft Factories | 14,326 | — | 1,281 | 13,045 | — |
| Ground Cooperation | 20,148 | — | 36 | 12,073 | 8,039 |
| City Areas | 795 | — | 749 | — | 46 |
| Ship Yards, Sub Pens | 2,216 | — | — | 2,216 | — |
| Other Communications | 11,165 | — | 775 | 8,929 | 1,461 |
| Miscellaneous | 26,754 | 3,251 | 19,696 | 3,807 | — |
| Jettisoned and unidentified | 29,948 | — | — | 23,619 | 6,329 |

## TONS OF BOMBS DROPPED BY U. S. ARMY AIR FORCES BY TYPE OF PLANE AND BY COUNTRY IN THEATERS AGAINST GERMANY

Source: U. S. Army Air Forces Office of Statistical Control

| Country | Grand Total | | | 1942 (June-Dec.) | | | 1943 | | | 1944 | | | 1945 (Jan.-May) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total Tons | European Theater | Mediterranean Theater | Total Tons | European Theater | Mediterranean Theater | Total Tons | European Theater | Mediterranean Theater | Total Tons | European Theater | Mediterranean Theater | Total Tons | European Theater | Mediterranean Theater |
| | ALL TYPES OF PLANES | | | | | | | | | | | | | | |
| Total | 1,554,463 | 971,762 | 582,701 | 6,123 | 1,713 | 4,410 | 154,117 | 55,655 | 98,462 | 938,952 | 591,959 | 346,993 | 455,271 | 322,435 | 132,836 |
| Albania | 371 | — | 371 | — | — | — | 91 | — | 91 | 280 | — | 280 | — | — | — |
| Austria | 76,026 | 400 | 75,626 | — | — | — | 665 | — | 665 | 34,552 | — | 34,552 | 40,809 | 400 | 40,409 |
| Bulgaria | 2,600 | — | 2,600 | — | — | — | 347 | — | 347 | 2,253 | — | 2,253 | — | — | — |
| Czechoslovakia | 14,799 | 4,360 | 10,439 | — | — | — | — | — | — | 8,989 | 796 | 8,193 | 5,810 | 3,564 | 2,246 |
| Denmark | 60 | 60 | — | — | — | — | — | — | — | 60 | 60 | — | — | — | — |
| France | 339,651 | 315,565 | 24,086 | 1,624 | 1,624 | — | 23,364 | 22,440 | 924 | 285,678 | 262,516 | 23,162 | 28,985 | 28,985 | — |
| Germany | 641,201 | 604,787 | 36,414 | — | — | — | 29,051 | 27,598 | 1,453 | 320,688 | 296,839 | 23,849 | 291,462 | 280,350 | 11,112 |
| Greece | 3,225 | — | 3,225 | — | — | — | 1,293 | — | 1,293 | 1,932 | — | 1,932 | — | — | — |
| Hungary | 22,228 | 364 | 21,864 | — | — | — | — | — | — | 19,614 | 364 | 19,250 | 2,614 | — | 2,614 |
| Italy | 276,312 | — | 276,312 | — | — | — | 46,448 | — | 46,448 | 166,494 | — | 166,494 | 63,370 | — | 63,370 |
| Low Countries | 15,519 | 15,519 | — | 36 | 36 | — | 767 | 767 | — | 13,681 | 13,681 | — | 1,035 | 1,035 | — |
| North Africa | 49,251 | — | 49,251 | 4,410 | — | 4,410 | 44,841 | — | 44,841 | — | — | — | — | — | — |
| Norway | 1,497 | 1,497 | — | — | — | — | 1,497 | 1,497 | — | — | — | — | — | — | — |
| Poland | 1,460 | 316 | 1,144 | — | — | — | — | — | — | 1,460 | 316 | 1,144 | — | — | — |
| Rumania | 26,415 | 287 | 26,128 | — | — | — | 1,382 | — | 1,382 | 25,033 | 287 | 24,746 | — | — | — |
| Yugoslavia | 24,040 | — | 24,040 | — | — | — | 1,018 | — | 1,018 | 17,519 | — | 17,519 | 5,503 | — | 5,503 |
| Other[1] | 59,808 | 28,607 | 31,201 | 53 | 53 | — | 3,353 | 3,353 | — | 40,719 | 17,100 | 23,619 | 15,683 | 8,101 | 7,582 |

| Country | Grand Total | | | 1942 (June-Dec.) | | | 1943 | | | 1944 | | | 1945 (Jan.-May) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total Tons | European Theater | Mediterranean Theater | Total Tons | European Theater | Mediterranean Theater | Total Tons | European Theater | Mediterranean Theater | Total Tons | European Theater | Mediterranean Theater | Total Tons | European Theater | Mediterranean Theater |
| | HEAVY BOMBERS | | | | | | | | | | | | | | |
| Total | 1,096,794 | 714,719 | 382,075 | 4,964 | 1,713 | 3,251 | 97,937 | 47,452 | 50,485 | 683,605 | 446,165 | 237,440 | 310,288 | 219,389 | 90,899 |
| Albania | 371 | — | 371 | — | — | — | 91 | — | 91 | 280 | — | 280 | — | — | — |
| Austria | 74,183 | 400 | 73,783 | — | — | — | 665 | — | 665 | 34,552 | — | 34,552 | 38,966 | 400 | 38,566 |
| Bulgaria | 2,600 | — | 2,600 | — | — | — | 347 | — | 347 | 2,253 | — | 2,253 | — | — | — |
| Czechoslovakia | 14,799 | 4,360 | 10,439 | — | — | — | — | — | — | 8,989 | 796 | 8,193 | 5,810 | 3,564 | 2,246 |
| Denmark | 60 | 60 | — | — | — | — | — | — | — | 60 | 60 | — | — | — | — |
| France | 162,059 | 142,949 | 19,110 | 1,624 | 1,624 | — | 15,161 | 14,237 | 924 | 137,646 | 119,460 | 18,186 | 7,628 | 7,628 | — |
| Germany | 557,643 | 521,729 | 35,914 | — | — | — | 29,051 | 27,598 | 1,453 | 319,319 | 295,470 | 23,849 | 209,273 | 198,661 | 10,612 |
| Greece | 3,225 | — | 3,225 | — | — | — | 1,293 | — | 1,293 | 1,932 | — | 1,932 | — | — | — |
| Hungary | 22,228 | 364 | 21,864 | — | — | — | — | — | — | 19,614 | 364 | 19,250 | 2,614 | — | 2,614 |
| Italy | 112,741 | — | 112,741 | — | — | — | 23,795 | — | 23,795 | 61,917 | — | 61,917 | 27,029 | — | 27,029 |
| Low Countries | 14,150 | 14,150 | — | 36 | 36 | — | 767 | 767 | — | 12,312 | 12,312 | — | 1,035 | 1,035 | — |
| North Africa | 22,768 | — | 22,768 | 3,251 | — | 3,251 | 19,517 | — | 19,517 | — | — | — | — | — | — |
| Norway | 1,497 | 1,497 | — | — | — | — | 1,497 | 1,497 | — | — | — | — | — | — | — |
| Poland | 1,460 | 316 | 1,144 | — | — | — | — | — | — | 1,460 | 316 | 1,144 | — | — | — |
| Rumania | 26,415 | 287 | 26,128 | — | — | — | 1,382 | — | 1,382 | 25,033 | 287 | 24,746 | — | — | — |
| Yugoslavia | 22,040 | — | 22,040 | — | — | — | 1,018 | — | 1,018 | 17,519 | — | 17,519 | 3,503 | — | 3,503 |
| Other[1] | 58,555 | 28,607 | 29,948 | 53 | 53 | — | 3,353 | 3,353 | — | 40,719 | 17,100 | 23,619 | 14,340 | 8,101 | 6,329 |
| | MEDIUM AND LIGHT BOMBERS AND FIGHTERS | | | | | | | | | | | | | | |
| Total | 457,669 | 257,043 | 200,626 | 1,159 | — | 1,159 | 56,180 | 8,203 | 47,977 | 255,347 | 145,794 | 109,553 | 144,983 | 103,046 | 41,937 |
| Albania | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Austria | 1,843 | — | 1,843 | — | — | — | — | — | — | — | — | — | 1,843 | — | 1,843 |
| Bulgaria | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Czechoslovakia | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Denmark | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| France | 177,592 | 172,616 | 4,976 | — | — | — | 8,203 | 8,203 | — | 148,032 | 143,056 | 4,976 | 21,357 | 21,357 | — |
| Germany | 83,558 | 83,058 | 500 | — | — | — | — | — | — | 1,369 | 1,369 | — | 82,189 | 81,689 | 500 |
| Greece | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Hungary | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Italy | 163,571 | — | 163,571 | — | — | — | 22,653 | — | 22,653 | 104,577 | — | 104,577 | 36,341 | — | 36,341 |
| Low Countries | 1,369 | 1,369 | — | — | — | — | — | — | — | 1,369 | 1,369 | — | — | — | — |
| North Africa | 26,483 | — | 26,483 | 1,159 | — | 1,159 | 25,324 | — | 25,324 | — | — | — | — | — | — |
| Norway | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Poland | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Rumania | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Yugoslavia | 2,000 | — | 2,000 | — | — | — | — | — | — | — | — | — | 2,000 | — | 2,000 |
| Other[1] | 1,253 | — | 1,253 | — | — | — | — | — | — | — | — | — | 1,253 | — | 1,253 |

[1] Includes tonnage jettisoned.

# DESTRUCTION OF JAPANESE AIRCRAFT PLANTS BY XXI BOMBER COMMAND, U. S. ARMY AIR FORCES

November 1944 to August 1945

Primary Targets Only

Source: U. S. Army Air Forces Office of Statistical Control

| Plant | Total Roof Area (Square Feet) | Roof Area Destroyed or Damaged (Square Feet) | Percent Destroyed or Damaged | Airplanes Bombing | Tons of Bombs Dropped | Airplanes Lost |
|---|---|---|---|---|---|---|
| Total | 52,954,940[1] | 31,662,260 | 60 | 2,838 | 14,152.2 | 103 |
| Aichi Eitoku Plant | 2,612,000 | 1,062,460 | 41 | 124 | 817.8 | 2 |
| Aichi Nagoya Plant | 467,500 | 302,600 | 65 | 42 | 271.0 | — |
| Aichi Ordnance Plant | 1,188,000 | 1,130,800 | 96 | | | |
| Hiro Kure Plant | 1,089,229 | 779,457 | 72 | 149 | 581.0 | 2 |
| Hitachi Engine Plant, Chiba | NA | None | None | 27 | 144.2 | — |
| Hitachi Engine Plant, Tachikawa | 1,140,000 | 838,626 | 74 | 101 | 473.5 | 5 |
| Japan Tomioka Plant | 748,400 | 247,900 | 33 | 32 | 172.5 | — |
| Kawanishi Fukae Plant | 1,281,451 | 504,247 | 39 | 92 | 459.5 | 1 |
| Kawanishi Himeji Plant | 953,100 | 948,650 | 99 | 52 | 350.7 | — |
| Kawanishi Naruo Plant | 2,457,700 | 1,807,250 | 73 | 44 | 263.5 | — |
| Kawanishi Takarazuka Plant | 1,747,600 | 1,488,800 | 85 | 78 | 457.5 | — |
| Kawasaki Akashi Plant | 3,371,100 | 2,511,450 | 74 | 144 | 637.7 | — |
| Kawasaki Kagamigahara Plant | 1,582,000 | 953,700 | 60 | 40 | 232.0 | 1 |
| Mitsubishi Kagamigahara Plant | 293,000 | 227,000 | 78 | 78 | 508.5 | 2 |
| Mitsubishi Nagoya Plant | 5,677,000 | 3,880,795 | 68 | 104 | 251.6 | 9 |
| Mitsubishi Tamashima Plant | 3,048,800 | 2,665,650 | 88 | 111 | 610.8 | 2 |
| Mitsubishi Engine Works, Nagoya | 3,811,000 | 3,584,100 | 94 | 570 | 2,068.5 | 18 |
| Nakajima Handa Plant | 1,509,950 | 615,700 | 41 | 78 | 544.3 | — |
| Nakajima Koizumi Plant | 3,700,000 | 882,900 | 24 | 48 | 274.7 | — |
| Nakajima Musashino Plant | 1,832,000 | 1,274,200 | 70 | 505 | 2,402.3 | 47 |
| Nakajima New Ota Plant | 2,400,000 | 1,699,450 | 73 | 87 | 245.5 | 12 |
| Nakajima Ogikubu Plant | NA | None | None | 7 | 38.0 | — |
| Omura Aircraft Factory | 2,800,000 | 544,025 | 19 | 39 | 87.3 | — |
| Shizuoka Engine Works | 1,683,610 | 823,100 | 49 | 59 | 237.2 | — |
| Tachikawa Plant | 2,870,000 | 807,000 | 28 | 73 | 549.6 | 1 |
| Tachikawa Depot | 4,232,500 | 1,623,400 | 39 | 37 | 197.5 | — |
| Tachiarai Machine Works | 459,000 | 459,000 | 100 | 105 | 416.7 | 1 |
| Other | — | — | — | 12 | 58.4 | — |

[1] Excludes roof area of Hitachi Aircraft Company, Chiba Plant, and Nakajima Aircraft Company, Ogikubu.
NA—Not available.

## DESTRUCTION OF JAPANESE URBAN AREAS BY XXI BOMBER COMMAND U. S. ARMY AIR FORCES

November 1944 to August 1945

Primary Targets Only

Source: U. S. Army Air Forces Office of Statistical Control

| Urban Area | Population | Sq. Mi. of Built-up Area | | % Destroyed | Airplanes Bombing | Tons of Bombs Dropped | Airplanes Lost |
|---|---|---|---|---|---|---|---|
| | | Total | Destroyed | | | | |
| Total | 20,836,646 | 411.00 | 178.10 | 43 | 16,112 | 104,930.4[1] | 179 |
| Akashi | 47,751 | 1.42 | 0.90 | 64 | 123 | 975.0 | — |
| Amagasaki | 181,011 | 6.90 | 0.76 | 11 | (Included in Osaka) | | |
| Aomori | 99,065 | 2.08 | 0.73 | 35 | 63 | 551.5 | — |
| Chiba | 92,061 | 1.98 | 0.86 | 43 | 125 | 892.3 | — |
| Choshi | 61,198 | 1.12 | 0.48 | 43 | 104 | 779.9 | — |
| Fukui | 97,967 | 1.90 | 1.61 | 85 | 128 | 960.4 | — |
| Fukuoka | 323,217 | 6.56 | 1.37 | 22 | 221 | 1,525.0 | — |
| Fukuyama | 56,653 | 1.20 | 0.88 | 73 | 91 | 555.7 | — |
| Gifu | 172,340 | 2.60 | 1.93 | 74 | 129 | 898.8 | 1 |
| Hachioji | 62,279 | 1.40 | 1.12 | 80 | 169 | 1,593.3 | 1 |
| Hamamatsu | 166,346 | 4.24 | 2.97 | 70 | 560 | 3,076.0 | 4 |
| Himeji | 104,249 | 1.92 | 1.48 | 72 | 106 | 767.1 | — |
| Hiratsuka | 43,148 | 2.35 | 1.04 | 44 | 133 | 1,162.5 | — |
| Hiroshima | 343,968 | 6.90 | 4.70 | 69 | 4 | 5.5[1] | — |
| Hitachi | 82,885 | 1.38 | 1.08 | 78 | 128 | 971.2 | 2 |
| Ichinomiya | 70,792 | 1.28 | 0.97 | 76 | 247 | 1,640.8 | — |
| Imabari | 55,557 | 0.97 | 0.73 | 76 | 76 | 586.5 | — |
| Isezaki | 40,004 | 1.00 | 0.17 | 17 | 87 | 614.1 | — |
| Kagoshima | 190,257 | 4.87 | 2.15 | 44 | 171 | 1,023.1 | 2 |
| Kawasaki | 300,777 | 11.30 | 3.70 | 33 | 250 | 1,515.0 | 12 |
| Kobe | 967,234 | 15.70 | 8.75 | 56 | 874 | 5,647.8 | 11 |
| Kochi | 106,644 | 1.90 | 0.92 | 48 | 134 | 1,117.6 | 1 |
| Kofu | 102,419 | 2.00 | 1.30 | 15 | 133 | 977.9 | — |
| Kumagaya | 48,899 | 0.60 | 0.27 | 45 | 82 | 593.4 | — |
| Kumamoto | 210,938 | 4.80 | 1.00 | 21 | 155 | 1,121.2 | 1 |
| Kure | 276,985 | 3.26 | 1.30 | 40 | 157 | 1,093.7 | — |
| Kuwana | 41,848 | 0.82 | 0.63 | 77 | 217 | 1,511.3 | — |
| Maebashi | 86,997 | 2.34 | 1.00 | 42 | 92 | 723.8 | — |
| Matsuyama | 117,534 | 1.67 | 1.22 | 73 | 128 | 896.0 | — |
| Mito | 66,293 | 2.60 | 1.70 | 65 | 161 | 1,151.4 | — |
| Moji | 138,997 | 1.12 | 0.30 | 27 | 92 | 626.9 | — |
| Nagaoka | 66,987 | 2.03 | 1.33 | 66 | 126 | 926.3 | — |
| Nagasaki | 252,630 | 3.30 | 1.45 | 44 | 2 | 5.0[1] | — |
| Nagoya | 1,328,084 | 39.70 | 12.37 | 31 | 1,647 | 10,144.8 | 23 |
| Nishinomiya | 111,796 | 9.46 | 3.50 | 37 | 255 | 2,003.9 | 1 |
| Nobeoka | 79,426 | 1.43 | 0.52 | 36 | 126 | 876.4 | — |
| Numazu | 53,165 | 1.40 | 1.25 | 90 | 125 | 1,051.7 | — |
| Ogaki | 56,117 | 1.20 | 0.48 | 40 | 93 | 663.7 | — |
| Oita | 76,985 | 2.20 | 0.56 | 25 | 131 | 801.9 | — |
| Okayama | 163,552 | 3.38 | 2.13 | 63 | 140 | 985.5 | 1 |
| Okazaki | 84,073 | 0.95 | 0.65 | 68 | 128 | 857.4 | — |
| Omuta | 177,034 | 5.37 | 2.27 | 43 | 240 | 1,733.8 | 1 |
| Osaka | 3,252,340 | 59.80 | 15.54 | 26 | 1,627 | 10,417.3 | 23 |
| Saga | 50,406 | 1.20 | — | — | 63 | 458.9 | 1 |
| Sakai | 182,147 | 2.32 | 1.02 | 44 | 116 | 778.9 | 1 |
| Sasebo | 205,989 | 2.34 | 0.97 | 42 | 145 | 1,070.9 | — |
| Sendai | 223,630 | 4.53 | 1.22 | 27 | 130 | 935.5 | 1 |
| Shimizu | 68,617 | 1.41 | 0.74 | 52 | 153 | 1,116.7 | 1 |
| Shimonoseki | 196,022 | 1.42 | 0.51 | 36 | 130 | 836.4 | 1 |
| Shizuoka | 212,198 | 3.46 | 2.28 | 66 | 158 | 1,022.3 | 2 |
| Takamatsu | 111,207 | 1.80 | 1.40 | 78 | 116 | 833.1 | 2 |
| Tokushima | 119,581 | 2.30 | 1.70 | 74 | 141 | 1,127.9 | — |
| Tokuyama | 38,419 | 1.27 | 0.68 | 54 | 107 | 789.5 | — |
| Tokyo | 6,778,804 | 110.80 | 56.30 | 50 | 2,531 | 14,054.1 | 74 |
| Toyama | 127,859 | 1.88 | 1.87 | 100 | 176 | 1,478.1 | — |
| Toyohashi | 142,716 | 3.30 | 1.70 | 52 | 160 | 1,026.1 | — |
| Tsu | 68,625 | 1.47 | 1.18 | 81 | 222 | 1,507.3 | — |
| Tsuruga | 31,346 | 1.13 | 0.77 | 68 | 94 | 692.2 | — |
| Ube | 100,680 | 1.80 | 0.42 | 23 | 103 | 726.7 | — |
| Ujiyamada | 52,555 | 0.93 | 0.36 | 39 | 119 | 839.5 | — |
| Utsonomiya | 87,868 | 2.75 | 0.94 | 34 | 115 | 802.9 | 1 |
| Uwajima | 52,101 | 1.00 | 0.52 | 52 | 159 | 1,106.3 | — |
| Wakayama | 195,203 | 4.00 | 2.10 | 53 | 125 | 883.8 | — |
| Yawata | 261,309 | 5.78 | 1.22 | 21 | 221 | 1,301.9 | 4 |
| Yokkaichi | 102,771 | 3.51 | 1.23 | 35 | 95 | 591.6 | — |
| Yokohama | 968,091 | 20.20 | 8.90 | 44 | 463 | 2,590.8 | 7 |
| Other | — | — | — | — | 490 | 2,336.6 | — |

[1] Excludes weight of atomic bomb.

## COMBAT SORTIES BY U. S. ARMY AIR FORCES

Source: U. S. Army Air Forces Office of Statistical Control

| Year and Month | Total | Theaters vs Germany | | | Theaters vs Japan | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | European Theater | Mediterranean Theater | Total | Pacific Ocean Areas | Far East Air Forces | China and India-Burma | Alaska | 20th Air Force |
| Grand Total | 2,362,800 | 1,693,565 | 1,034,052 | 659,513 | 669,235 | 59,101 | 415,979 | 148,029 | 7,318 | 38,808 |
| *Annually* | | | | | | | | | | |
| 1941 (Dec.) | 212 | — | — | — | 212 | — | 212 | — | — | — |
| 1942 | 26,688 | 9,749 | 2,453 | 7,296 | 16,939 | 130 | 14,311 | 1,341 | 1,157 | — |
| 1943 | 365,940 | 233,523 | 63,929 | 169,594 | 132,417 | 1,413 | 103,147 | 23,151 | 4,706 | — |
| 1944 | 1,284,195 | 1,012,101 | 655,289 | 356,812 | 272,094 | 26,364 | 163,397 | 78,999 | 815 | 2,519 |
| 1945 (Jan.-Aug.) | 685,765 | 438,192 | 312,381 | 125,811 | 247,573 | 31,194 | 134,912 | 44,538 | 640 | 36,289 |
| *Monthly* | | | | | | | | | | |
| 1941 | | | | | | | | | | |
| Dec. | * 212 | — | — | — | 212 | — | 212 | — | — | — |
| 1942 | | | | | | | | | | |
| Jan. | 353 | — | — | — | 353 | — | 341 | — | 12 | — |
| Feb. | 761 | — | — | — | 761 | — | 742 | 5 | 14 | — |
| Mar. | 1,019 | — | — | — | 1,019 | — | 979 | 23 | 17 | — |
| April | 1,229 | — | — | — | 1,229 | — | 1,181 | 30 | 18 | — |
| May | 1,306 | — | — | — | 1,306 | 6 | 1,223 | 52 | 25 | — |
| June | 1,561 | 70 | — | 70 | 1,491 | 59 | 1,180 | 158 | 94 | — |
| July | 1,579 | 166 | — | 166 | 1,413 | — | 1,172 | 111 | 130 | — |
| Aug. | 2,041 | 579 | 324 | 255 | 1,462 | — | 1,197 | 115 | 150 | — |
| Sept. | 2,679 | 999 | 423 | 576 | 1,680 | — | 1,352 | 171 | 157 | — |
| Oct. | 4,020 | 2,053 | 534 | 1,519 | 1,967 | — | 1,604 | 191 | 172 | — |
| Nov. | 5,218 | 3,173 | 629 | 2,544 | 2,045 | 10 | 1,663 | 199 | 173 | — |
| Dec. | 4,922 | 2,709 | 543 | 2,166 | 2,213 | 55 | 1,677 | 286 | 195 | — |
| 1943 | | | | | | | | | | |
| Jan. | 10,149 | 5,097 | 767 | 4,330 | 5,052 | 37 | 4,315 | 485 | 215 | — |
| Feb. | 8,272 | 4,338 | 976 | 3,362 | 3,934 | 9 | 2,816 | 797 | 312 | — |
| Mar. | 14,171 | 8,042 | 1,564 | 6,478 | 6,129 | — | 4,257 | 1,237 | 635 | — |
| April | 21,664 | 13,952 | 989 | 12,963 | 7,712 | 29 | 5,023 | 1,522 | 1,138 | — |
| May | 24,721 | 16,639 | 3,915 | 12,724 | 8,082 | 27 | 5,517 | 1,760 | 778 | — |
| June | 24,605 | 17,352 | 4,104 | 13,248 | 7,253 | 22 | 5,874 | 955 | 402 | — |
| July | 40,718 | 29,901 | 5,531 | 24,370 | 10,817 | 29 | 8,826 | 1,454 | 508 | — |
| Aug. | 40,787 | 27,358 | 5,826 | 21,532 | 13,429 | — | 11,472 | 1,304 | 653 | — |
| Sept. | 44,597 | 29,953 | 9,294 | 20,659 | 14,644 | 49 | 12,777 | 1,798 | 20 | — |
| Oct. | 36,586 | 21,587 | 7,463 | 14,124 | 14,999 | 4 | 12,149 | 2,818 | 28 | — |
| Nov. | 42,890 | 25,480 | 9,624 | 15,856 | 17,410 | 362 | 13,073 | 3,969 | 6 | — |
| Dec. | 56,780 | 33,824 | 13,876 | 19,948 | 22,956 | 845 | 17,048 | 5,052 | 11 | — |
| 1944 | | | | | | | | | | |
| Jan. | 65,603 | 44,175 | 15,183 | 28,992 | 21,428 | 1,402 | 17,064 | 2,962 | — | — |
| Feb. | 64,913 | 44,993 | 24,425 | 20,568 | 19,920 | 1,090 | 15,233 | 3,589 | 8 | — |
| Mar. | 78,366 | 56,748 | 31,950 | 24,798 | 21,618 | 1,189 | 15,185 | 5,171 | 73 | — |
| April | 94,145 | 74,079 | 43,434 | 30,645 | 20,066 | 1,365 | 13,671 | 4,971 | 59 | — |
| May | 134,500 | 110,518 | 67,979 | 42,539 | 23,982 | 1,086 | 16,084 | 6,750 | 62 | — |
| June | 151,796 | 130,043 | 96,096 | 33,947 | 21,753 | 950 | 14,410 | 6,115 | 112 | 166 |
| July | 130,829 | 108,865 | 74,878 | 33,987 | 21,964 | 4,142 | 10,402 | 7,261 | 45 | 114 |
| Aug. | 136,578 | 115,944 | 77,976 | 37,968 | 20,634 | 3,317 | 9,644 | 7,413 | 89 | 171 |
| Sept. | 106,096 | 83,743 | 57,384 | 26,359 | 22,353 | 2,384 | 12,476 | 7,146 | 130 | 217 |
| Oct. | 98,139 | 75,203 | 52,596 | 22,607 | 22,936 | 2,105 | 11,846 | 8,575 | 100 | 310 |
| Nov. | 104,100 | 78,354 | 52,299 | 26,055 | 25,746 | 2,854 | 13,111 | 9,087 | 83 | 611 |
| Dec. | 119,130 | 89,436 | 61,089 | 28,347 | 29,694 | 4,480 | 14,271 | 9,959 | 54 | 930 |
| 1945 | | | | | | | | | | |
| Jan. | 96,528 | 64,491 | 47,577 | 16,914 | 32,037 | 3,520 | 17,277 | 10,162 | 69 | 1,009 |
| Feb. | 131,649 | 99,713 | 68,365 | 31,348 | 31,936 | 3,015 | 17,919 | 9,607 | 64 | 1,331 |
| Mar. | 186,377 | 146,880 | 111,472 | 35,408 | 39,497 | 4,270 | 21,658 | 10,352 | 114 | 3,103 |
| Apr. | 157,978 | 120,897 | 79,402 | 41,495 | 37,081 | 3,105 | 22,953 | 7,429 | 107 | 3,487 |
| May | 39,180 | 6,211 | 5,565 | 646 | 32,969 | 2,988 | 22,461 | 2,866 | 92 | 4,562 |
| June | 33,164 | — | — | — | 33,164 | 6,538 | 19,292 | 1,663 | 90 | 5,581 |
| July | 27,871 | — | — | — | 27,871 | 6,406 | 9,054 | 1,955 | 75 | 10,291 |
| Aug. | 13,018 | — | — | — | 13,018 | 1,262 | 4,298 | 504 | 29 | 6,925 |

*Note*—A sortie is one flight by one plane.

## AIRPLANES LOST BY U. S. ARMY AIR FORCES ON COMBAT MISSIONS

January 1942 to August 1945

Source: U. S. Army Air Forces Office of Statistical Control

| Year and Month | Total | Theaters vs Germany | | | Theaters vs Japan | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | European Theater | Mediterranean Theater | Total | Pacific Ocean Areas | Far East Air Forces | China and India-Burma | Alaska | 20th Air Force |
| Grand Total... | 22,948 | 18,418 | 11,687 | 6,731 | 4,530 | 378 | 2,494 | 1,076 | 88 | 494 |
| *Annually* | | | | | | | | | | |
| 1942........ | 482 | 141 | 55 | 86 | 341 | 13 | 276 | 35 | 17 | — |
| 1943........ | 3,847 | 3,028 | 1,261 | 1,767 | 819 | 25 | 539 | 217 | 38 | — |
| 1944........ | 13,289 | 11,618 | 7,749 | 3,869 | 1,671 | 116 | 910 | 532 | 18 | 95 |
| 1945 (Jan.-Aug.) .. | 5,330 | 3,631 | 2,622 | 1,009 | 1,699 | 224 | 769 | 292 | 15 | 399 |
| *Monthly* | | | | | | | | | | |
| 1942 | | | | | | | | | | |
| Jan.......... | 5 | — | — | — | 5 | — | 5 | — | — | — |
| Feb.......... | 46 | — | — | — | 46 | — | 46 | — | — | — |
| Mar.......... | 12 | — | — | — | 12 | — | 12 | — | — | — |
| April........ | 4 | — | — | — | 4 | — | 3 | 1 | — | — |
| May.......... | 50 | — | — | — | 50 | — | 49 | 1 | — | — |
| June......... | 52 | 5 | — | 5 | 47 | 7 | 32 | 6 | 2 | — |
| July......... | 28 | 3 | — | 3 | 25 | 2 | 16 | 4 | 3 | — |
| Aug.......... | 42 | 14 | 8 | 6 | 28 | — | 24 | 2 | 2 | — |
| Sept......... | 38 | 8 | 2 | 6 | 30 | — | 25 | 1 | 4 | — |
| Oct.......... | 33 | 17 | 11 | 6 | 16 | 1 | 3 | 7 | 5 | — |
| Nov.......... | 92 | 35 | 17 | 18 | 57 | 2 | 44 | 11 | — | — |
| Dec.......... | 80 | 59 | 17 | 42 | 21 | 1 | 17 | 2 | 1 | — |
| 1943 | | | | | | | | | | |
| Jan.......... | 160 | 133 | 21 | 112 | 27 | — | 23 | 1 | 3 | — |
| Feb.......... | 135 | 110 | 24 | 86 | 25 | — | 22 | 3 | — | — |
| Mar.......... | 129 | 105 | 22 | 83 | 24 | — | 15 | 6 | 3 | — |
| April........ | 242 | 202 | 34 | 168 | 40 | 2 | 28 | 6 | 4 | — |
| May.......... | 286 | 249 | 92 | 157 | 37 | 1 | 18 | 10 | 8 | — |
| June......... | 274 | 215 | 98 | 117 | 59 | 2 | 36 | 18 | 3 | — |
| July......... | 497 | 390 | 134 | 256 | 107 | 2 | 84 | 16 | 5 | — |
| Aug.......... | 504 | 418 | 135 | 283 | 86 | — | 58 | 26 | 2 | — |
| Sept......... | 358 | 281 | 118 | 163 | 77 | 2 | 50 | 15 | 10 | — |
| Oct.......... | 416 | 321 | 201 | 120 | 95 | — | 66 | 29 | — | — |
| Nov.......... | 369 | 247 | 160 | 87 | 122 | 4 | 84 | 34 | — | — |
| Dec.......... | 477 | 357 | 222 | 135 | 120 | 12 | 55 | 53 | — | — |
| 1944 | | | | | | | | | | |
| Jan.......... | 643 | 498 | 277 | 221 | 145 | 35 | 85 | 25 | — | — |
| Feb.......... | 775 | 661 | 393 | 268 | 114 | 22 | 53 | 36 | 3 | — |
| Mar.......... | 891 | 753 | 551 | 202 | 138 | 5 | 94 | 39 | — | — |
| April........ | 1,170 | 1,043 | 732 | 311 | 127 | 7 | 87 | 33 | — | — |
| May.......... | 1,245 | 1,148 | 761 | 387 | 97 | 5 | 46 | 45 | 1 | — |
| June......... | 1,457 | 1,323 | 904 | 419 | 134 | 8 | 66 | 50 | — | 10 |
| July......... | 1,294 | 1,185 | 712 | 473 | 109 | 9 | 45 | 52 | — | 3 |
| Aug.......... | 1,558 | 1,455 | 968 | 487 | 103 | 10 | 31 | 47 | 1 | 14 |
| Sept......... | 1,103 | 991 | 758 | 233 | 112 | 5 | 54 | 46 | 4 | 3 |
| Oct.......... | 963 | 815 | 552 | 263 | 148 | 3 | 88 | 50 | 2 | 5 |
| Nov.......... | 1,054 | 819 | 538 | 281 | 235 | 2 | 157 | 50 | 3 | 23 |
| Dec.......... | 1,136 | 927 | 603 | 324 | 209 | 5 | 104 | 59 | 4 | 37 |
| 1945 | | | | | | | | | | |
| Jan.......... | 1,084 | 835 | 646 | 189 | 249 | 15 | 134 | 67 | 2 | 31 |
| Feb.......... | 1,043 | 853 | 580 | 273 | 190 | 11 | 101 | 48 | — | 30 |
| Mar.......... | 1,266 | 1,058 | 774 | 284 | 208 | 9 | 112 | 51 | — | 36 |
| April........ | 1,067 | 825 | 579 | 246 | 242 | 30 | 101 | 54 | — | 57 |
| May.......... | 316 | 60 | 43 | 17 | 256 | 32 | 104 | 25 | 7 | 88 |
| June......... | 216 | — | — | — | 216 | 63 | 85 | 21 | 3 | 44 |
| July......... | 194 | — | — | — | 194 | 64 | 49 | 24 | 3 | 54 |
| Aug.......... | 144 | — | — | — | 144 | — | 83 | 2 | — | 59 |

# ALL AIRPLANES LOST BY U. S. ARMY AIR FORCES IN THE UNITED STATES AND OVERSEAS BY TYPE OF PLANE

December 1941 to August 1945

Source: U. S. Army Air Forces Office of Statistical Control

| Year and Month | TOTAL ARMY AIR FORCES | | | | | | CONTINENTAL U. S. | | | | | | OVERSEAS[1] | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | Very Heavy Bombers | Heavy Bombers | Medium and Light Bombers | Fighters | Others | Total | Very Heavy Bombers | Heavy Bombers | Medium and Light Bombers | Fighters | Others | Total | Very Heavy Bombers | Heavy Bombers | Medium and Light Bombers | Fighters | Others |
| Grand Total | 65,164 | 772 | 14,280 | 8,479 | 26,743 | 14,890 | 21,583 | 260 | 1,989 | 3,254 | 6,779 | 9,301 | 43,581 | 512 | 12,291 | 5,225 | 19,964 | 5,589 |
| *Annually* | | | | | | | | | | | | | | | | | | |
| 1941 (Dec.) | 445 | — | 31 | 53 | 318 | 43 | 33 | — | 1 | 11 | 8 | 13 | 412 | — | 30 | 42 | 310 | 30 |
| 1942 | 5,415 | — | 412 | 949 | 2,149 | 1,905 | 3,525 | — | 114 | 656 | 997 | 1,758 | 1,890 | — | 298 | 293 | 1,152 | 147 |
| 1943 | 15,032 | 3 | 2,607 | 2,298 | 5,609 | 4,515 | 7,759 | 3 | 624 | 1,239 | 2,139 | 3,754 | 7,273 | — | 1,983 | 1,059 | 3,470 | 761 |
| 1944 | 28,300 | 203 | 7,871 | 3,161 | 11,995 | 5,070 | 7,314 | 45 | 865 | 920 | 2,579 | 2,905 | 20,986 | 158 | 7,006 | 2,241 | 9,416 | 2,165 |
| 1945 (Jan.-Aug.) | 15,972 | 566 | 3,359 | 2,018 | 6,672 | 3,357 | 2,952 | 212 | 385 | 428 | 1,056 | 871 | 13,020 | 354 | 2,974 | 1,590 | 5,616 | 2,486 |
| *Monthly* | | | | | | | | | | | | | | | | | | |
| 1941 | | | | | | | | | | | | | | | | | | |
| Dec. | 445 | — | 31 | 53 | 318 | 43 | 33 | — | 1 | 11 | 8 | 13 | 412 | — | 30 | 42 | 310 | 30 |
| 1942 | | | | | | | | | | | | | | | | | | |
| Jan. | 154 | — | 22 | 34 | 48 | 50 | 118 | — | 6 | 25 | 38 | 49 | 36 | — | 16 | 9 | 10 | 1 |
| Feb. | 264 | — | 27 | 32 | 132 | 73 | 149 | — | 2 | 26 | 52 | 69 | 115 | — | 25 | 6 | 80 | 4 |
| Mar. | 347 | — | 16 | 42 | 210 | 79 | 184 | — | 7 | 33 | 69 | 75 | 163 | — | 9 | 9 | 141 | 4 |
| April | 318 | — | 13 | 65 | 129 | 111 | 217 | — | 9 | 37 | 64 | 107 | 101 | — | 4 | 28 | 65 | 4 |
| May | 357 | — | 21 | 71 | 153 | 112 | 203 | — | 10 | 42 | 50 | 101 | 154 | — | 11 | 29 | 103 | 11 |
| June | 399 | — | 28 | 60 | 177 | 134 | 261 | — | 6 | 37 | 90 | 128 | 138 | — | 22 | 23 | 87 | 6 |
| July | 470 | — | 26 | 72 | 133 | 239 | 370 | — | 8 | 52 | 76 | 234 | 100 | — | 18 | 20 | 57 | 5 |
| Aug. | 594 | — | 48 | 123 | 205 | 218 | 420 | — | 16 | 82 | 122 | 200 | 174 | — | 32 | 41 | 83 | 18 |
| Sept. | 547 | — | 44 | 90 | 189 | 224 | 387 | — | 9 | 68 | 100 | 210 | 160 | — | 35 | 22 | 89 | 14 |
| Oct. | 566 | — | 46 | 107 | 199 | 214 | 402 | — | 12 | 78 | 124 | 188 | 164 | — | 34 | 29 | 75 | 26 |
| Nov. | 632 | — | 57 | 82 | 281 | 212 | 343 | — | 10 | 47 | 100 | 186 | 289 | — | 47 | 35 | 181 | 26 |
| Dec. | 767 | — | 64 | 171 | 293 | 239 | 471 | — | 19 | 129 | 112 | 211 | 296 | — | 45 | 42 | 181 | 28 |

| Year and Month | TOTAL ARMY AIR FORCES | | | | | | CONTINENTAL U. S. | | | | | | OVERSEAS[1] | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | Very Heavy Bombers | Heavy Bombers | Medium and Light Bombers | Fighters | Others | Total | Very Heavy Bombers | Heavy Bombers | Medium and Light Bombers | Fighters | Others | Total | Very Heavy Bombers | Heavy Bombers | Medium and Light Bombers | Fighters | Others |
| **1943** | | | | | | | | | | | | | | | | | | |
| Jan. | 1,029 | — | 106 | 213 | 402 | 308 | 625 | — | 45 | 142 | 158 | 280 | 404 | — | 61 | 71 | 244 | 28 |
| Feb. | 793 | 1 | 113 | 156 | 307 | 216 | 442 | 1 | 30 | 95 | 123 | 193 | 351 | — | 83 | 61 | 184 | 23 |
| Mar. | 925 | — | 96 | 195 | 394 | 240 | 510 | — | 39 | 123 | 153 | 195 | 415 | — | 57 | 72 | 241 | 45 |
| April | 1,242 | — | 126 | 201 | 488 | 427 | 692 | — | 41 | 117 | 151 | 383 | 550 | — | 85 | 84 | 337 | 44 |
| May | 970 | — | 166 | 192 | 435 | 177 | 432 | — | 40 | 94 | 169 | 129 | 538 | — | 126 | 98 | 266 | 48 |
| June | 1,087 | — | 179 | 159 | 429 | 320 | 631 | — | 41 | 93 | 224 | 273 | 456 | — | 138 | 66 | 205 | 47 |
| July | 1,463 | — | 243 | 202 | 500 | 518 | 738 | — | 48 | 92 | 167 | 431 | 725 | — | 195 | 110 | 333 | 87 |
| Aug. | 1,357 | — | 332 | 200 | 592 | 233 | 550 | — | 71 | 95 | 212 | 172 | 807 | — | 261 | 105 | 380 | 61 |
| Sept. | 1,554 | — | 247 | 234 | 555 | 518 | 795 | — | 74 | 101 | 185 | 435 | 759 | — | 173 | 133 | 370 | 83 |
| Oct. | 1,564 | 1 | 389 | 184 | 503 | 487 | 774 | 1 | 68 | 99 | 203 | 403 | 790 | — | 321 | 85 | 300 | 84 |
| Nov. | 1,490 | 1 | 250 | 176 | 496 | 567 | 848 | 1 | 62 | 101 | 215 | 469 | 642 | — | 188 | 75 | 281 | 98 |
| Dec. | 1,558 | — | 360 | 186 | 508 | 504 | 722 | — | 65 | 87 | 179 | 391 | 836 | — | 295 | 99 | 329 | 113 |
| **1944** | | | | | | | | | | | | | | | | | | |
| Jan. | 1,617 | — | 470 | 187 | 550 | 410 | 634 | — | 83 | 67 | 157 | 327 | 983 | — | 387 | 120 | 393 | 83 |
| Feb. | 1,713 | 1 | 553 | 227 | 553 | 379 | 575 | 1 | 66 | 67 | 141 | 300 | 1,138 | — | 487 | 160 | 412 | 79 |
| Mar. | 1,987 | — | 560 | 246 | 760 | 421 | 794 | — | 75 | 117 | 264 | 338 | 1,193 | — | 485 | 129 | 496 | 83 |
| April | 2,355 | 4 | 808 | 231 | 913 | 399 | 659 | — | 61 | 64 | 254 | 280 | 1,696 | 4 | 747 | 167 | 659 | 119 |
| May | 2,571 | 7 | 731 | 283 | 1,130 | 420 | 765 | 1 | 68 | 105 | 290 | 301 | 1,806 | 6 | 663 | 178 | 840 | 119 |
| June | 3,050 | 24 | 764 | 249 | 1,447 | 566 | 770 | 5 | 64 | 53 | 298 | 350 | 2,280 | 19 | 700 | 196 | 1,149 | 216 |
| July | 2,705 | 14 | 851 | 226 | 1,109 | 505 | 810 | 6 | 78 | 68 | 301 | 357 | 1,895 | 8 | 773 | 158 | 808 | 148 |
| Aug. | 2,938 | 25 | 747 | 311 | 1,386 | 469 | 710 | 5 | 81 | 92 | 286 | 246 | 2,228 | 20 | 666 | 219 | 1,100 | 223 |
| Sept. | 2,365 | 18 | 637 | 270 | 997 | 443 | 491 | 7 | 69 | 73 | 202 | 140 | 1,874 | 11 | 568 | 197 | 795 | 303 |
| Oct. | 2,208 | 19 | 568 | 275 | 1,034 | 312 | 441 | 8 | 89 | 93 | 179 | 72 | 1,767 | 11 | 479 | 182 | 855 | 240 |
| Nov. | 2,255 | 36 | 625 | 242 | 996 | 356 | 309 | 6 | 73 | 42 | 73 | 115 | 1,946 | 30 | 552 | 200 | 923 | 241 |
| Dec. | 2,536 | 55 | 557 | 414 | 1,120 | 390 | 356 | 6 | 58 | 79 | 134 | 79 | 2,180 | 49 | 499 | 335 | 986 | 311 |
| **1945** | | | | | | | | | | | | | | | | | | |
| Jan. | 2,345 | 44 | 647 | 283 | 961 | 410 | 360 | 10 | 70 | 48 | 122 | 110 | 1,985 | 34 | 577 | 235 | 839 | 300 |
| Feb. | 1,993 | 46 | 450 | 282 | 885 | 330 | 273 | 11 | 40 | 50 | 81 | 91 | 1,720 | 35 | 410 | 232 | 804 | 239 |
| Mar. | 2,580 | 50 | 624 | 292 | 1,107 | 507 | 310 | 12 | 29 | 52 | 134 | 83 | 2,270 | 38 | 595 | 240 | 973 | 424 |
| April | 2,342 | 83 | 468 | 251 | 1,104 | 436 | 359 | 24 | 38 | 50 | 139 | 108 | 1,983 | 59 | 430 | 201 | 965 | 328 |
| May | 1,832 | 113 | 385 | 218 | 635 | 481 | 445 | 22 | 34 | 64 | 160 | 165 | 1,387 | 91 | 351 | 154 | 475 | 316 |
| June | 1,672 | 70 | 248 | 291 | 659 | 404 | 383 | 17 | 73 | 58 | 132 | 103 | 1,289 | 53 | 175 | 233 | 527 | 301 |
| July | 1,524 | 98 | 188 | 240 | 565 | 433 | 480 | 72 | 48 | 61 | 173 | 126 | 1,044 | 26 | 140 | 179 | 392 | 307 |
| Aug. | 1,684 | 62 | 349 | 161 | 756 | 356 | 342 | 44 | 53 | 45 | 115 | 85 | 1,342 | 18 | 296 | 116 | 641 | 271 |

[1] Includes losses suffered enroute to and from overseas as well as losses in theaters, ATC foreign divisions and other overseas commands.

## ENEMY AIRCRAFT DESTROYED BY U. S. ARMY AIR FORCES

February 1942 to August 1945

Source: U. S. Army Air Forces Office of Statistical Control

| Year and Month | Total | Theaters vs Germany | | | Theaters vs Japan | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | European Theater | Mediterranean Theater | Total | Pacific Ocean Areas | Far East Air Forces | China and India-Burma | Alaska | 20th Air Force |
| Grand Total | 40,259[1] | 29,916[1] | 20,419 | 9,497[1] | 10,343[1] | 794 | 6,298[1] | 1,913[1] | 113[1] | 1,225 |
| *Annually* | | | | | | | | | | |
| 1942 (Feb.-Dec.) | 935 | 327 | 169 | 158 | 608 | — | 518 | 53 | 37 | — |
| 1943 | 10,837 | 7,605 | 3,865 | 3,740 | 3,232 | 96 | 2,466 | 636 | 34 | — |
| 1944 | 19,442 | 15,664 | 10,425 | 5,239 | 3,778 | 226 | 2,518 | 772 | 8 | 254 |
| 1945 (Jan.-Aug.) | 8,477 | 6,251 | 5,960 | 291 | 2,226 | 472 | 416 | 361 | 6 | 971 |
| *Monthly* | | | | | | | | | | |
| 1942 | | | | | | | | | | |
| Feb. | 27 | — | — | — | 27 | — | 27 | — | — | — |
| Mar. | 25 | — | — | — | 25 | — | 25 | — | — | — |
| April | 18 | — | — | — | 18 | — | 18 | — | — | — |
| May | 36 | — | — | — | 36 | — | 36 | — | — | — |
| June | 41 | — | — | — | 41 | — | 33 | — | 8 | — |
| July | 33 | 2 | — | 2 | 31 | — | 18 | 13 | — | — |
| Aug. | 83 | 3 | 3 | — | 80 | — | 75 | 3 | 2 | — |
| Sept. | 75 | 17 | 16 | 1 | 58 | — | 48 | 5 | 5 | — |
| Oct. | 167 | 92 | 49 | 43 | 75 | — | 46 | 16 | 13 | — |
| Nov. | 170 | 83 | 47 | 36 | 87 | — | 76 | 3 | 8 | — |
| Dec. | 260 | 130 | 54 | 76 | 130 | — | 116 | 13 | 1 | — |
| 1943 | | | | | | | | | | |
| Jan. | 353 | 244 | 50 | 194 | 109 | — | 101 | 8 | — | — |
| Feb. | 322 | 217 | 74 | 143 | 105 | — | 72 | 26 | 7 | — |
| Mar. | 450 | 353 | 142 | 211 | 97 | — | 86 | 9 | 2 | — |
| April | 740 | 673 | 150 | 523 | 67 | — | 50 | 17 | — | — |
| May | 852 | 730 | 380 | 350 | 122 | — | 35 | 81 | 6 | — |
| June | 697 | 578 | 311 | 267 | 119 | — | 108 | 11 | — | — |
| July | 1,081 | 888 | 575 | 313 | 193 | 18 | 120 | 55 | — | — |
| Aug. | 1,567 | 1,059 | 457 | 602 | 508 | — | 416 | 86 | 6 | — |
| Sept. | 1,116 | 786 | 303 | 483 | 330 | 8 | 247 | 62 | 13 | — |
| Oct. | 1,902 | 1,160 | 870 | 290 | 742 | 1 | 676 | 65 | — | — |
| Nov. | 778 | 397 | 222 | 175 | 381 | 18 | 291 | 72 | — | — |
| Dec. | 979 | 520 | 331 | 189 | 459 | 51 | 264 | 144 | — | — |
| 1944 | | | | | | | | | | |
| Jan. | 1,369 | 1,115 | 795 | 320 | 254 | 56 | 192 | 6 | — | — |
| Feb. | 1,340 | 1,118 | 741 | 377 | 222 | — | 210 | 12 | — | — |
| Mar. | 1,629 | 1,217 | 910 | 307 | 412 | 4 | 306 | 102 | — | — |
| April | 2,566 | 2,249 | 1,291 | 958 | 317 | 2 | 214 | 101 | — | — |
| May | 1,924 | 1,752 | 1,220 | 532 | 172 | 4 | 91 | 77 | — | — |
| June | 1,489 | 1,225 | 663 | 562 | 264 | 7 | 237 | 20 | — | — |
| July | 1,689 | 1,533 | 661 | 872 | 156 | 19 | 82 | 55 | — | — |
| Aug. | 1,763 | 1,611 | 1,013 | 598 | 152 | 19 | 68 | 46 | 1 | 18 |
| Sept. | 1,482 | 1,342 | 1,091 | 251 | 140 | 12 | 71 | 37 | 1 | 19 |
| Oct. | 941 | 612 | 353 | 259 | 329 | 8 | 190 | 53 | 2 | 76 |
| Nov. | 1,323 | 788 | 702 | 86 | 535 | 14 | 421 | 52 | 4 | 44 |
| Dec. | 1,927 | 1,102 | 985 | 117 | 825 | 81 | 436 | 211 | — | 97 |
| 1945 | | | | | | | | | | |
| Jan. | 1,014 | 473 | 465 | 8 | 541 | 7 | 161 | 217 | 5 | 151 |
| Feb. | 683 | 488 | 460 | 28 | 195 | 7 | 57 | 56 | — | 75 |
| Mar. | 1,024 | 895 | 750 | 145 | 129 | 2 | 67 | 44 | — | 16 |
| April | 4,878 | 4,367 | 4,257 | 110 | 511 | 94 | 59 | 37 | — | 321 |
| May | 305 | 28 | 28 | — | 277 | 92 | 14 | 1 | — | 170 |
| June | 291 | — | — | — | 291 | 141 | 8 | 5 | 1 | 136 |
| July | 161 | — | — | — | 161 | 112 | 11 | 1 | — | 37 |
| Aug. | 121 | — | — | — | 121 | 17 | 39 | — | — | 65 |

[1] Includes 568 enemy aircraft destroyed, which destraction cannot be allocated to specific months: 69 in theaters vs Germany (MTO), 499 in theaters vs Japan (FEAF—380, C & I-B—91, Alaska—28).

## ENEMY AIRCRAFT DESTROYED BY U. S. ARMY AIR FORCES BY TYPE OF AAF PLANE

### European Theater of Operations

August 1942 to May 1945

Source: U. S. Army Air Forces Office of Statistical Control

| Year and Month | By All Types | | | By Heavy Bombers | | | By Medium and Light Bombers | | | By Fighters | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | In the Air | On the Ground | Total | In the Air | On the Ground | Total | In the Air | On the Ground | Total | In the Air | On the Ground |
| Grand Total | 20,419 | 13,623 | 6,796 | 6,098 | 6,098 | — | 103 | 103 | — | 14,218 | 7,422 | 6,796 |
| *Annually* | | | | | | | | | | | | |
| 1942 (Aug.-Dec.) | 169 | 169 | — | 162 | 162 | — | — | — | — | 7 | 7 | — |
| 1943 | 3,865 | 3,865 | — | 3,381 | 3,381 | — | 33 | 33 | — | 451 | 451 | — |
| 1944 | 10,425 | 8,050 | 2,375 | 2,398 | 2,398 | — | 50 | 50 | — | 7,977 | 5,602 | 2,375 |
| 1945 (Jan.-May) | 5,960 | 1,539 | 4,421 | 157 | 157 | — | 20 | 20 | — | 5,783 | 1,362 | 4,421 |
| *Monthly* | | | | | | | | | | | | |
| 1942 | | | | | | | | | | | | |
| Aug. | 3 | 3 | — | 2 | 2 | — | — | — | — | 1 | 1 | — |
| Sept. | 16 | 16 | — | 16 | 16 | — | — | — | — | — | — | — |
| Oct. | 49 | 49 | — | 44 | 44 | — | — | — | — | 5 | 5 | — |
| Nov. | 47 | 47 | — | 47 | 47 | — | — | — | — | — | — | — |
| Dec. | 54 | 54 | — | 53 | 53 | — | — | — | — | 1 | 1 | — |
| 1943 | | | | | | | | | | | | |
| Jan. | 50 | 50 | — | 45 | 45 | — | — | — | — | 5 | 5 | — |
| Feb. | 74 | 74 | — | 72 | 72 | — | — | — | — | 2 | 2 | — |
| Mar. | 142 | 142 | — | 142 | 142 | — | — | — | — | — | — | — |
| April | 150 | 150 | — | 146 | 146 | — | — | — | — | 4 | 4 | — |
| May | 380 | 380 | — | 372 | 372 | — | — | — | — | 8 | 8 | — |
| June | 311 | 311 | — | 293 | 293 | — | — | — | — | 18 | 18 | — |
| July | 575 | 575 | — | 527 | 527 | — | 6 | 6 | — | 42 | 42 | — |
| Aug. | 457 | 457 | — | 401 | 401 | — | 3 | 3 | — | 53 | 53 | — |
| Sept. | 303 | 303 | — | 255 | 255 | — | 10 | 10 | — | 38 | 38 | — |
| Oct. | 870 | 870 | — | 791 | 791 | — | 3 | 3 | — | 76 | 76 | — |
| Nov. | 222 | 222 | — | 106 | 106 | — | 11 | 11 | — | 105 | 105 | — |
| Dec. | 331 | 331 | — | 231 | 231 | — | — | — | — | 100 | 100 | — |
| 1944 | | | | | | | | | | | | |
| Jan. | 795 | 795 | — | 582 | 582 | — | 10 | 10 | — | 203 | 203 | — |
| Feb. | 741 | 740 | 1 | 397 | 397 | — | 2 | 2 | — | 342 | 341 | 1 |
| Mar. | 910 | 834 | 76 | 363 | 363 | — | 2 | 2 | — | 545 | 469 | 76 |
| April | 1,291 | 764 | 527 | 346 | 346 | — | — | — | — | 945 | 418 | 527 |
| May | 1,220 | 978 | 242 | 380 | 380 | — | 2 | 2 | — | 838 | 596 | 242 |
| June | 663 | 515 | 148 | 42 | 42 | — | 3 | 3 | — | 618 | 470 | 148 |
| July | 661 | 508 | 153 | 98 | 98 | — | 3 | 3 | — | 560 | 407 | 153 |
| Aug. | 1,013 | 576 | 437 | 23 | 23 | — | 2 | 2 | — | 988 | 551 | 437 |
| Sept. | 1,091 | 651 | 440 | 65 | 65 | — | — | — | — | 1,026 | 586 | 440 |
| Oct. | 353 | 214 | 139 | 12 | 12 | — | — | — | — | 341 | 202 | 139 |
| Nov. | 702 | 521 | 181 | 29 | 29 | — | — | — | — | 673 | 492 | 181 |
| Dec. | 985 | 954 | 31 | 61 | 61 | — | 26 | 26 | — | 898 | 867 | 31 |
| 1945 | | | | | | | | | | | | |
| Jan. | 465 | 376 | 87 | 41 | 41 | — | — | — | — | 424 | 337 | 87 |
| Feb. | 460 | 165 | 295 | 1 | 1 | — | 1 | 1 | — | 458 | 163 | 295 |
| Mar. | 750 | 429 | 321 | 23 | 23 | — | 11 | 11 | — | 716 | 395 | 321 |
| April | 4,257 | 554 | 3,703 | 92 | 92 | — | 8 | 8 | — | 4,157 | 454 | 3,703 |
| May | 28 | 13 | 15 | — | — | — | — | — | — | 28 | 13 | 15 |

## ENEMY AIRCRAFT DESTROYED BY U. S. ARMY AIR FORCES BY TYPE OF AAF PLANE

### Mediterranean Theater of Operations

July 1942 to May 1945

Source: U. S. Army Air Forces Office of Statistical Control

| Year and Month | By All Types | | | By Heavy Bombers | | | By Medium and Light Bombers | | | By Fighters | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | In the Air | On the Ground | Total | In the Air | On the Ground | Total | In the Air | On the Ground | Total | In the Air | On the Ground |
| Grand Total | 9,497[1] | 7,003[1] | 2,494[1] | 3,948 | 3,178 | 770 | 816 | 510 | 306 | 4,664 | 3,300 | 1,364 |
| *Annually* | | | | | | | | | | | | |
| 1942 (July-Dec.) | 158 | 123 | 35 | 42 | 36 | 6 | 24 | 6 | 18 | 92 | 81 | 11 |
| 1943 | 3,740 | 2,968 | 772 | 1,549 | 1,244 | 305 | 732 | 454 | 278 | 1,459 | 1,270 | 189 |
| 1944 | 5,239 | 3,693 | 1,546 | 2,340 | 1,889 | 451 | 54 | 44 | 10 | 2,845 | 1,760 | 1,085 |
| 1945 (Jan.-May) | 291 | 204 | 87 | 17 | 9 | 8 | 6 | 6 | — | 268 | 189 | 79 |
| *Monthly* | | | | | | | | | | | | |
| 1942 | | | | | | | | | | | | |
| July | 2 | 2 | — | 2 | 2 | — | — | — | — | — | — | — |
| Aug. | — | — | — | — | — | — | — | — | — | — | — | — |
| Sept. | 1 | 1 | — | 1 | 1 | — | — | — | — | — | — | — |
| Oct. | 43 | 33 | 10 | 8 | 8 | — | 13 | 3 | 10 | 22 | 22 | — |
| Nov. | 36 | 22 | 14 | 11 | 6 | 5 | — | — | — | 25 | 16 | 9 |
| Dec. | 76 | 65 | 11 | 20 | 19 | 1 | 11 | 3 | 8 | 45 | 43 | 2 |
| 1943 | | | | | | | | | | | | |
| Jan. | 194 | 163 | 31 | 74 | 74 | — | 63 | 33 | 30 | 57 | 56 | 1 |
| Feb. | 143 | 137 | 6 | 47 | 47 | — | 39 | 33 | 6 | 57 | 57 | — |
| Mar. | 211 | 187 | 24 | 75 | 63 | 12 | 33 | 21 | 12 | 103 | 103 | — |
| April | 523 | 421 | 102 | 175 | 75 | 100 | 29 | 27 | 2 | 319 | 319 | — |
| May | 350 | 269 | 81 | 114 | 107 | 7 | 71 | 30 | 41 | 165 | 132 | 33 |
| June | 267 | 233 | 34 | 98 | 81 | 17 | 42 | 37 | 5 | 127 | 115 | 12 |
| July | 313 | 250 | 63 | 138 | 89 | 49 | 50 | 36 | 14 | 125 | 125 | — |
| Aug. | 602 | 539 | 63 | 308 | 308 | — | 114 | 114 | — | 180 | 117 | 63 |
| Sept. | 483 | 314 | 169 | 166 | 124 | 42 | 178 | 88 | 90 | 139 | 102 | 37 |
| Oct. | 290 | 170 | 120 | 117 | 64 | 53 | 67 | 25 | 42 | 106 | 81 | 25 |
| Nov. | 175 | 114 | 61 | 106 | 84 | 22 | 42 | 9 | 33 | 27 | 21 | 6 |
| Dec. | 189 | 171 | 18 | 131 | 128 | 3 | 4 | 1 | 3 | 54 | 42 | 12 |
| 1944 | | | | | | | | | | | | |
| Jan. | 320 | 320 | — | 135 | 135 | — | 15 | 15 | — | 170 | 170 | — |
| Feb. | 377 | 355 | 22 | 249 | 230 | 19 | 14 | 14 | — | 114 | 111 | 3 |
| Mar. | 307 | 210 | 97 | 179 | 105 | 74 | 8 | 2 | 6 | 120 | 103 | 17 |
| April | 958 | 653 | 305 | 631 | 429 | 202 | — | — | — | 327 | 224 | 103 |
| May | 532 | 432 | 100 | 280 | 242 | 38 | — | — | — | 252 | 190 | 62 |
| June | 562 | 511 | 51 | 246 | 226 | 20 | — | — | — | 316 | 285 | 31 |
| July | 872 | 713 | 159 | 375 | 336 | 39 | 1 | 1 | — | 496 | 376 | 120 |
| Aug. | 598 | 273 | 325 | 166 | 122 | 44 | 4 | — | 4 | 428 | 151 | 277 |
| Sept. | 251 | 31 | 220 | 18 | 13 | 5 | — | — | — | 233 | 18 | 215 |
| Oct. | 259 | 62 | 197 | — | — | — | 2 | 2 | — | 257 | 60 | 197 |
| Nov. | 86 | 44 | 42 | 13 | 3 | 10 | 7 | 7 | — | 66 | 34 | 32 |
| Dec. | 117 | 89 | 28 | 48 | 48 | — | 3 | 3 | — | 66 | 38 | 28 |
| 1945 | | | | | | | | | | | | |
| Jan. | 8 | 8 | — | — | — | — | — | — | — | 8 | 8 | — |
| Feb. | 28 | 9 | 19 | — | — | — | 1 | 1 | — | 27 | 8 | 19 |
| Mar. | 145 | 119 | 26 | 17 | 9 | 8 | 5 | 5 | — | 123 | 105 | 18 |
| April | 110 | 68 | 42 | — | — | — | — | — | — | 110 | 68 | 42 |
| May | — | — | — | — | — | — | — | — | — | — | — | — |

[1] Includes 69 enemy aircraft destroyed, 15 in the air and 54 on the ground, by unidentified AAF airplanes.

## ENEMY AIRCRAFT DESTROYED BY U. S. ARMY AIR FORCES BY TYPE OF AAF PLANE

### Far East Air Forces

February 1942 to August 1945

Source: U. S. Army Air Forces Office of Statistical Control

| Year and Month | By All Types | | | By Heavy Bombers | | | By Medium and Light Bombers | | | By Fighters | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | In the Air | On the Ground | Total | In the Air | On the Ground | Total | In the Air | On the Ground | Total | In the Air | On the Ground |
| Grand Total | 6,298[1] | 4,502[1] | 1,796[1] | 1,964 | 1,344 | 620 | 946 | 231 | 715 | 3,008 | 2,709 | 299 |
| *Annually* | | | | | | | | | | | | |
| 1942 (Feb.-Dec.) | 518 | 439 | 79 | 231 | 205 | 26 | 75 | 44 | 31 | 212 | 190 | 22 |
| 1943 | 2,466 | 1,927 | 539 | 636 | 547 | 89 | 575 | 147 | 428 | 1,255 | 1,233 | 22 |
| 1944 | 2,518 | 1,729 | 789 | 993 | 580 | 413 | 251 | 29 | 222 | 1,274 | 1,120 | 154 |
| 1945 (Jan.-Aug.) | 416 | 189 | 227 | 104 | 12 | 92 | 45 | 11 | 34 | 267 | 166 | 101 |
| *Monthly* | | | | | | | | | | | | |
| 1942 | | | | | | | | | | | | |
| Feb. | 27 | 27 | — | 7 | 7 | — | — | — | — | 20 | 20 | — |
| Mar. | 25 | 19 | 6 | 11 | 7 | 4 | — | — | — | 14 | 12 | 2 |
| April | 18 | 9 | 9 | — | — | — | 4 | — | 4 | 14 | 9 | 5 |
| May | 36 | 29 | 7 | — | — | — | 22 | 15 | 7 | 14 | 14 | — |
| June | 33 | 30 | 3 | 5 | 2 | 3 | 8 | 8 | — | 20 | 20 | — |
| July | 18 | 18 | — | 12 | 12 | — | 2 | 2 | — | 4 | 4 | — |
| Aug. | 75 | 58 | 17 | 31 | 29 | 2 | 3 | 3 | — | 41 | 26 | 15 |
| Sept. | 48 | 29 | 19 | 31 | 29 | 2 | 17 | — | 17 | — | — | — |
| Oct. | 46 | 34 | 12 | 36 | 26 | 10 | 4 | 2 | 2 | 6 | 6 | — |
| Nov. | 76 | 76 | — | 38 | 38 | — | 13 | 13 | — | 25 | 25 | — |
| Dec. | 116 | 110 | 6 | 60 | 55 | 5 | 2 | 1 | 1 | 54 | 54 | — |
| 1943 | | | | | | | | | | | | |
| Jan. | 101 | 96 | 5 | 57 | 55 | 2 | 3 | — | 3 | 41 | 41 | — |
| Feb. | 72 | 67 | 5 | 26 | 23 | 3 | 2 | — | 2 | 44 | 44 | — |
| Mar. | 86 | 86 | — | 48 | 48 | — | — | — | — | 38 | 38 | — |
| April | 50 | 44 | 6 | 23 | 23 | — | 7 | 1 | 6 | 20 | 20 | — |
| May | 35 | 31 | 4 | 22 | 20 | 2 | 2 | — | 2 | 11 | 11 | — |
| June | 108 | 106 | 2 | 21 | 21 | — | 1 | — | 1 | 86 | 85 | 1 |
| July | 120 | 118 | 2 | 13 | 12 | 1 | 3 | 2 | 1 | 104 | 104 | — |
| Aug. | 416 | 241 | 175 | 117 | 95 | 22 | 169 | 16 | 153 | 130 | 130 | — |
| Sept. | 247 | 247 | — | 79 | 79 | — | 14 | 14 | — | 154 | 154 | — |
| Oct. | 676 | 414 | 262 | 146 | 105 | 41 | 284 | 75 | 209 | 246 | 234 | 12 |
| Nov. | 291 | 217 | 74 | 47 | 30 | 17 | 78 | 30 | 48 | 166 | 157 | 9 |
| Dec. | 264 | 260 | 4 | 37 | 36 | 1 | 12 | 9 | 3 | 215 | 215 | — |
| 1944 | | | | | | | | | | | | |
| Jan. | 192 | 166 | 26 | 78 | 68 | 10 | 12 | 1 | 11 | 102 | 97 | 5 |
| Feb. | 210 | 78 | 132 | 64 | 14 | 50 | 73 | 3 | 70 | 73 | 61 | 12 |
| Mar. | 306 | 175 | 131 | 200 | 74 | 126 | 4 | 3 | 1 | 102 | 98 | 4 |
| April | 214 | 123 | 91 | 122 | 90 | 32 | 59 | — | 59 | 33 | 33 | — |
| May | 91 | 52 | 39 | 32 | 22 | 10 | 24 | — | 24 | 35 | 30 | 5 |
| June | 237 | 184 | 53 | 139 | 109 | 30 | 33 | 14 | 19 | 65 | 61 | 4 |
| July | 82 | 77 | 5 | 57 | 57 | — | 5 | — | 5 | 20 | 20 | — |
| Aug. | 68 | 19 | 49 | 24 | 2 | 22 | 21 | 2 | 19 | 23 | 15 | 8 |
| Sept. | 71 | 33 | 38 | 50 | 17 | 33 | 8 | 4 | 4 | 13 | 12 | 1 |
| Oct. | 190 | 163 | 27 | 100 | 86 | 14 | 2 | 1 | 1 | 88 | 76 | 12 |
| Nov. | 421 | 306 | 115 | 74 | 29 | 45 | 8 | 1 | 7 | 339 | 276 | 63 |
| Dec. | 436 | 353 | 83 | 53 | 12 | 41 | 2 | — | 2 | 381 | 341 | 40 |
| 1945 | | | | | | | | | | | | |
| Jan. | 161 | 60 | 101 | 19 | 2 | 17 | 27 | — | 27 | 115 | 58 | 57 |
| Feb. | 57 | 21 | 36 | 19 | — | 19 | — | — | — | 38 | 21 | 17 |
| Mar. | 67 | 48 | 19 | 8 | — | 8 | 17 | 10 | 7 | 42 | 38 | 4 |
| April | 59 | 16 | 43 | 30 | 5 | 25 | — | — | — | 29 | 11 | 18 |
| May | 14 | 7 | 7 | 7 | 3 | 4 | 1 | 1 | — | 6 | 3 | 3 |
| June | 8 | 5 | 3 | 5 | 2 | 3 | — | — | — | 3 | 3 | — |
| July | 11 | 9 | 2 | 2 | — | 2 | — | — | — | 9 | 9 | — |
| Aug. | 39 | 23 | 16 | 14 | — | 14 | — | — | — | 25 | 23 | 2 |

[1] Includes 380 enemy aircraft destroyed, 218 in the air and 162 on the ground, by unidentified AAF Airplanes.

## ENEMY AIRCRAFT DESTROYED BY U. S. ARMY AIR FORCES BY TYPE OF AAF PLANE

### China and India-Burma

July 1942 to August 1945

Source: U. S. Army Air Forces Office of Statistical Control

| Year and Month | By All Types | | | By Heavy Bombers | | | By Medium and Light Bombers | | | By Fighters | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | In the Air | On the Ground | Total | In the Air | On the Ground | Total | In the Air | On the Ground | Total | In the Air | On the Ground |
| Grand Total | 1,913[1] | 1,202[1] | 711[1] | 299 | 283 | 16 | 56 | 46 | 10 | 1,467 | 847 | 620 |
| *Annually* | | | | | | | | | | | | |
| 1942 (July-Dec.) | 53 | 53 | — | — | — | — | 1 | 1 | — | 52 | 52 | — |
| 1943 | 636 | 582 | 54 | 280 | 264 | 16 | 31 | 30 | 1 | 325 | 288 | 37 |
| 1944 | 772 | 452 | 320 | 19 | 19 | — | 24 | 15 | 9 | 729 | 418 | 311 |
| 1945 (Jan.-Aug.) | 361 | 89 | 272 | — | — | — | — | — | — | 361 | 89 | 272 |
| *Monthly* | | | | | | | | | | | | |
| 1942 | | | | | | | | | | | | |
| July | 13 | 13 | — | — | — | — | — | — | — | 13 | 13 | — |
| Aug. | 3 | 3 | — | — | — | — | — | — | — | 3 | 3 | — |
| Sept. | 5 | 5 | — | — | — | — | — | — | — | 5 | 5 | — |
| Oct. | 16 | 16 | — | — | — | — | — | — | — | 16 | 16 | — |
| Nov. | 3 | 3 | — | — | — | — | — | — | — | 3 | 3 | — |
| Dec. | 13 | 13 | — | — | — | — | 1 | 1 | — | 12 | 12 | — |
| 1943 | | | | | | | | | | | | |
| Jan. | 8 | 8 | — | — | — | — | — | — | — | 8 | 8 | — |
| Feb. | 26 | 11 | 15 | 5 | 2 | 3 | — | — | — | 21 | 9 | 12 |
| Mar. | 9 | 8 | 1 | 9 | 8 | 1 | — | — | — | — | — | — |
| April | 17 | 17 | — | — | — | — | — | — | — | 17 | 17 | — |
| May | 81 | 67 | 14 | 37 | 25 | 12 | 7 | 7 | — | 37 | 35 | 2 |
| June | 11 | 11 | — | — | — | — | — | — | — | 11 | 11 | — |
| July | 55 | 55 | — | 15 | 15 | — | 5 | 5 | — | 35 | 35 | — |
| Aug. | 86 | 86 | — | 62 | 62 | — | 3 | 3 | — | 21 | 21 | — |
| Sept. | 62 | 61 | 1 | 13 | 13 | — | 13 | 13 | — | 36 | 35 | 1 |
| Oct. | 65 | 63 | 2 | 55 | 55 | — | 1 | — | 1 | 9 | 8 | 1 |
| Nov. | 72 | 65 | 7 | 40 | 40 | — | 2 | 2 | — | 30 | 23 | 7 |
| Dec. | 144 | 130 | 14 | 44 | 44 | — | — | — | — | 100 | 86 | 14 |
| 1944 | | | | | | | | | | | | |
| Jan. | 6 | 6 | — | — | — | — | — | — | — | 6 | 6 | — |
| Feb. | 12 | 12 | — | — | — | — | — | — | — | 12 | 12 | — |
| Mar. | 102 | 55 | 47 | 2 | 2 | — | 10 | 1 | 9 | 90 | 52 | 38 |
| April | 101 | 32 | 69 | 3 | 3 | — | 6 | 6 | — | 92 | 23 | 69 |
| May | 77 | 64 | 13 | — | — | — | 2 | 2 | — | 75 | 62 | 13 |
| June | 20 | 19 | 1 | — | — | — | — | — | — | 20 | 19 | 1 |
| July | 55 | 49 | 6 | 2 | 2 | — | 3 | 3 | — | 50 | 44 | 6 |
| Aug. | 46 | 41 | 5 | 11 | 11 | — | — | — | — | 35 | 30 | 5 |
| Sept. | 37 | 23 | 14 | — | — | — | — | — | — | 37 | 23 | 14 |
| Oct. | 53 | 27 | 26 | 1 | 1 | — | 3 | 3 | — | 49 | 23 | 26 |
| Nov. | 52 | 31 | 21 | — | — | — | — | — | — | 52 | 31 | 21 |
| Dec. | 211 | 93 | 118 | — | — | — | — | — | — | 211 | 93 | 118 |
| 1945 | | | | | | | | | | | | |
| Jan. | 217 | 56 | 161 | — | — | — | — | — | — | 217 | 56 | 161 |
| Feb. | 56 | 15 | 41 | — | — | — | — | — | — | 56 | 15 | 41 |
| Mar. | 44 | 13 | 31 | — | — | — | — | — | — | 44 | 13 | 31 |
| April | 37 | 2 | 35 | — | — | — | — | — | — | 37 | 2 | 35 |
| May | 1 | 1 | — | — | — | — | — | — | — | 1 | 1 | — |
| June | 5 | 1 | 4 | — | — | — | — | — | — | 5 | 1 | 4 |
| July | 1 | 1 | — | — | — | — | — | — | — | 1 | 1 | — |
| Aug. | — | — | — | — | — | — | — | — | — | — | — | — |

[1] Includes 91 enemy aircraft destroyed, 26 in the air and 65 on the ground, by unidentified AAF airplanes.

## ENEMY AIRCRAFT DESTROYED BY U. S. ARMY AIR FORCES BY TYPE OF AAF PLANE

### Pacific Ocean Areas

July 1943 to August 1945

Source: U. S. Army Air Forces Office of Statistical Control

| Year and Month | By All Types | | | By Heavy Bombers | | | By Medium and Light Bombers | | | By Fighters | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | In the Air | On the Ground | Total | In the Air | On the Ground | Total | In the Air | On the Ground | Total | In the Air | On the Ground |
| Grand Total.. | 794 | 575 | 219 | 267 | 183 | 84 | 26 | 22 | 4 | 501 | 370 | 131 |
| *Annually* | | | | | | | | | | | | |
| 1943, (July-Dec.)... | 96 | 87 | 9 | 81 | 81 | — | — | — | — | 15 | 6 | 9 |
| 1944.......... | 226 | 150 | 76 | 163 | 90 | 73 | 22 | 22 | — | 41 | 38 | 3 |
| 1945 (Jan.-Aug.)... | 472 | 338 | 134 | 23 | 12 | 11 | 4 | — | 4 | 445 | 326 | 119 |
| *Monthly* | | | | | | | | | | | | |
| 1943 | | | | | | | | | | | | |
| July........ | 18 | 18 | — | 18 | 18 | — | — | — | — | — | — | — |
| Aug.......... | — | — | — | — | — | — | — | — | — | — | — | — |
| Sept......... | 8 | 8 | — | 8 | 8 | — | — | — | — | — | — | — |
| Oct.......... | 1 | 1 | — | — | — | — | — | — | — | 1 | 1 | — |
| Nov.......... | 18 | 18 | — | 18 | 18 | — | — | — | — | — | — | — |
| Dec.......... | 51 | 42 | 9 | 37 | 37 | — | — | — | — | 14 | 5 | 9 |
| 1944 | | | | | | | | | | | | |
| Jan.......... | 56 | 46 | 10 | 26 | 16 | 10 | 18 | 18 | — | 12 | 12 | — |
| Feb.......... | — | — | — | — | — | — | — | — | — | — | — | — |
| Mar.......... | 4 | 4 | — | — | — | — | 4 | 4 | — | — | — | — |
| April........ | 2 | 2 | — | 2 | 2 | — | — | — | — | — | — | — |
| May.......... | 4 | 4 | — | 4 | 4 | — | — | — | — | — | — | — |
| June......... | 7 | 6 | 1 | 5 | 5 | — | — | — | — | 2 | 1 | 1 |
| July......... | 19 | 19 | — | 17 | 17 | — | — | — | — | 2 | 2 | — |
| Aug.......... | 19 | 17 | 2 | 19 | 17 | 2 | — | — | — | — | — | — |
| Sept......... | 12 | 12 | — | 12 | 12 | — | — | — | — | — | — | — |
| Oct.......... | 8 | 8 | — | 7 | 7 | — | — | — | — | 1 | 1 | — |
| Nov.......... | 14 | 13 | 1 | 2 | 1 | 1 | — | — | — | 12 | 12 | — |
| Dec.......... | 81 | 19 | 62 | 69 | 9 | 60 | — | — | — | 12 | 10 | 2 |
| 1945 | | | | | | | | | | | | |
| Jan.......... | 7 | 7 | — | 4 | 4 | — | — | — | — | 3 | 3 | — |
| Feb.......... | 7 | 7 | — | 2 | 2 | — | — | — | — | 5 | 5 | — |
| Mar.......... | 2 | 2 | — | — | — | — | — | — | — | 2 | 2 | — |
| April........ | 94 | 71 | 23 | — | — | — | — | — | — | 94 | 71 | 23 |
| May.......... | 92 | 88 | 4 | 1 | — | 1 | — | — | — | 91 | 88 | 3 |
| June......... | 141 | 113 | 28 | — | — | — | — | — | — | 141 | 113 | 28 |
| July......... | 112 | 47 | 65 | 3 | 3 | — | — | — | — | 109 | 44 | 65 |
| Aug.......... | 17 | 3 | 14 | 13 | 3 | 10 | 4 | — | 4 | — | — | — |

## ENEMY AIRCRAFT DESTROYED BY U. S. ARMY AIR FORCES BY TYPE OF AAF PLANE

### Alaska

June 1942 to August 1945

Source: U. S. Army Air Forces Office of Statistical Control

| Year and Month | By All Types | | | By Heavy Bombers | | | By Medium and Light Bombers | | | By Fighters | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | In the Air | On the Ground | Total | In the Air | On the Ground | Total | In the Air | On the Ground | Total | In the Air | On the Ground |
| Grand Total | 113[1] | 89[1] | 24[1] | 29 | 29 | — | 9 | 9 | — | 47 | 34 | 13 |
| *Annually* | | | | | | | | | | | | |
| 1942 (June-Dec.) | 37 | 25 | 12 | 4 | 4 | — | — | — | — | 33 | 21 | 12 |
| 1943 | 34 | 33 | 1 | 18 | 18 | — | 2 | 2 | — | 14 | 13 | 1 |
| 1944 | 8 | 8 | — | 3 | 3 | — | 5 | 5 | — | — | — | — |
| 1945 (Jan.-Aug.) | 6 | 6 | — | 4 | 4 | — | 2 | 2 | — | — | — | — |
| *Monthly* | | | | | | | | | | | | |
| 1942 | | | | | | | | | | | | |
| June | 8 | 8 | — | — | — | — | — | — | — | 8 | 8 | — |
| July | — | — | — | — | — | — | — | — | — | — | — | — |
| Aug. | 2 | 2 | — | — | — | — | — | — | — | 2 | 2 | — |
| Sept. | 5 | 4 | 1 | 3 | 3 | — | — | — | — | 2 | 1 | 1 |
| Oct. | 13 | 10 | 3 | 1 | 1 | — | — | — | — | 12 | 9 | 3 |
| Nov. | 8 | — | 8 | — | — | — | — | — | — | 8 | — | 8 |
| Dec. | 1 | 1 | — | — | — | — | — | — | — | 1 | 1 | — |
| 1943 | | | | | | | | | | | | |
| Jan. | — | — | — | — | — | — | — | — | — | — | — | — |
| Feb. | 7 | 7 | — | — | — | — | 1 | 1 | — | 6 | 6 | — |
| Mar. | 2 | 2 | — | — | — | — | — | — | — | 2 | 2 | — |
| April | — | — | — | — | — | — | — | — | — | — | — | — |
| May | 6 | 5 | 1 | — | — | — | — | — | — | 6 | 5 | 1 |
| June | — | — | — | — | — | — | — | — | — | — | — | — |
| July | — | — | — | — | — | — | — | — | — | — | — | — |
| Aug. | 6 | 6 | — | 6 | 6 | — | — | — | — | — | — | — |
| Sept. | 13 | 13 | — | 12 | 12 | — | 1 | 1 | — | — | — | — |
| Oct. | — | — | — | — | — | — | — | — | — | — | — | — |
| Nov. | — | — | — | — | — | — | — | — | — | — | — | — |
| Dec. | — | — | — | — | — | — | — | — | — | — | — | — |
| 1944 | | | | | | | | | | | | |
| Jan. | — | — | — | — | — | — | — | — | — | — | — | — |
| Feb. | — | — | — | — | — | — | — | — | — | — | — | — |
| Mar. | — | — | — | — | — | — | — | — | — | — | — | — |
| April | — | — | — | — | — | — | — | — | — | — | — | — |
| May | — | — | — | — | — | — | — | — | — | — | — | — |
| June | — | — | — | — | — | — | — | — | — | — | — | — |
| July | — | — | — | — | — | — | — | — | — | — | — | — |
| Aug. | 1 | 1 | — | 1 | 1 | — | — | — | — | — | — | — |
| Sept. | 1 | 1 | — | 1 | 1 | — | — | — | — | — | — | — |
| Oct. | 2 | 2 | — | — | — | — | 2 | 2 | — | — | — | — |
| Nov. | 4 | 4 | — | 1 | 1 | — | 3 | 3 | — | — | — | — |
| Dec. | — | — | — | — | — | — | — | — | — | — | — | — |
| 1945 | | | | | | | | | | | | |
| Jan. | 5 | 5 | — | 3 | 3 | — | 2 | 2 | — | — | — | — |
| Feb. | — | — | — | — | — | — | — | — | — | — | — | — |
| Mar. | — | — | — | — | — | — | — | — | — | — | — | — |
| April | — | — | — | — | — | — | — | — | — | — | — | — |
| May | — | — | — | — | — | — | — | — | — | — | — | — |
| June | 1 | 1 | — | 1 | 1 | — | — | — | — | — | — | — |
| July | — | — | — | — | — | — | — | — | — | — | — | — |
| Aug. | — | — | — | — | — | — | — | — | — | — | — | — |

[1]Includes 28 enemy aircraft destroyed, 17 in the air and 11 on the ground, by unidentified AAF airplanes.

## ENEMY AIRCRAFT DESTROYED BY 20th AIR FORCE

## U. S. ARMY AIR FORCES

## BY TYPE OF AAF PLANE

August 1944 to August 1945

Source: U. S. Army Air Forces Office of Statistical Control

| Year and Month | By All Types | | | By Very Heavy Bombers | | | | | | By Fighters | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | XX Bomber Command | | | XXI Bomber Command | | | | | |
| | Total | In the Air | On the Ground | Total | In the Air | On the Ground | Total | In the Air | On the Ground | Total | In the Air | On the Ground |
| Grand Total | 1,225 | 994 | 231 | 213 | 158 | 55 | 915 | 756 | 159 | 97 | 80 | 17 |
| *Annually* | | | | | | | | | | | | |
| 1944 (Aug.-Dec.) | 254 | 199 | 55 | 198 | 143 | 55 | 56 | 56 | — | — | — | — |
| 1945 (Jan.-Aug.) | 971 | 795 | 176 | 15 | 15 | — | 859 | 700 | 159 | 97 | 80 | 17 |
| *Monthly* | | | | | | | | | | | | |
| 1944 | | | | | | | | | | | | |
| Aug. | 18 | 18 | — | 18 | 18 | — | — | — | — | — | — | — |
| Sept. | 19 | 19 | — | 19 | 19 | — | — | — | — | — | — | — |
| Oct. | 76 | 21 | 55 | 76 | 21 | 55 | — | — | — | — | — | — |
| Nov. | 44 | 44 | — | 37 | 37 | — | 7 | 7 | — | — | — | — |
| Dec. | 97 | 97 | — | 48 | 48 | — | 49 | 49 | — | — | — | — |
| 1945 | | | | | | | | | | | | |
| Jan. | 151 | 150 | 1 | 10 | 10 | — | 141 | 140 | 1 | — | — | — |
| Feb. | 75 | 75 | — | 4 | 4 | — | 71 | 71 | — | — | — | — |
| Mar. | 16 | 16 | — | 1 | 1 | — | 15 | 15 | — | — | — | — |
| April | 321 | 202 | 119 | — | — | — | 321 | 202 | 119 | — | — | — |
| May | 170 | 131 | 39 | — | — | — | 170 | 131 | 39 | — | — | — |
| June | 136 | 136 | — | — | — | — | 136 | 136 | — | — | — | — |
| July | 37 | 34 | 3 | — | — | — | 3 | 3 | — | 34 | 31 | 3 |
| Aug. | 65 | 51 | 14 | — | — | — | 2 | 2 | — | 63 | 49 | 14 |

## BATTLE CASUALTIES OF U. S. ARMY AIR FORCES IN ALL OVERSEAS THEATERS

Source: U. S. Army Air Forces Office of Statistical Control

| Year and Month | Total Personnel | | | | Officers | | | | Enlisted Personnel | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total Casualties | Died | Wounded and Evacuated | Missing, Interned and Captured | Total Casualties | Died | Wounded and Evacuated | Missing, Interned and Captured | Total Casualties | Died | Wounded and Evacuated | Missing, Interned and Captured |
| Grand Total | 121,867[1] | 40,061 | 18,238 | 63,568 | 50,415 | 17,021 | 6,442 | 26,952 | 71,452 | 23,040 | 11,796 | 36,616 |
| *Annually* | | | | | | | | | | | | |
| 1941 (Dec.) | 728 | 315 | 401 | 12 | 79 | 49 | 29 | 1 | 649 | 266 | 372 | 11 |
| 1942 | 8,788 | 3,477 | 469 | 4,842 | 1,840 | 987 | 149 | 704 | 6,948 | 2,490 | 320 | 4,138 |
| 1943 | 22,512 | 10,002 | 4,181 | 8,329 | 8,881 | 3,999 | 1,213 | 3,669 | 13,631 | 6,003 | 2,968 | 4,660 |
| 1944 | 68,617 | 21,072 | 9,957 | 37,588 | 29,790 | 9,481 | 3,705 | 16,604 | 38,827 | 11,591 | 6,252 | 20,984 |
| 1945 (Jan.-Aug.) | 19,560 | 4,600 | 3,046 | 11,914 | 9,325 | 2,413 | 1,290 | 5,622 | 10,235 | 2,187 | 1,756 | 6,292 |
| Date unknown | 1,662 | 595 | 184 | 883 | 500 | 92 | 56 | 352 | 1,162 | 503 | 128 | 531 |
| *Monthly* | | | | | | | | | | | | |
| 1941 Dec. | 728 | 315 | 401 | 12 | 79 | 49 | 29 | 1 | 649 | 266 | 372 | 11 |
| 1942 Jan. | 192 | 125 | 53 | 14 | 76 | 62 | 8 | 6 | 116 | 63 | 45 | 8 |
| Feb. | 282 | 141 | 36 | 105 | 145 | 63 | 7 | 75 | 137 | 78 | 29 | 30 |
| Mar. | 77 | 60 | 10 | 7 | 35 | 30 | 3 | 2 | 42 | 30 | 7 | 5 |
| April | 119 | 96 | 5 | 18 | 78 | 66 | 1 | 11 | 41 | 30 | 4 | 7 |
| May | 6,136 | 1,926 | 16 | 4,194 | 482 | 113 | 9 | 360 | 5,654 | 1,813 | 7 | 3,834 |
| June | 176 | 127 | 18 | 31 | 90 | 74 | 7 | 9 | 86 | 53 | 11 | 22 |
| July | 176 | 126 | 12 | 38 | 108 | 77 | 3 | 28 | 68 | 49 | 9 | 10 |
| Aug. | 206 | 107 | 18 | 81 | 115 | 68 | 5 | 42 | 91 | 39 | 13 | 39 |
| Sept. | 229 | 111 | 43 | 75 | 110 | 61 | 13 | 36 | 119 | 50 | 30 | 39 |
| Oct. | 265 | 145 | 58 | 62 | 135 | 92 | 15 | 28 | 130 | 53 | 43 | 34 |
| Nov. | 407 | 207 | 98 | 102 | 204 | 119 | 32 | 53 | 203 | 88 | 66 | 49 |
| Dec. | 523 | 306 | 102 | 115 | 262 | 162 | 46 | 54 | 261 | 144 | 56 | 61 |

| Year and Month | | Total Personnel: Total Casualties | Total Personnel: Died | Total Personnel: Wounded and Evacuated | Total Personnel: Missing, Interned and Captured | Officers: Total Casualties | Officers: Died | Officers: Wounded and Evacuated | Officers: Missing, Interned and Captured | Enlisted Personnel: Total Casualties | Enlisted Personnel: Died | Enlisted Personnel: Wounded and Evacuated | Enlisted Personnel: Missing, Interned and Captured |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1943 | Jan. | 1,305 | 713 | 322 | 270 | 575 | 351 | 100 | 124 | 730 | 362 | 222 | 146 |
| | Feb. | 1,447 | 740 | 274 | 433 | 503 | 271 | 65 | 167 | 944 | 469 | 209 | 266 |
| | Mar. | 743 | 385 | 205 | 153 | 346 | 183 | 82 | 81 | 397 | 202 | 123 | 72 |
| | April | 973 | 451 | 220 | 302 | 442 | 206 | 71 | 165 | 531 | 245 | 149 | 137 |
| | May | 1,450 | 733 | 286 | 431 | 603 | 293 | 108 | 202 | 847 | 440 | 178 | 229 |
| | June | 1,358 | 617 | 229 | 512 | 567 | 248 | 71 | 248 | 791 | 369 | 158 | 264 |
| | July | 2,442 | 1,169 | 462 | 811 | 1,061 | 550 | 156 | 355 | 1,381 | 619 | 306 | 456 |
| | Aug. | 2,612 | 1,096 | 338 | 1,178 | 1,093 | 464 | 110 | 519 | 1,519 | 632 | 228 | 659 |
| | Sept. | 1,618 | 651 | 268 | 699 | 687 | 300 | 98 | 289 | 931 | 351 | 170 | 410 |
| | Oct. | 2,798 | 1,056 | 370 | 1,372 | 1,131 | 441 | 114 | 576 | 1,667 | 615 | 256 | 796 |
| | Nov. | 3,259 | 1,585 | 794 | 880 | 844 | 360 | 122 | 362 | 2,415 | 1,225 | 672 | 518 |
| | Dec. | 2,507 | 806 | 413 | 1,288 | 1,029 | 332 | 116 | 581 | 1,478 | 474 | 297 | 707 |
| 1944 | Jan. | 3,512 | 1,314 | 491 | 1,707 | 1,504 | 585 | 169 | 750 | 2,008 | 729 | 322 | 957 |
| | Feb. | 4,937 | 1,544 | 576 | 2,817 | 2,006 | 687 | 164 | 1,155 | 2,931 | 857 | 412 | 1,662 |
| | Mar. | 5,242 | 1,710 | 661 | 2,871 | 2,142 | 726 | 215 | 1,201 | 3,100 | 984 | 446 | 1,670 |
| | April | 7,777 | 2,426 | 861 | 4,490 | 3,074 | 878 | 309 | 1,887 | 4,703 | 1,548 | 552 | 2,603 |
| | May | 6,517 | 2,161 | 948 | 3,408 | 2,720 | 874 | 337 | 1,509 | 3,797 | 1,287 | 611 | 1,899 |
| | June | 7,165 | 2,613 | 1,157 | 3,395 | 3,362 | 1,290 | 534 | 1,538 | 3,803 | 1,323 | 623 | 1,857 |
| | July | 7,105 | 2,357 | 1,051 | 3,697 | 3,066 | 1,066 | 418 | 1,582 | 4,039 | 1,291 | 633 | 2,115 |
| | Aug. | 6,389 | 1,832 | 898 | 3,659 | 2,942 | 938 | 403 | 1,601 | 3,447 | 894 | 495 | 2,058 |
| | Sept. | 5,321 | 1,410 | 859 | 3,052 | 2,463 | 672 | 348 | 1,443 | 2,858 | 738 | 511 | 1,609 |
| | Oct. | 4,196 | 1,134 | 675 | 2,387 | 1,836 | 535 | 245 | 1,056 | 2,360 | 599 | 430 | 1,331 |
| | Nov. | 5,056 | 1,356 | 917 | 2,783 | 2,167 | 628 | 230 | 1,309 | 2,889 | 728 | 687 | 1,474 |
| | Dec. | 5,400 | 1,215 | 863 | 3,322 | 2,508 | 602 | 333 | 1,573 | 2,892 | 613 | 530 | 1,749 |
| 1945 | Jan. | 3,706 | 1,085 | 695 | 1,926 | 1,740 | 554 | 285 | 901 | 1,966 | 531 | 410 | 1,025 |
| | Feb. | 4,061 | 781 | 533 | 2,747 | 1,874 | 389 | 217 | 1,268 | 2,187 | 392 | 316 | 1,479 |
| | Mar. | 5,523 | 1,292 | 937 | 3,294 | 2,627 | 679 | 435 | 1,513 | 2,896 | 613 | 502 | 1,781 |
| | April | 3,550 | 825 | 477 | 2,248 | 1,682 | 443 | 184 | 1,055 | 1,868 | 382 | 293 | 1,193 |
| | May | 1,270 | 277 | 200 | 793 | 586 | 138 | 71 | 377 | 684 | 139 | 129 | 416 |
| | June | 786 | 181 | 115 | 490 | 416 | 99 | 53 | 264 | 370 | 82 | 62 | 226 |
| | July | 435 | 102 | 60 | 273 | 260 | 72 | 31 | 157 | 175 | 30 | 29 | 116 |
| | Aug. | 229 | 57 | 29 | 143 | 140 | 39 | 14 | 87 | 89 | 18 | 15 | 56 |

[1] Subject to revision as later information becomes available. Figures include personnel returned to duty after being wounded, missing or captured.

## RECIPIENTS OF U. S. MILITARY AIRPLANES FROM ALL FACTORY DELIVERIES

July 1940—August 1945

Source: U. S. Army Air Forces Office of Statistical Control

Includes experimental and U. S. financed Canadian production. Subsequent reallocations are not reflected.

| Type of Airplane and Recipient | Total | 1940 (July-Dec.) | 1941 | 1942 | 1943 | 1944 | 1945 (Jan.-Aug.) |
|---|---|---|---|---|---|---|---|
| Grand Total | 295,959 | 3,611 | 18,466 | 46,907 | 84,853 | 96,270 | 45,852 |
| Army Air Forces | 158,880 | 1,209 | 8,723 | 26,448 | 45,889 | 51,547 | 25,064 |
| U. S. Navy | 73,711 | 517 | 3,517 | 8,347 | 20,005 | 25,579 | 15,746 |
| Other U. S. | 3,714 | 71 | 114 | 23 | 1,484 | 2,012 | 10 |
| British Empire | 38,811 | 1,507 | 5,249 | 7,698 | 10,565 | 10,956 | 2,836 |
| Russia | 14,717 | 1 | 221 | 3,032 | 5,141 | 4,636 | 1,686 |
| China | 1,225 | 30 | 141 | 410 | 384 | 223 | 37 |
| Other Foreign | 4,901 | 276 | 501 | 949 | 1,385 | 1,317 | 473 |
| *Combat Airplanes—Total* | 200,443 | 1,771 | 8,395 | 24,669 | 53,183 | 74,564 | 37,861 |
| Army Air Forces | 99,487 | 256 | 2,772 | 11,235 | 27,108 | 38,648 | 19,468 |
| U. S. Navy | 56,695 | 208 | 1,463 | 4,443 | 13,502 | 22,489 | 14,590 |
| Other U. S. | 8 | — | — | 8 | — | — | — |
| British Empire | 27,152 | 1,160 | 3,618 | 5,537 | 6,759 | 8,051 | 2,027 |
| Russia | 13,929 | 1 | 221 | 3,002 | 4,966 | 4,386 | 1,353 |
| China | 829 | — | 71 | 222 | 360 | 176 | — |
| Other Foreign | 2,343 | 146 | 250 | 222 | 488 | 814 | 423 |
| *Very Heavy Bombers* | | | | | | | |
| Army Air Forces | 3,740 | — | — | 4 | 91 | 1,147 | 2,498 |
| *Heavy Bombers—Total* | 31,685 | 46 | 282 | 2,513 | 9,574 | 15,057 | 4,213 |
| Army Air Forces | 27,867 | 19 | 181 | 2,241 | 8,695 | 13,057 | 3,674 |
| U. S. Navy | 1,683 | 1 | 5 | 86 | 382 | 747 | 462 |
| British Empire | 2,135 | 26 | 96 | 186 | 497 | 1,253 | 77 |
| *Medium Bombers—Total* | 21,461 | 52 | 762 | 4,040 | 7,256 | 6,732 | 2,619 |
| Army Air Forces | 11,835 | 24 | 326 | 2,429 | 3,989 | 3,636 | 1,431 |
| U. S. Navy | 4,693 | 21 | 214 | 597 | 1,657 | 1,287 | 917 |
| Other U. S. | 8 | — | — | 8 | — | — | — |
| British Empire | 3,247 | 7 | 175 | 792 | 1,205 | 1,032 | 36 |
| Russia | 1,010 | — | 5 | 154 | 212 | 486 | 153 |
| China | 134 | — | — | — | 59 | 75 | — |
| Other Foreign | 534 | — | 42 | 60 | 134 | 216 | 82 |
| *Light Bombers—Total* | 39,986 | 453 | 2,617 | 5,954 | 11,848 | 12,376 | 6,738 |
| Army Air Forces | 7,779 | 16 | 373 | 1,153 | 2,247 | 2,276 | 1,714 |
| U. S. Navy | 20,703 | 65 | 404 | 1,410 | 5,791 | 8,202 | 4,831 |
| British Empire | 8,003 | 320 | 1,674 | 2,188 | 2,397 | 1,231 | 193 |
| Russia | 3,021 | — | 81 | 1,136 | 1,204 | 600 | — |
| China | 29 | — | 18 | 11 | — | — | — |
| Other Foreign | 451 | 52 | 67 | 56 | 209 | 67 | — |
| *Fighters—Total* | 99,465 | 1,157 | 4,036 | 10,721 | 23,621 | 38,848 | 21,082 |
| Army Air Forces | 47,050 | 187 | 1,727 | 5,213 | 11,766 | 18,291 | 9,866 |
| U. S. Navy | 27,163 | 68 | 340 | 1,259 | 5,449 | 12,090 | 7,957 |
| British Empire | 13,417 | 807 | 1,673 | 2,271 | 2,410 | 4,535 | 1,721 |
| Russia | 9,868 | 1 | 105 | 1,712 | 3,550 | 3,300 | 1,200 |
| China | 666 | — | 53 | 211 | 301 | 101 | — |
| Other Foreign | 1,301 | 94 | 138 | 55 | 145 | 531 | 338 |
| *Reconnaissance—Total* | 4,106 | 63 | 698 | 1,437 | 793 | 404 | 711 |
| Army Air Forces | 1,216 | 10 | 165 | 195 | 320 | 241 | 285 |
| U. S. Navy | 2,453 | 53 | 500 | 1,091 | 223 | 163 | 423 |
| British Empire | 350 | — | — | 100 | 250 | — | — |
| Russia | 30 | — | 30 | — | — | — | — |
| Other Foreign | 57 | — | 3 | 51 | — | — | 3 |
| *Transports—Total* | 23,900 | 164 | 525 | 1,887 | 6,913 | 9,925 | 4,486 |
| Army Air Forces | 15,769 | 5 | 133 | 1,264 | 5,072 | 6,430 | 2,865 |
| U. S. Navy | 2,702 | 23 | 155 | 290 | 535 | 1,215 | 484 |
| Other U. S. | 267 | 71 | 114 | 15 | 14 | 43 | 10 |
| British Empire | 3,789 | 25 | 65 | 197 | 922 | 1,808 | 772 |
| Russia | 703 | — | — | — | 175 | 250 | 278 |
| China | 119 | — | — | 31 | 24 | 27 | 37 |
| Other Foreign | 551 | 40 | 58 | 90 | 171 | 152 | 40 |
| *Trainers—Total* | 58,085 | 1,676 | 9,294 | 17,237 | 20,590 | 7,936 | 1,352 |
| Army Air Forces | 34,469 | 948 | 5,585 | 11,004 | 11,246 | 4,861 | 825 |
| U. S. Navy | 13,859 | 286 | 1,899 | 3,586 | 5,845 | 1,787 | 456 |
| Other U. S. | 3 | — | — | — | 2 | 1 | — |
| British Empire | 7,640 | 322 | 1,547 | 1,933 | 2,880 | 952 | 6 |
| Russia | 85 | — | — | 30 | — | — | 55 |
| China | 277 | 30 | 70 | 157 | — | 20 | — |
| Other Foreign | 1,752 | 90 | 193 | 527 | 617 | 315 | 10 |

## RECIPIENTS OF U. S. MILITARY AIRPLANES FROM ALL FACTORY DELIVERIES

### (Continued)

July 1940—August 1945

| Type of Airplane and Recipient | Total | 1940 (July-Dec.) | 1941 | 1942 | 1943 | 1944 | 1945 (Jan.-Aug.) |
|---|---|---|---|---|---|---|---|
| *Communications—Total* | 13,531 | — | 252 | 3,114 | 4,167 | 3,845 | 2,153 |
| Army Air Forces | 9,155 | — | 233 | 2,945 | 2,463 | 1,608 | 1,906 |
| U. S. Navy | 455 | — | — | 28 | 123 | 88 | 216 |
| Other U. S. | 3,436 | — | — | — | 1,468 | 1,968 | — |
| British Empire | 230 | — | 19 | 31 | 4 | 145 | 31 |
| Other Foreign | 255 | — | — | 110 | 109 | 36 | — |

## U. S. ARMY AIR FORCES GRADUATES FROM TECHNICAL TRAINING COURSES

July 1939—August 1945

Source: U. S. Army Air Forces Office of Statistical Control

| Course | Grand Total | 1939 (July-Dec.) | 1940 | 1941 | 1942 | 1943 | 1944 | 1945 (Jan.-Aug.) |
|---|---|---|---|---|---|---|---|---|
| Total | 1,436,744[1] | 1,588 | 14,375 | 43,028 | 286,411 | 615,628 | 311,330 | 164,384 |
| *Officers & Officer Candidates—Total* | 125,984 | — | — | 1,402 | 30,802 | 40,385 | 27,812 | 25,583 |
| Administrative | 52,780 | — | — | — | 24,856 | 21,959 | 5,079 | 886 |
| Armament | 5,266 | — | — | 356 | 1,425 | 1,678 | 823 | 984 |
| Cold Weather Flying | 84 | — | — | — | — | 34 | 25 | 25 |
| Communications | 12,172 | — | — | 237 | 1,582 | 3,869 | 5,450 | 1,034 |
| Cryptography | 942 | — | — | — | — | 294 | 361 | 287 |
| Emergency Rescue Boat | 13 | — | — | — | — | — | 13 | — |
| Engineering—Total | 31,630 | — | — | 571 | 1,828 | 6,980 | 8,808 | 13,443 |
| Engineering Maintenance Cadets | 5,812 | — | — | 571 | 888 | 2,521 | 1,783 | 49 |
| Engineering Officer Maintenance | 15,467 | — | — | — | 934 | 3,068 | 4,278 | 7,187 |
| Flight Engineer | 7,766 | — | — | — | — | 388 | 1,652 | 5,726 |
| Pre-Flight Engineer | 1,095 | — | — | — | — | — | 1,095 | — |
| Weight & Balance Control | 1,490 | — | — | — | 6 | 1,003 | — | 481 |
| Helicopter Training | 5 | — | — | — | — | — | — | 5 |
| Link Trainer | 236 | — | — | — | 12 | 84 | 99 | 41 |
| Navigator-Bombardier-Radar | 990 | — | — | — | — | — | 990 | — |
| Navigator-Instructor-Radar | 62 | — | — | — | — | — | 62 | — |
| Photography | 2,235 | — | — | 126 | 475 | 1,027 | 537 | 70 |
| Radar—Total | 13,569 | — | — | — | 54 | 662 | 4,248 | 8,605 |
| Air Radar | 580 | — | — | — | — | — | 226 | 354 |
| Air Radar (MIT) | 390 | — | — | — | — | 38 | 167 | 185 |
| Radar Air Intelligence | 712 | — | — | — | — | 108 | 324 | 280 |
| Radar Maintenance | 273 | — | — | — | 31 | 52 | 41 | 149 |
| Radar Observer Bomb (BTO) | 7,623 | — | — | — | — | — | 1,882 | 5,741 |
| Radar Observer Night Fighter Cadets | 1,087 | — | — | — | 5 | 120 | 687 | 275 |
| Radar Observer (RCM) | 524 | — | — | — | — | 38 | 427 | 59 |
| Other | 2,380 | — | — | — | 18 | 306 | 494 | 1,562 |
| Rescue Arctic | 76 | — | — | — | — | 66 | 1 | 9 |
| Weather | 5,924 | — | — | 112 | 570 | 3,732 | 1,316 | 194 |
| *Enlisted Men—Total* | 1,310,760 | 1,588 | 14,375 | 41,626 | 255,609 | 575,243 | 283,518 | 138,801 |
| Aircraft Maintenance | 695,866 | 872 | 8,932 | 27,407 | 159,903 | 299,042 | 128,849 | 70,861 |
| Armament | 158,766 | 191 | 1,396 | 3,927 | 26,895 | 79,461 | 38,553 | 8,343 |
| Communications | 222,223 | 292 | 2,148 | 5,825 | 35,642 | 90,199 | 65,238 | 22,879 |
| Emergency Rescue Boat | 414 | — | — | — | — | 297 | 69 | 48 |
| Photography | 15,805 | 118 | 498 | 871 | 3,487 | 7,606 | 2,172 | 1,053 |
| Radar | 71,854 | — | — | — | 2,634 | 7,816 | 34,082 | 27,322 |
| Weather | 18,513 | 14 | 238 | 803 | 3,092 | 9,116 | 4,856 | 394 |
| Other | 127,319 | 101 | 1,163 | 2,793 | 23,956 | 81,706 | 9,699 | 7,901 |

[1] Totals do not mean that number of different individuals. Some graduated from several courses.

# U. S. ARMY AIR FORCES GRADUATES FROM FLYING TRAINING COURSES

July 1939—August 1945

Source: U. S. Army Air Forces Office of Statistical Control

| Course | Grand Total | 1939 (July-Dec.) | 1940 | 1941 | 1942 | 1943 | 1944 | 1945 (Jan.-Aug.) |
|---|---|---|---|---|---|---|---|---|
| Total | 1,561,288[1] | 982 | 8,125 | 27,531 | 192,468 | 561,072 | 617,961 | 153,149 |
| *Pilot—Total* | 768,991 | 982 | 8,043 | 27,071 | 107,871 | 256,145 | 299,405 | 69,474 |
| Primary | 233,198 | 757 | 3,831 | 11,209 | 46,353 | 92,544 | 71,319 | 7,185 |
| Basic | 202,986 | 225 | 2,426 | 8,618 | 32,802 | 72,022 | 77,091 | 9,802 |
| Advanced—Total | 193,440 | — | 1,786 | 7,244 | 24,948 | 61,872 | 81,024 | 16,566 |
| Single Engine | 102,907 | — | 1,786 | 6,853 | 13,885 | 49,503 | 25,733 | 5,147 |
| Two Engine | 90,533 | — | — | 391 | 11,063 | 12,369 | 55,291 | 11,419 |
| Transition—Total | 108,337 | — | — | — | 3,768 | 17,464 | 57,590 | 29,515 |
| Single Engine | 262 | — | — | — | — | 14 | 248 | — |
| Two Engine | 1,983 | — | — | — | — | 1,974 | 9 | — |
| Four Engine | 11,938 | — | — | — | 3,514 | 7,846 | 578 | — |
| P-38 | 252 | — | — | — | — | — | — | 252 |
| P-39 | 3,448 | — | — | — | — | — | 3,448 | — |
| P-40 | 14,917 | — | — | — | — | — | 9,955 | 4,962 |
| B-25 | 2,890 | — | — | — | — | 521 | 1,723 | 646 |
| B-26 | 4,691 | — | — | — | — | 382 | 2,679 | 1,630 |
| B-17 | 24,843 | — | — | — | — | 1,680 | 16,082 | 7,081 |
| B-24 | 24,222 | — | — | — | — | 1,239 | 15,818 | 7,165 |
| B-29 | 5,072 | — | — | — | — | — | 139 | 4,933 |
| B-32 | 240 | — | — | — | — | — | — | 240 |
| Liaison FA | 2,792 | — | — | — | — | 1,683 | 788 | 321 |
| Advanced Liaison | 1,155 | — | — | — | — | 904 | 221 | 30 |
| Photographic Ren (P322) | 204 | — | — | — | — | — | 204 | — |
| Helicopter | 129 | — | — | — | — | — | 36 | 93 |
| Observation | 931 | — | — | — | 184 | 747 | — | — |
| Primary ATC | 35 | — | — | — | 35 | — | — | — |
| Advanced Phase—ATC | 35 | — | — | — | 35 | — | — | — |
| ATC | 3,464 | — | — | — | — | — | 3,246 | 218 |
| B-17 Instructor | 1,621 | — | — | — | — | — | 345 | 1,276 |
| B-24 Instructor | 1,067 | — | — | — | — | — | 399 | 668 |
| Four Engine Instructor | 2,146 | — | — | — | — | 474 | 1,672 | — |
| Women | 1,282 | — | — | — | — | 380 | 902 | — |
| U. S. in British Schools | 552 | — | — | — | — | 297 | 255 | — |
| Instructor Training | 24,805 | — | — | — | — | 9,002 | 9,948 | 5,855 |
| Pilot Instructor | 16,985 | — | — | — | — | 8,193 | 6,468 | 2,324 |
| Instrument Pilot | 7,820 | — | — | — | — | 809 | 3,480 | 3,531 |
| Other | 4,391 | — | — | — | — | 2,564 | 1,276 | 551 |
| *Bombardier—Total* | 28,361 | — | 18 | 206 | 3,858 | 15,246 | 2,501 | 6,532 |
| Precision | 9,444 | — | — | — | — | 9,053 | 391 | — |
| Instructor | 14,571 | — | 18 | 206 | 3,858 | 6,193 | 2,110 | 2,186 |
| Refresher | 4,346 | — | — | — | — | — | — | 4,346 |
| *Navigation—Total* | 56,119 | — | 44 | 137 | 3,609 | 15,905 | 23,217 | 13,207 |
| Celestial | 47,273 | — | 44 | 137 | 3,609 | 14,351 | 21,919 | 7,213 |
| Dead Reckoning | 1,597 | — | — | — | — | 1,536 | 61 | — |
| Instructor | 2,815 | — | — | — | — | 18 | 1,237 | 1,560 |
| Refresher | 4,434 | — | — | — | — | — | — | 4,434 |
| *Bombardier-Navigation—Total* | 28,480 | — | — | — | 666 | 2,076 | 18,783 | 6,955 |
| Bombardier-Navigation | 2,546 | — | — | — | — | 292 | 1,257 | 997 |
| Bombdr-DR & DS Navigation | 25,828 | — | — | — | 666 | 1,700 | 17,504 | 5,958 |
| Instr Bombdr-DR Navigation | 106 | — | — | — | — | 84 | 22 | — |
| *Radar Obsr Bombardment* | 1,477 | — | — | — | — | — | — | 1,477 |
| *Flt Engr Officer Training* | 403 | — | — | — | — | — | — | 403 |
| *Flt Engr B-29 Transition* | 3,707 | — | — | — | — | — | 31 | 3,676 |
| *Aerial Engr B-32 Transition* | 146 | — | — | — | — | — | — | 146 |
| *Flexible Gunnery—Total* | 309,236 | — | 20 | 117 | 21,081 | 94,481 | 154,592 | 38,945 |
| Cadets and Enlisted Men | 290,628 | — | — | — | 20,728 | 91,587 | 146,202 | 32,111 |
| Gunnery Officer | 1,175 | — | — | — | — | — | 650 | 525 |
| Observer Non-Pilot | 866 | — | 20 | 117 | 353 | 376 | — | — |
| Instructor | 16,567 | — | — | — | — | 2,518 | 7,740 | 6,309 |
| *Aircrew-Pre-Flight* | 335,495 | — | — | — | 45,471 | 168,856 | 110,480 | 10,688 |
| *Instructor—Total* | 4,593 | — | — | — | — | 96 | 2,932 | 1,565 |
| Instrument Training | 4,245 | — | — | — | — | 96 | 2,932 | 1,217 |
| Other | 348 | — | — | — | — | — | — | 348 |
| *Glider Pilot—Total* | 21,240 | — | — | — | 9,802 | 7,463 | 3,894 | 81 |
| Basic | 6,354 | — | — | — | 2,466 | 2,334 | 1,554 | — |
| Elementary-Advanced | 777 | — | — | — | 445 | — | 332 | — |
| Other | 14,109 | — | — | — | 6,891 | 5,129 | 2,008 | 81 |
| *Other* | 3,040 | — | — | — | 110 | 804 | 2,126 | — |

[1] These totals do not mean that number of different individuals. The same airman graduated from several courses.

## U. S. ARMY AIR FORCES MILITARY PERSONNEL IN UNITED STATES AND OVERSEAS BY TYPE OF PERSONNEL

July 1939—August 1945

Source: U. S. Army Air Forces Office of Statistical Control

| End of Month | Total Army Air Forces | | | Continental U. S. | | | Overseas | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | Officers | Enlisted Personnel | Total | Officers | Enlisted Personnel | Total | Officers | Enlisted Personnel |
| **1939** | | | | | | | | | |
| July | 24,724 | 2,636 | 22,088 | 20,733 | 2,364 | 18,369 | 3,991 | 272 | 3,719 |
| **1940** | | | | | | | | | |
| Jan. | 45,948 | 3,003 | 42,945 | 38,241 | 2,647 | 35,594 | 7,707 | 356 | 7,351 |
| July | 57,150 | 3,650 | 53,500 | 46,339 | 3,269 | 43,070 | 10,811 | 381 | 10,430 |
| **1941** | | | | | | | | | |
| Jan. | 100,513 | 6,546 | 93,967 | 81,473 | 6,230 | 75,243 | 19,040 | 316 | 18,724 |
| July | 194,626 | 13,175 | 181,451 | 171,679 | 11,947 | 159,732 | 22,947 | 1,228 | 21,719 |
| **1942** | | | | | | | | | |
| Jan. | 417,526 | 30,040 | 387,486 | 366,582 | 27,211 | 339,371 | 50,944 | 2,829 | 48,115 |
| July | 840,637 | 68,894 | 771,743 | 708,191 | 56,454 | 651,737 | 132,446 | 12,440 | 120,006 |
| Aug. | 986,338 | 82,130 | 904,208 | 826,967 | 67,207 | 759,760 | 159,371 | 14,923 | 144,448 |
| Sept. | 1,089,930 | 88,918 | 1,001,012 | 920,810 | 73,095 | 847,715 | 169,120 | 15,823 | 153,297 |
| Oct. | 1,261,172 | 105,089 | 1,156,083 | 1,076,861 | 85,492 | 991,369 | 184,311 | 19,597 | 164,714 |
| Nov. | 1,511,323 | 111,727 | 1,399,596 | 1,301,704 | 88,862 | 1,212,842 | 209,619 | 22,865 | 186,754 |
| Dec. | 1,597,049 | 127,267 | 1,469,782 | 1,355,028 | 100,475 | 1,254,553 | 242,021 | 26,792 | 215,229 |
| **1943** | | | | | | | | | |
| Jan. | 1,696,866 | 139,976 | 1,556,890 | 1,436,236 | 111,944 | 1,324,292 | 260,630 | 28,032 | 232,598 |
| Feb. | 1,859,569 | 153,077 | 1,706,492 | 1,573,089 | 121,373 | 1,451,716 | 286,480 | 31,704 | 254,776 |
| Mar. | 2,045,649 | 173,213 | 1,872,436 | 1,721,211 | 136,004 | 1,585,207 | 324,438 | 37,209 | 287,229 |
| April | 2,133,925 | 181,757 | 1,952,168 | 1,802,824 | 143,280 | 1,659,544 | 331,101 | 38,477 | 292,624 |
| May | 2,184,041 | 197,519 | 1,986,522 | 1,780,635 | 150,978 | 1,629,657 | 403,906 | 46,541 | 356,865 |
| June | 2,197,114 | 205,874 | 1,991,240 | 1,764,969 | 156,417 | 1,608,552 | 432,145 | 49,457 | 382,688 |
| July | 2,238,802 | 217,161 | 2,021,641 | 1,768,402 | 164,346 | 1,604,056 | 470,400 | 52,815 | 417,585 |
| Aug. | 2,305,320 | 232,922 | 2,072,398 | 1,778,873 | 174,628 | 1,604,245 | 526,447 | 58,294 | 468,153 |
| Sept. | 2,321,858 | 246,329 | 2,075,529 | 1,766,464 | 184,075 | 1,582,389 | 555,394 | 62,254 | 493,140 |
| Oct. | 2,356,167 | 253,796 | 2,102,371 | 1,728,019 | 183,653 | 1,544,366 | 628,148 | 70,143 | 558,005 |
| Nov. | 2,383,370 | 265,630 | 2,117,740 | 1,711,492 | 187,980 | 1,523,512 | 671,878 | 77,650 | 594,228 |
| Dec. | 2,373,882 | 274,347 | 2,099,535 | 1,638,216 | 193,275 | 1,444,941 | 735,666 | 81,072 | 654,594 |
| **1944** | | | | | | | | | |
| Jan. | 2,400,151 | 287,294 | 2,112,857 | 1,606,394 | 198,510 | 1,407,884 | 793,757 | 88,784 | 704,973 |
| Feb. | 2,403,499 | 296,561 | 2,106,938 | 1,555,969 | 202,842 | 1,353,127 | 847,530 | 93,719 | 753,811 |
| Mar. | 2,411,294 | 306,889 | 2,104,405 | 1,504,959 | 202,025 | 1,302,934 | 906,335 | 104,864 | 801,471 |
| April | 2,356,504 | 313,874 | 2,042,630 | 1,410,704 | 201,981 | 1,208,723 | 945,800 | 111,893 | 833,907 |
| May | 2,372,447 | 322,350 | 2,050,097 | 1,372,933 | 200,386 | 1,172,547 | 999,514 | 121,964 | 877,550 |
| June | 2,372,292 | 333,401 | 2,038,891 | 1,334,958 | 205,156 | 1,129,802 | 1,037,334 | 128,245 | 909,089 |
| July | 2,403,806 | 342,914 | 2,060,892 | 1,342,025 | 207,447 | 1,134,578 | 1,061,781 | 135,467 | 926,314 |
| Aug. | 2,403,056 | 350,060 | 2,052,996 | 1,320,980 | 212,650 | 1,108,330 | 1,082,076 | 137,410 | 944,666 |
| Sept. | 2,391,281 | 357,924 | 2,033,357 | 1,313,143 | 220,526 | 1,092,617 | 1,078,138 | 137,398 | 940,740 |
| Oct. | 2,382,410 | 360,843 | 2,021,567 | 1,261,050 | 214,948 | 1,046,102 | 1,121,360 | 145,895 | 975,465 |
| Nov. | 2,383,453 | 368,804 | 2,014,649 | 1,231,978 | 217,471 | 1,014,507 | 1,151,475 | 151,333 | 1,000,142 |
| Dec. | 2,359,456 | 375,973 | 1,983,483 | 1,195,320 | 222,428 | 972,892 | 1,164,136 | 153,545 | 1,010,591 |
| **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 |
| Feb. | 2,324,377 | 385,111 | 1,939,266 | 1,138,146 | 223,985 | 914,161 | 1,186,231 | 161,126 | 1,025,105 |
| Mar. | 2,325,842 | 385,916 | 1,939,926 | 1,108,705 | 220,424 | 888,281 | 1,217,137 | 165,492 | 1,051,645 |
| April | 2,329,534 | 388,278 | 1,941,256 | 1,105,528 | 224,392 | 881,136 | 1,224,006 | 163,886 | 1,060,120 |
| May | 2,310,436 | 388,295 | 1,922,141 | 1,101,932 | 225,537 | 876,395 | 1,208,504 | 162,758 | 1,045,746 |
| June | 2,282,259 | 381,454 | 1,900,805 | 1,153,373 | 239,561 | 913,812 | 1,128,886 | 141,893 | 986,993 |
| July | 2,262,092 | 371,269 | 1,890,823 | 1,185,712 | 238,771 | 946,941 | 1,076,380 | 132,498 | 943,882 |
| Aug. | 2,253,182 | 368,344 | 1,884,838 | 1,253,573 | 245,511 | 1,008,062 | 999,609 | 122,833 | 876,776 |

# U. S. ARMY AIR FORCES MILITARY PERSONNEL BY SPECIALTY

June 1944—August 1945

Source: U. S. Army Air Forces Office of Statistical Control

| End of Month | OFFICERS | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | Pilot | Bombardier | Navigator | Other Aircrew[1] | Administrative | Armament and Ordnance | Communications | Engineering | Medical | Operations | Supply | Other |
| **1944** | | | | | | | | | | | | | |
| June | 333,401 | 130,907 | 18,478 | 23,964 | 193 | 24,892 | 6,522 | 13,325 | 16,759 | 19,940 | 11,031 | 13,987 | 53,403 |
| July | 342,914 | 132,477 | 18,812 | 24,991 | 201 | 29,534 | 7,546 | 14,570 | 17,821 | 19,560 | 11,026 | 16,496 | 49,880 |
| Aug. | 350,060 | 138,621 | 19,662 | 26,395 | 201 | 29,092 | 7,614 | 14,871 | 18,079 | 19,021 | 10,968 | 16,461 | 49,075 |
| Sept. | 357,924 | 144,607 | 22,320 | 29,088 | 188 | 28,877 | 7,663 | 14,927 | 18,558 | 18,143 | 11,039 | 16,444 | 46,070 |
| Oct. | 360,843 | 142,384 | 24,584 | 29,922 | 186 | 28,863 | 7,566 | 15,233 | 19,114 | 17,611 | 11,260 | 16,435 | 47,685 |
| Nov. | 368,804 | 148,001 | 26,170 | 32,303 | 185 | 28,744 | 7,592 | 15,737 | 19,388 | 17,383 | 11,535 | 16,294 | 45,472 |
| Dec. | 375,973 | 152,757 | 26,788 | 33,871 | 183 | 29,151 | 7,563 | 16,016 | 19,461 | 16,722 | 11,921 | 16,839 | 44,701 |
| **1945** | | | | | | | | | | | | | |
| Jan. | 377,426 | 151,787 | 27,711 | 35,417 | 2,645 | 28,979 | 7,534 | 15,393 | 18,571 | 16,727 | 12,300 | 16,802 | 43,560 |
| Feb. | 385,111 | 155,866 | 28,030 | 37,030 | 3,077 | 29,120 | 7,632 | 15,466 | 18,476 | 16,561 | 12,728 | 17,024 | 44,111 |
| Mar. | 385,916 | 157,542 | 28,455 | 36,188 | 4,018 | 29,220 | 7,515 | 15,069 | 18,603 | 16,444 | 13,086 | 17,094 | 42,682 |
| April | 388,278 | 159,677 | 28,660 | 35,558 | 6,095 | 29,198 | 7,439 | 15,035 | 18,752 | 16,430 | 13,476 | 17,338 | 40,600 |
| May | 388,295 | 155,195 | 28,143 | 32,111 | 7,390 | 28,936 | 7,311 | 14,765 | 18,548 | 16,444 | 13,606 | 17,266 | 48,380 |
| June | 381,454 | 153,716 | 27,755 | 32,442 | 8,816 | 28,286 | 7,031 | 14,551 | 18,269 | 16,368 | 12,927 | 16,939 | 44,354 |
| July | 371,269 | 140,552 | 26,059 | 31,529 | 9,878 | 27,857 | 6,947 | 14,433 | 18,093 | 16,413 | 12,604 | 16,882 | 50,022 |
| Aug. | 368,344 | 142,246 | 26,894 | 31,972 | 12,478 | 26,770 | 6,777 | 14,065 | 17,244 | 16,547 | 12,501 | 15,936 | 44,914 |

| End of Month | ENLISTED PERSONNEL | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Total | Airplane Maintenance | Aerial Gunner | Other Aircrew | Armament | Communications | Radar | Medical |
| **1944** | | | | | | | | |
| June | 2,038,891 | 332,978 | 127,105 | 19,166 | 93,775 | 150,576 | 30,453 | 46,800 |
| July | 2,060,892 | 351,710 | 135,098 | 29,037 | 101,931 | 144,532 | 34,117 | 49,013 |
| Aug. | 2,052,996 | 351,473 | 140,418 | 33,816 | 100,715 | 143,621 | 34,701 | 50,321 |
| Sept. | 2,033,357 | 355,719 | 145,308 | 35,962 | 102,375 | 148,339 | 34,580 | 50,993 |
| Oct. | 2,021,567 | 355,974 | 150,681 | 37,520 | 100,885 | 148,709 | 34,996 | 50,534 |
| Nov. | 2,014,649 | 358,688 | 156,896 | 39,086 | 100,640 | 150,110 | 35,966 | 49,782 |
| Dec. | 1,983,483 | 358,478 | 165,390 | 40,118 | 99,637 | 151,391 | 36,938 | 39,288 |
| **1945** | | | | | | | | |
| Jan. | 1,967,642 | 358,961 | 167,809 | 43,696 | 97,864 | 153,643 | 36,439 | 37,826 |
| Feb. | 1,939,266 | 359,103 | 168,883 | 45,167 | 96,674 | 153,476 | 36,854 | 37,347 |
| Mar. | 1,939,926 | 359,865 | 165,942 | 46,473 | 96,464 | 154,495 | 39,513 | 37,526 |
| April | 1,941,256 | 360,365 | 164,187 | 48,094 | 95,703 | 153,740 | 40,857 | 37,559 |
| May | 1,922,141 | 325,254 | 166,107 | 45,919 | 96,349 | 148,254 | 43,738 | 45,710 |
| June | 1,900,805 | 321,018 | 159,778 | 46,096 | 94,242 | 148,164 | 42,636 | 45,440 |
| July | 1,890,823 | 319,231 | 146,070 | 45,510 | 91,788 | 145,840 | 43,246 | 45,834 |
| Aug. | 1,884,838 | 317,949 | 155,134 | 45,166 | 89,843 | 142,844 | 43,713 | 44,750 |

| End of Month | ENLISTED PERSONNEL (Continued) | | | | | |
|---|---|---|---|---|---|---|
| | Supply | Utility and Construction | Automotive | Administrative | Other Specialists | Non-Specialists |
| **1944** | | | | | | |
| June | 79,416 | 52,346 | 182,360 | 224,766 | 429,381 | 269,769 |
| July | 81,386 | 55,480 | 182,898 | 243,026 | 205,119 | 445,545 |
| Aug. | 82,339 | 55,011 | 181,149 | 243,604 | 216,393 | 419,435 |
| Sept. | 84,245 | 58,602 | 184,946 | 244,185 | 193,420 | 394,683 |
| Oct. | 85,099 | 57,983 | 184,713 | 244,793 | 190,732 | 378,948 |
| Nov. | 85,737 | 57,586 | 186,080 | 245,549 | 189,674 | 358,855 |
| Dec. | 86,892 | 57,688 | 185,964 | 250,214 | 178,361 | 333,124 |
| **1945** | | | | | | |
| Jan. | 87,188 | 58,285 | 185,072 | 247,827 | 175,755 | 317,277 |
| Feb. | 87,221 | 57,977 | 183,135 | 244,972 | 172,905 | 295,552 |
| Mar. | 88,668 | 60,116 | 184,693 | 245,929 | 169,152 | 291,090 |
| April | 90,452 | 63,105 | 183,387 | 246,405 | 172,633 | 284,769 |
| May | 96,347 | 71,955 | 210,490 | 243,266 | 176,017 | 252,735 |
| June | 95,752 | 71,789 | 212,812 | 238,152 | 172,279 | 252,047 |
| July | 94,910 | 70,682 | 211,784 | 234,670 | 175,545 | 265,713 |
| Aug. | 92,443 | 68,651 | 202,331 | 231,973 | 192,074 | 257,968 |

[1] Flight Engineers included in "Engineering" and Radar Observers in "Communications" prior to Jan. 1945.

## U. S. ARMY AIR FORCES FLYING TIME IN UNITED STATES AND OVERSEAS BY TYPE OF PLANE

Source: U. S. Army Air Forces Office of Statistical Control

In Thousands of Hours

| Year and Month | Total | Continental U. S. | | | | | Overseas | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | Combat Planes | Transports | Trainers | Communications | Total | Theaters | | ATC[1] |
| | | | | | | | | Combat Planes | Non-Combat Planes | |
| Grand Total | 107,886 | 81,367 | 23,132 | 7,584 | 49,060 | 1,591 | 26,519 | 13,821 | 5,652 | 7,046 |
| *Annually* | | | | | | | | | | |
| 1943 | 35,664 | 32,099 | 6,209 | 1,989 | 22,977 | 924 | 3,565 | 1,865 | 669 | 1,031 |
| 1944 | 47,761 | 35,755 | 10,443 | 3,952 | 20,871 | 489 | 12,006 | 6,957 | 2,250 | 2,799 |
| 1945 (Jan.-Aug.) | 24,461 | 13,513 | 6,480 | 1,643 | 5,212 | 178 | 10,948 | 4,999 | 2,733 | 3,216 |
| *Monthly* | | | | | | | | | | |
| 1943 | | | | | | | | | | |
| Jan. | 2,070 | 1,940 | 258 | 55 | 1,552 | 75 | 130 | 53 | 33 | 44 |
| Feb. | 2,158 | 2,022 | 292 | 60 | 1,600 | 70 | 136 | 45 | 38 | 53 |
| Mar. | 2,326 | 2,149 | 341 | 82 | 1,665 | 61 | 177 | 64 | 38 | 75 |
| April | 2,533 | 2,322 | 399 | 103 | 1,756 | 64 | 211 | 96 | 39 | 76 |
| May | 2,561 | 2,290 | 441 | 127 | 1,657 | 65 | 271 | 129 | 41 | 101 |
| June | 2,978 | 2,702 | 537 | 168 | 1,927 | 70 | 276 | 134 | 51 | 91 |
| July | 3,304 | 2,944 | 633 | 207 | 2,022 | 82 | 360 | 219 | 57 | 84 |
| Aug. | 3,465 | 3,117 | 675 | 213 | 2,139 | 90 | 348 | 204 | 63 | 81 |
| Sept. | 3,455 | 3,054 | 672 | 223 | 2,064 | 95 | 401 | 240 | 68 | 93 |
| Oct. | 3,719 | 3,333 | 697 | 230 | 2,307 | 99 | 386 | 207 | 78 | 101 |
| Nov. | 3,627 | 3,233 | 644 | 265 | 2,229 | 95 | 394 | 217 | 74 | 103 |
| Dec. | 3,468 | 2,993 | 620 | 256 | 2,059 | 58 | 475 | 257 | 89 | 129 |
| 1944 | | | | | | | | | | |
| Jan. | 4,093 | 3,524 | 697 | 316 | 2,437 | 74 | 569 | 287 | 118 | 164 |
| Feb. | 3,515 | 2,935 | 644 | 285 | 1,952 | 54 | 580 | 304 | 106 | 170 |
| Mar. | 4,355 | 3,620 | 764 | 363 | 2,435 | 58 | 735 | 392 | 124 | 219 |
| April | 4,105 | 3,224 | 813 | 331 | 2,032 | 48 | 881 | 503 | 154 | 224 |
| May | 4,758 | 3,646 | 994 | 391 | 2,209 | 52 | 1,112 | 712 | 171 | 229 |
| June | 4,422 | 3,324 | 967 | 410 | 1,908 | 39 | 1,098 | 737 | 173 | 188 |
| July | 4,337 | 3,200 | 958 | 396 | 1,809 | 37 | 1,137 | 724 | 178 | 235 |
| Aug. | 4,216 | 2,969 | 971 | 356 | 1,605 | 37 | 1,247 | 759 | 222 | 266 |
| Sept. | 3,849 | 2,681 | 950 | 313 | 1,381 | 37 | 1,168 | 658 | 265 | 245 |
| Oct. | 3,898 | 2,747 | 1,015 | 325 | 1,384 | 23 | 1,151 | 616 | 255 | 280 |
| Nov. | 3,206 | 2,049 | 843 | 252 | 936 | 18 | 1,157 | 621 | 245 | 291 |
| Dec. | 3,007 | 1,836 | 827 | 214 | 783 | 12 | 1,171 | 644 | 239 | 288 |
| 1945 | | | | | | | | | | |
| Jan. | 3,270 | 2,118 | 932 | 246 | 926 | 14 | 1,152 | 571 | 259 | 322 |
| Feb. | 3,000 | 1,592 | 768 | 191 | 620 | 13 | 1,408 | 772 | 315 | 321 |
| Mar. | 3,766 | 1,976 | 987 | 225 | 739 | 25 | 1,790 | 1,037 | 378 | 375 |
| April | 3,530 | 1,713 | 849 | 187 | 653 | 24 | 1,817 | 952 | 480 | 385 |
| May | 3,157 | 1,774 | 861 | 191 | 697 | 25 | 1,383 | 560 | 423 | 400 |
| June | 2,872 | 1,613 | 789 | 194 | 603 | 27 | 1,259 | 457 | 333 | 469 |
| July | 2,800 | 1,571 | 758 | 212 | 572 | 29 | 1,229 | 391 | 326 | 512 |
| Aug. | 2,066 | 1,156 | 536 | 197 | 402 | 21 | 910 | 259 | 219 | 432 |

[1] Air Transport Command, AAF.

## OFFICERS IN U. S. ARMY AIR FORCES BY ARM OR SERVICE

February 1943—August 1945

Source: U. S. Army Air Forces Office of Statistical Control

| End of Month | | Grand Total | Air Corps | Arm or Service | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Total | Chaplain | Chemical Warfare | Engineer | Finance | Medical | Military Police | Ordnance | Quarter-master | Signal | Other |
| 1943 | Feb. | 153,077 | 116,513 | 36,564 | 663 | 1,169 | 3,296 | 676 | 14,536 | 264 | 3,063 | 3,737 | 6,005 | 3,155 |
| | Mar. | 173,213 | 132,005 | 41,208 | 758 | 1,344 | 4,032 | 766 | 15,282 | 432 | 3,434 | 4,348 | 7,108 | 3,704 |
| | April | 181,757 | 138,131 | 43,626 | 866 | 1,346 | 4,579 | 789 | 15,728 | 448 | 3,634 | 4,559 | 7,816 | 3,881 |
| | May | 197,519 | 150,074 | 47,445 | 930 | 1,358 | 4,985 | 901 | 16,567 | 540 | 3,719 | 5,002 | 8,340 | 5,103 |
| | June | 205,874 | 156,566 | 49,308 | 977 | 1,309 | 4,687 | 897 | 16,918 | 507 | 3,684 | 5,031 | 8,410 | 6,888 |
| | July | 217,161 | 165,842 | 51,319 | 1,030 | 1,379 | 5,079 | 1,023 | 17,686 | 628 | 3,705 | 5,731 | 8,897 | 6,161 |
| | Aug. | 232,922 | 178,624 | 54,298 | 1,112 | 1,422 | 5,505 | 1,009 | 18,143 | 672 | 3,817 | 6,155 | 9,257 | 7,206 |
| | Sept. | 246,329 | 190,165 | 56,164 | 1,121 | 1,476 | 5,510 | 987 | 18,650 | 771 | 3,749 | 6,150 | 9,104 | 8,646 |
| | Oct. | 253,796 | 197,647 | 56,149 | 1,102 | 1,324 | 5,448 | 960 | 19,151 | 770 | 3,441 | 5,518 | 9,238 | 9,197 |
| | Nov. | 265,630 | 209,442 | 56,188 | 1,154 | 1,247 | 5,354 | 914 | 19,107 | 684 | 3,389 | 5,146 | 9,356 | 9,857 |
| | Dec. | 274,347 | 219,415 | 54,932 | 1,636 | 1,766 | 5,426 | 1,222 | 21,358 | 766 | 4,384 | 5,851 | 9,998 | 2,525 |
| 1944 | Jan. | 287,294 | 231,160 | 56,134 | 1,656 | 1,841 | 5,372 | 1,368 | 21,631 | 737 | 4,509 | 6,230 | 10,218 | 2,572 |
| | Feb. | 296,561 | 240,944 | 55,617 | 1,740 | 1,859 | 5,335 | 1,289 | 21,627 | 687 | 4,565 | 6,099 | 10,166 | 2,250 |
| | Mar. | 306,889 | 252,556 | 54,333 | 1,742 | 1,818 | 5,147 | 1,292 | 21,310 | 659 | 4,619 | 6,018 | 9,622 | 2,106 |
| | April | 313,874 | 260,430 | 53,444 | 1,737 | 1,864 | 5,028 | 1,287 | 21,185 | 665 | 4,494 | 5,915 | 9,418 | 1,851 |
| | May | 322,350 | 268,685 | 53,665 | 1,733 | 1,866 | 5,066 | 1,283 | 21,270 | 746 | 4,475 | 5,665 | 9,371 | 2,190 |
| | June | 333,401 | 280,586 | 52,815 | 1,785 | 1,696 | 5,006 | 1,239 | 20,977 | 763 | 4,491 | 5,479 | 9,279 | 2,100 |
| | July | 342,914 | 290,474 | 52,440 | 1,833 | 1,696 | 5,064 | 1,267 | 20,889 | 772 | 4,553 | 5,387 | 8,999 | 1,980 |
| | Aug. | 350,060 | 298,495 | 51,565 | 1,853 | 1,694 | 5,040 | 1,266 | 20,196 | 766 | 4,672 | 5,287 | 8,856 | 1,935 |
| | Sept. | 357,924 | 307,682 | 50,242 | 1,835 | 1,629 | 5,022 | 1,267 | 19,371 | 748 | 4,617 | 5,088 | 8,656 | 2,009 |
| | Oct. | 360,843 | 310,393 | 50,450 | 1,826 | 1,628 | 5,653 | 1,285 | 18,787 | 745 | 4,675 | 4,990 | 8,710 | 2,151 |
| | Nov. | 368,804 | 318,379 | 50,425 | 1,875 | 1,625 | 5,754 | 1,325 | 18,639 | 752 | 4,750 | 4,985 | 8,567 | 2,153 |
| | Dec. | 375,973 | 326,890 | 49,083 | 1,895 | 1,596 | 5,599 | 1,298 | 18,478 | 592 | 4,475 | 4,590 | 8,360 | 2,200 |
| 1945 | Jan. | 377,426 | 326,859 | 50,567 | 1,865 | 1,593 | 5,942 | 1,340 | 18,791 | 738 | 4,826 | 4,836 | 8,567 | 2,069 |
| | Feb. | 385,111 | 334,757 | 50,354 | 1,841 | 1,565 | 6,061 | 1,336 | 18,728 | 730 | 4,734 | 4,739 | 8,433 | 2,187 |
| | Mar. | 385,916 | 335,909 | 50,007 | 1,861 | 1,568 | 6,036 | 1,335 | 18,345 | 753 | 4,706 | 4,678 | 8,379 | 2,346 |
| | April | 388,278 | 338,679 | 49,599 | 1,861 | 1,521 | 6,098 | 1,271 | 18,519 | 665 | 4,443 | 4,438 | 8,391 | 2,392 |
| | May | 388,295 | 339,971 | 48,324 | 1,840 | 1,399 | 6,153 | 1,154 | 18,520 | 679 | 4,313 | 4,027 | 7,951 | 2,288 |
| | June | 381,454 | 336,091 | 45,363 | 1,858 | 1,119 | 5,973 | 973 | 18,776 | 621 | 3,806 | 3,138 | 6,961 | 2,138 |
| | July | 371,269 | 328,693 | 42,576 | 1,785 | 959 | 5,586 | 807 | 18,679 | 548 | 3,290 | 2,544 | 6,401 | 1,977 |
| | Aug. | 368,344 | 327,004 | 41,340 | 1,706 | 908 | 5,790 | 719 | 18,690 | 510 | 2,991 | 2,363 | 5,818 | 1,845 |

# U. S. ARMY AIR FORCES ENLISTED PERSONNEL BY ARM OR SERVICE

February 1943—August 1945

Source: U. S. Army Air Forces Office of Statistical Control

| | End of Month | Grand Total | Air Corps | Arm or Service | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Total | Chemical Warfare | Engineer | Finance | Medical | Military Police | Ordnance | Quarter-master | Signal | Other |
| 1943 | Feb. | 1,706,492 | 1,349,137 | 357,355 | 13,183 | 49,724 | 5,921 | 55,140 | 6,803 | 44,310 | 58,963 | 79,126 | 44,185 |
| | Mar. | 1,872,436 | 1,373,102 | 499,334 | 14,812 | 73,978 | 6,397 | 58,633 | 11,349 | 53,662 | 61,522 | 94,194 | 124,787 |
| | April | 1,952,168 | 1,421,571 | 530,597 | 16,552 | 78,240 | 5,754 | 63,061 | 13,152 | 56,660 | 64,525 | 103,347 | 129,306 |
| | May | 1,986,522 | 1,491,289 | 495,233 | 17,412 | 83,260 | 6,262 | 64,361 | 15,037 | 55,628 | 67,771 | 107,087 | 78,415 |
| | June | 1,991,240 | 1,479,557 | 511,683 | 16,024 | 76,884 | 5,937 | 63,478 | 15,721 | 54,904 | 67,757 | 107,667 | 103,311 |
| | July | 2,021,641 | 1,498,483 | 523,158 | 16,455 | 88,768 | 6,061 | 63,669 | 20,463 | 56,547 | 72,376 | 112,932 | 85,887 |
| | Aug. | 2,072,398 | 1,528,547 | 543,851 | 15,887 | 97,430 | 6,365 | 63,330 | 19,900 | 57,612 | 72,888 | 118,683 | 91,756 |
| | Sept. | 2,075,529 | 1,526,247 | 549,282 | 15,418 | 99,919 | 6,096 | 61,754 | 21,457 | 56,327 | 72,954 | 122,378 | 92,779 |
| | Oct. | 2,102,371 | 1,564,041 | 538,330 | 13,191 | 103,038 | 6,118 | 59,908 | 21,217 | 55,028 | 70,357 | 120,141 | 89,332 |
| | Nov. | 2,117,740 | 1,575,798 | 541,942 | 12,782 | 104,167 | 5,917 | 58,635 | 19,087 | 53,822 | 67,235 | 120,561 | 99,736 |
| | Dec. | 2,099,535 | 1,594,154 | 505,381 | 14,849 | 104,272 | 7,645 | 69,035 | 19,486 | 64,901 | 69,369 | 119,283 | 36,541 |
| 1944 | Jan. | 2,112,857 | 1,614,933 | 497,924 | 13,497 | 100,939 | 7,692 | 69,407 | 19,685 | 62,693 | 68,705 | 115,227 | 40,079 |
| | Feb. | 2,106,938 | 1,622,369 | 484,569 | 12,760 | 100,997 | 7,545 | 68,967 | 18,667 | 63,800 | 66,914 | 112,917 | 32,002 |
| | Mar. | 2,104,405 | 1,627,107 | 477,298 | 12,807 | 99,154 | 7,877 | 69,736 | 18,161 | 66,926 | 69,543 | 113,504 | 19,590 |
| | April | 2,042,630 | 1,581,610 | 461,020 | 12,703 | 99,435 | 7,899 | 68,319 | 18,702 | 66,432 | 71,583 | 112,671 | 3,276 |
| | May | 2,050,097 | 1,593,144 | 456,953 | 12,732 | 98,683 | 7,996 | 68,615 | 18,362 | 66,879 | 69,580 | 111,247 | 2,859 |
| | June | 2,038,891 | 1,581,382 | 457,509 | 12,398 | 99,961 | 7,745 | 67,647 | 19,176 | 68,177 | 68,416 | 111,932 | 2,057 |
| | July | 2,060,892 | 1,603,420 | 457,472 | 12,513 | 103,829 | 7,908 | 67,981 | 18,685 | 68,248 | 67,221 | 109,419 | 1,668 |
| | Aug. | 2,052,996 | 1,598,744 | 454,252 | 12,427 | 102,479 | 7,781 | 67,644 | 17,594 | 68,185 | 67,217 | 109,720 | 1,205 |
| | Sept. | 2,033,357 | 1,583,854 | 449,503 | 12,308 | 103,258 | 7,814 | 67,215 | 17,973 | 67,254 | 66,532 | 106,284 | 865 |
| | Oct. | 2,021,567 | 1,578,412 | 443,155 | 12,314 | 103,169 | 7,688 | 65,117 | 17,658 | 66,998 | 64,979 | 105,047 | 185 |
| | Nov. | 2,014,649 | 1,580,130 | 434,519 | 11,937 | 103,206 | 7,718 | 63,827 | 17,387 | 65,769 | 62,811 | 101,707 | 157 |
| | Dec. | 1,983,483 | 1,575,197 | 408,286 | 11,746 | 103,653 | 7,487 | 59,109 | 12,650 | 59,563 | 56,061 | 97,822 | 195 |
| 1945 | Jan. | 1,967,642 | 1,536,055 | 431,587 | 11,758 | 110,072 | 8,004 | 59,082 | 17,676 | 64,288 | 58,756 | 101,795 | 156 |
| | Feb. | 1,939,266 | 1,515,605 | 423,661 | 11,683 | 111,790 | 8,079 | 58,017 | 17,288 | 62,524 | 55,928 | 98,131 | 221 |
| | Mar. | 1,939,926 | 1,521,589 | 418,337 | 10,976 | 111,051 | 7,704 | 57,990 | 17,494 | 59,403 | 55,757 | 97,630 | 332 |
| | April | 1,941,256 | 1,574,904 | 366,352 | 9,482 | 105,932 | 3,182 | 57,485 | 14,503 | 46,340 | 40,615 | 88,714 | 99 |
| | May | 1,922,141 | 1,575,581 | 346,560 | 8,966 | 104,281 | 1,986 | 56,473 | 13,244 | 42,685 | 35,094 | 83,428 | 403 |
| | June | 1,900,805 | 1,567,630 | 333,175 | 8,629 | 101,060 | 1,864 | 55,309 | 12,406 | 41,161 | 32,208 | 79,902 | 636 |
| | July | 1,890,823 | 1,577,080 | 313,743 | 8,729 | 96,943 | 1,611 | 49,303 | 11,951 | 35,410 | 31,059 | 78,406 | 331 |
| | Aug. | 1,884,838 | 1,584,549 | 300,289 | 8,459 | 97,292 | 1,353 | 45,909 | 11,445 | 31,703 | 29,192 | 74,884 | 52 |

# FACTORY ACCEPTANCES OF U. S. MILITARY AIRPLANES

January 1940—August 1945

Source: U. S. Army Air Forces Office of Statistical Control

Includes experimental and U. S. financed Canadian production

| Year and Month | Total | Very Heavy Bombers | Heavy Bombers | Medium Bombers | Light Bombers | Fighters | Reconnaissance | Transports | Trainers | Communications |
|---|---|---|---|---|---|---|---|---|---|---|
| Grand Total | 299,230 | 3,764 | 31,890 | 22,110 | 40,646 | 100,554 | 3,981 | 24,059 | 58,568 | 13,658 |
| Annually | | | | | | | | | | |
| 1940 | 6,028 | — | 61 | 95 | 1,038 | 1,689 | 123 | 290 | 2,731 | 1 |
| 1941 | 19,445 | 1 | 318 | 865 | 2,935 | 4,421 | 727 | 532 | 9,376 | 270 |
| 1942 | 47,675 | 3 | 2,615 | 4,122 | 5,894 | 10,780 | 1,468 | 1,985 | 17,632 | 3,176 |
| 1943 | 85,433 | 92 | 9,524 | 7,624 | 12,122 | 24,005 | 734 | 7,013 | 19,942 | 4,377 |
| 1944 | 95,272 | 1,161 | 15,173 | 6,782 | 11,892 | 38,895 | 261 | 9,834 | 7,578 | 3,696 |
| 1945 (Jan.-Aug.) | 45,377 | 2,507 | 4,199 | 2,622 | 6,765 | 20,764 | 668 | 4,405 | 1,309 | 2,138 |
| Monthly | | | | | | | | | | |
| 1940 Jan. | 255 | — | 6 | 5 | 103 | 28 | 35 | 12 | 66 | — |
| Feb. | 258 | — | 4 | 14 | 72 | 51 | 9 | 17 | 91 | — |
| Mar. | 296 | — | 5 | 7 | 59 | 91 | 3 | 22 | 109 | — |
| April | 402 | — | — | 1 | 74 | 97 | 3 | 26 | 201 | — |
| May | 450 | — | — | 3 | 100 | 106 | 5 | 28 | 208 | — |
| June | 553 | — | — | 8 | 107 | 150 | 5 | 21 | 262 | — |
| July | 576 | — | 2 | 13 | 103 | 176 | 4 | 25 | 253 | — |
| Aug. | 543 | — | 9 | 8 | 83 | 156 | 9 | 26 | 252 | — |
| Sept. | 548 | — | 7 | 7 | 35 | 163 | 21 | 26 | 288 | 1 |
| Oct. | 626 | — | 15 | 3 | 52 | 196 | 16 | 33 | 311 | — |
| Nov. | 683 | — | 6 | 8 | 105 | 211 | 13 | 40 | 300 | — |
| Dec. | 838 | — | 7 | 18 | 145 | 264 | — | 14 | 390 | — |
| 1941 Jan. | 1,013 | — | 1 | 23 | 145 | 258 | 27 | 28 | 531 | — |
| Feb. | 982 | — | 13 | 34 | 198 | 204 | 27 | 41 | 463 | 2 |
| Mar. | 1,133 | — | 10 | 38 | 231 | 222 | 25 | 22 | 576 | 9 |
| April | 1,386 | — | 27 | 71 | 249 | 289 | 14 | 25 | 696 | 15 |
| May | 1,341 | — | 13 | 72 | 229 | 252 | 25 | 31 | 711 | 8 |
| June | 1,480 | — | 10 | 100 | 254 | 224 | 68 | 28 | 779 | 17 |
| July | 1,459 | — | 2 | 80 | 266 | 202 | 34 | 31 | 822 | 22 |
| Aug. | 1,851 | — | 19 | 101 | 234 | 441 | 86 | 60 | 880 | 30 |
| Sept. | 1,926 | — | 32 | 80 | 281 | 472 | 100 | 50 | 865 | 46 |
| Oct. | 2,282 | — | 42 | 82 | 295 | 571 | 101 | 62 | 1,119 | 10 |
| Nov. | 2,128 | 1 | 55 | 36 | 237 | 588 | 98 | 53 | 975 | 85 |
| Dec. | 2,464 | — | 94 | 148 | 316 | 698 | 122 | 101 | 959 | 26 |

| Year and Month | | Total | Very Heavy Bombers | Heavy Bombers | Medium Bombers | Light Bombers | Fighters | Recon-naissance | Transports | Trainers | Communi-cations |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1942 | Jan. | 2,971 | — | 86 | 89 | 323 | 757 | 185 | 104 | 1,334 | 93 |
| | Feb. | 3,078 | — | 134 | 158 | 325 | 755 | 115 | 117 | 1,156 | 318 |
| | Mar. | 3,468 | — | 156 | 316 | 307 | 756 | 136 | 109 | 1,355 | 333 |
| | April | 3,497 | — | 171 | 284 | 266 | 747 | 106 | 152 | 1,413 | 358 |
| | May | 3,913 | — | 178 | 323 | 520 | 773 | 94 | 114 | 1,617 | 294 |
| | June | 3,703 | — | 197 | 380 | 430 | 934 | 127 | 130 | 1,234 | 271 |
| | July | 4,097 | — | 213 | 398 | 440 | 1,010 | 130 | 247 | 1,345 | 314 |
| | Aug. | 4,276 | — | 234 | 407 | 505 | 874 | 184 | 165 | 1,617 | 290 |
| | Sept. | 4,303 | — | 263 | 449 | 599 | 912 | 118 | 202 | 1,578 | 182 |
| | Oct. | 4,065 | — | 288 | 334 | 700 | 895 | 83 | 163 | 1,382 | 220 |
| | Nov. | 4,815 | — | 304 | 448 | 720 | 1,143 | 110 | 242 | 1,606 | 242 |
| | Dec. | 5,489 | 3 | 391 | 536 | 759 | 1,224 | 80 | 240 | 1,995 | 261 |
| 1943 | Jan. | 5,013 | — | 355 | 439 | 649 | 1,055 | 74 | 368 | 1,769 | 304 |
| | Feb. | 5,452 | — | 473 | 534 | 781 | 1,184 | 43 | 321 | 1,851 | 265 |
| | Mar. | 6,203 | — | 543 | 619 | 724 | 1,470 | 113 | 564 | 1,824 | 346 |
| | April | 6,404 | — | 642 | 649 | 749 | 1,672 | 45 | 589 | 1,861 | 197 |
| | May | 7,015 | — | 722 | 707 | 1,129 | 1,614 | 42 | 566 | 1,816 | 419 |
| | June | 7,061 | — | 736 | 744 | 1,031 | 1,816 | 39 | 574 | 1,765 | 356 |
| | July | 7,329 | 7 | 823 | 656 | 966 | 2,083 | 26 | 639 | 1,728 | 401 |
| | Aug. | 7,571 | 4 | 931 | 669 | 1,078 | 2,310 | 20 | 631 | 1,562 | 366 |
| | Sept. | 7,575 | 15 | 962 | 547 | 1,241 | 2,175 | 121 | 655 | 1,541 | 318 |
| | Oct. | 8,271 | 13 | 1,065 | 635 | 1,165 | 2,726 | 27 | 644 | 1,518 | 478 |
| | Nov. | 8,758 | 18 | 1,083 | 607 | 1,372 | 3,002 | 47 | 678 | 1,395 | 466 |
| | Dec. | 8,781 | 35 | 1,189 | 728 | 1,237 | 2,898 | 137 | 784 | 1,312 | 461 |
| 1944 | Jan. | 8,766 | 54 | 1,286 | 661 | 1,217 | 3,173 | 43 | 798 | 1,112 | 422 |
| | Feb. | 8,735 | 57 | 1,340 | 695 | 1,175 | 3,229 | — | 884 | 974 | 381 |
| | Mar. | 9,068 | 60 | 1,509 | 720 | 1,140 | 3,534 | — | 925 | 901 | 279 |
| | April | 8,286 | 51 | 1,366 | 635 | 1,050 | 3,315 | 4 | 838 | 775 | 252 |
| | May | 8,851 | 88 | 1,493 | 655 | 1,136 | 3,462 | — | 992 | 740 | 285 |
| | June | 7,912 | 82 | 1,468 | 584 | 989 | 3,202 | — | 909 | 363 | 315 |
| | July | 7,859 | 75 | 1,349 | 490 | 882 | 3,247 | 2 | 866 | 631 | 317 |
| | Aug. | 7,791 | 94 | 1,260 | 462 | 958 | 3,374 | 6 | 814 | 505 | 318 |
| | Sept. | 7,465 | 122 | 1,250 | 446 | 893 | 3,219 | 14 | 730 | 473 | 318 |
| | Oct. | 7,322 | 125 | 1,074 | 465 | 849 | 3,308 | 29 | 727 | 430 | 315 |
| | Nov. | 6,632 | 163 | 926 | 494 | 779 | 2,852 | 97 | 702 | 382 | 237 |
| | Dec. | 6,585 | 190 | 852 | 475 | 824 | 2,980 | 66 | 649 | 292 | 257 |
| 1945 | Jan. | 6,420 | 221 | 818 | 535 | 823 | 2,811 | 102 | 644 | 252 | 214 |
| | Feb. | 6,216 | 260 | 781 | 397 | 825 | 2,798 | 80 | 599 | 207 | 269 |
| | Mar. | 6,968 | 291 | 826 | 425 | 1,002 | 3,227 | 104 | 613 | 176 | 304 |
| | April | 6,332 | 321 | 686 | 355 | 908 | 2,937 | 84 | 589 | 168 | 284 |
| | May | 6,274 | 330 | 531 | 329 | 958 | 2,927 | 92 | 617 | 184 | 286 |
| | June | 5,713 | 370 | 405 | 231 | 909 | 2,683 | 97 | 553 | 150 | 315 |
| | July | 4,635 | 375 | 114 | 209 | 792 | 2,115 | 79 | 522 | 110 | 319 |
| | Aug. | 2,819 | 319 | 38 | 141 | 548 | 1,266 | 30 | 268 | 62 | 147 |

## U. S. ARMY AIR FORCES AIRPLANES ON HAND, BY MAJOR TYPE

July 1939—August 1945

Source: U. S. Army Air Forces Office of Statistical Control

| End of Month | Total | Very Heavy Bombers | Heavy Bombers | Medium Bombers | Light Bombers | Fighters | Reconnaissance | Transports | Trainers | Communications |
|---|---|---|---|---|---|---|---|---|---|---|
| **1939** | | | | | | | | | | |
| July | 2,402 | — | 16 | 400 | 276 | 494 | 356 | 118 | 735 | 7 |
| **1940** | | | | | | | | | | |
| Jan. | 2,588 | — | 45 | 466 | 271 | 464 | 409 | 128 | 798 | 7 |
| July | 3,102 | — | 56 | 483 | 161 | 500 | 410 | 128 | 1,357 | 7 |
| **1941** | | | | | | | | | | |
| Jan. | 4,219 | — | 92 | 478 | 165 | 630 | 403 | 122 | 2,326 | 3 |
| July | 7,423 | — | 121 | 642 | 323 | 1,101 | 434 | 159 | 4,568 | 75 |
| Aug. | 8,242 | — | 121 | 696 | 339 | 1,374 | 458 | 174 | 4,979 | 101 |
| Sept. | 9,063 | — | 126 | 722 | 350 | 1,513 | 482 | 187 | 5,544 | 139 |
| Oct. | 9,964 | — | 137 | 751 | 356 | 1,696 | 473 | 206 | 6,199 | 146 |
| Nov. | 10,329 | — | 157 | 685 | 350 | 1,618 | 495 | 216 | 6,594 | 214 |
| Dec. | 12,297 | — | 288 | 745 | 799 | 2,170 | 475 | 254 | 7,340 | 226 |
| **1942** | | | | | | | | | | |
| Jan. | 13,401 | — | 315 | 709 | 798 | 2,349 | 458 | 273 | 8,200 | 299 |
| Feb. | 14,420 | — | 365 | 690 | 756 | 2,446 | 440 | 292 | 9,008 | 423 |
| Mar. | 16,364 | — | 504 | 799 | 745 | 2,646 | 436 | 423 | 10,014 | 797 |
| April | 17,807 | — | 627 | 829 | 722 | 2,731 | 453 | 557 | 10,853 | 1,035 |
| May | 19,617 | — | 721 | 886 | 670 | 2,762 | 461 | 663 | 11,948 | 1,506 |
| June | 21,173 | — | 846 | 1,047 | 696 | 2,950 | 468 | 824 | 12,610 | 1,732 |
| July | 23,237 | — | 1,062 | 1,380 | 819 | 3,375 | 463 | 1,066 | 13,054 | 2,018 |
| Aug. | 25,456 | — | 1,223 | 1,656 | 874 | 4,064 | 465 | 1,224 | 13,683 | 2,267 |
| Sept. | 27,105 | — | 1,433 | 1,872 | 961 | 4,321 | 480 | 1,388 | 14,278 | 2,372 |
| Oct. | 29,150 | — | 1,605 | 2,074 | 1,099 | 4,789 | 484 | 1,549 | 15,029 | 2,521 |
| Nov. | 30,825 | — | 1,802 | 2,300 | 1,127 | 4,915 | 470 | 1,693 | 15,879 | 2,639 |
| Dec. | 33,304 | 3 | 2,076 | 2,556 | 1,201 | 5,303 | 468 | 1,857 | 17,044 | 2,796 |
| **1943** | | | | | | | | | | |
| Jan. | 35,710 | 3 | 2,305 | 2,753 | 1,308 | 5,490 | 511 | 2,109 | 18,338 | 2,893 |
| Feb. | 38,163 | 2 | 2,625 | 2,927 | 1,574 | 5,837 | 497 | 2,264 | 19,423 | 3,014 |
| Mar. | 41,184 | 2 | 3,029 | 3,309 | 1,601 | 6,415 | 545 | 2,984 | 20,325 | 2,974 |
| April | 44,216 | 2 | 3,518 | 3,630 | 1,614 | 7,110 | 514 | 3,472 | 21,239 | 3,127 |
| May | 46,534 | 2 | 3,954 | 3,890 | 1,572 | 7,617 | 487 | 3,823 | 22,145 | 3,044 |
| June | 49,018 | 2 | 4,421 | 4,242 | 1,689 | 8,010 | 486 | 4,268 | 22,849 | 3,051 |
| July | 51,783 | 3 | 4,921 | 4,415 | 1,786 | 8,749 | 458 | 4,648 | 23,345 | 3,458 |
| Aug. | 53,531 | 11 | 5,415 | 4,472 | 1,836 | 9,020 | 458 | 4,991 | 23,871 | 3,457 |
| Sept. | 55,720 | 21 | 5,974 | 4,473 | 1,867 | 9,442 | 547 | 5,405 | 24,339 | 3,652 |
| Oct. | 58,506 | 24 | 6,572 | 4,217 | 2,175 | 10,142 | 528 | 5,776 | 25,231 | 3,841 |
| Nov. | 61,190 | 47 | 7,288 | 4,144 | 2,235 | 10,948 | 582 | 6,138 | 25,819 | 3,989 |
| Dec. | 64,232 | 91 | 8,027 | 4,370 | 2,371 | 11,875 | 714 | 6,466 | 26,051 | 4,267 |
| **1944** | | | | | | | | | | |
| Jan. | 67,030 | 142 | 8,701 | 4,552 | 2,609 | 13,040 | 767 | 6,802 | 26,533 | 3,884 |
| Feb. | 70,043 | 196 | 9,278 | 4,754 | 2,660 | 14,103 | 797 | 7,264 | 26,997 | 3,994 |
| Mar. | 73,173 | 248 | 10,000 | 4,961 | 2,730 | 14,963 | 843 | 7,864 | 27,412 | 4,152 |
| April | 74,968 | 307 | 10,492 | 5,021 | 2,799 | 15,256 | 941 | 8,325 | 27,694 | 4,133 |
| May | 77,434 | 388 | 11,111 | 5,120 | 2,917 | 15,818 | 1,029 | 8,921 | 27,923 | 4,207 |
| June | 78,757 | 445 | 11,720 | 5,427 | 2,914 | 15,644 | 1,056 | 9,433 | 27,907 | 4,211 |
| July | 79,908 | 500 | 11,967 | 5,606 | 3,043 | 15,793 | 1,332 | 9,908 | 27,568 | 4,191 |
| Aug. | 79,660 | 564 | 12,255 | 6,246 | 3,249 | 16,019 | 1,475 | 10,196 | 26,085 | 3,571 |
| Sept. | 77,959 | 652 | 12,526 | 6,211 | 3,338 | 16,183 | 1,675 | 10,387 | 23,254 | 3,733 |
| Oct. | 74,522 | 748 | 12,590 | 6,262 | 3,202 | 16,646 | 1,763 | 10,384 | 19,786 | 3,141 |
| Nov. | 72,567 | 862 | 12,840 | 6,254 | 3,047 | 16,958 | 1,719 | 10,299 | 17,479 | 3,109 |
| Dec. | 72,726 | 977 | 12,813 | 6,189 | 2,980 | 17,198 | 1,804 | 10,456 | 17,060 | 3,249 |
| **1945** | | | | | | | | | | |
| Jan. | 71,430 | 1,151 | 12,844 | 6,208 | 2,813 | 17,332 | 1,866 | 10,237 | 15,840 | 3,139 |
| Feb. | 70,735 | 1,373 | 12,890 | 6,137 | 2,757 | 17,664 | 1,890 | 10,138 | 14,708 | 3,178 |
| Mar. | 70,583 | 1,613 | 12,883 | 6,094 | 2,753 | 17,708 | 1,950 | 9,955 | 14,124 | 3,503 |
| April | 69,581 | 1,852 | 12,919 | 6,022 | 2,750 | 17,440 | 2,007 | 9,540 | 13,494 | 3,557 |
| May | 69,089 | 2,083 | 12,718 | 5,869 | 2,844 | 17,725 | 2,009 | 9,367 | 12,873 | 3,601 |
| June | 68,398 | 2,374 | 12,221 | 5,576 | 3,063 | 17,703 | 1,990 | 9,473 | 12,581 | 3,417 |
| July | 65,795 | 2,624 | 11,778 | 5,523 | 3,002 | 17,279 | 1,977 | 9,593 | 10,671 | 3,348 |
| Aug. | 63,715 | 2,865 | 11,065 | 5,384 | 3,079 | 16,799 | 1,971 | 9,561 | 9,558 | 3,433 |

## U. S. NAVY SERVICE AIRCRAFT

**1941—1945**

**Including U. S. Marine Corps**

Source: U. S. Navy Office of Public Information

| Type | Dec. 31, 1941 | | Dec. 31, 1942 | | Dec. 31, 1943 | | Dec. 31, 1944 | | Nov. 30, 1945 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | On Hand | Acceptances | On Hand | Acceptances | On Hand | Acceptances | On Hand | Acceptances | On Hand | Acceptances |
| | *COMBAT* | | | | | | | | | |
| Fighter | 514 | 342 | 1,253 | 1,394 | 5,516 | 5,541 | 11,974 | 11,962 | 10,081 | 7,088 |
| Fighter (M) | 0 | 0 | 0 | 0 | 0 | 0 | 60 | 63 | 239 | 201 |
| Scout Bomber | 709 | 383 | 983 | 877 | 3,958 | 3,786 | 5,418 | 4,888 | 3,441 | 2,030 |
| Torpedo Bomber | 100 | 0 | 582 | 648 | 2,227 | 2,114 | 3,020 | 3,203 | 4,320 | 2,068 |
| Scout Observation | 682 | 499 | 1,594 | 1,114 | 1,512 | 255 | 1,104 | 231 | 819 | 539 |
| Patrol Bomber (HL) | 0 | 0 | 51 | 51 | 313 | 264 | 1,063 | 890 | 855 | 486 |
| Patrol Bomber (ML) | 18 | 20 | 102 | 90 | 809 | 831 | 1,207 | 649 | 865 | 525 |
| Patrol Bomber (HS) | 5 | 4 | 43 | 30 | 74 | 97 | 90 | 0 | 30 | 0 |
| Patrol Bomber (MS) | 0 | 0 | 0 | 0 | 0 | 0 | 1,602 | 661 | 1,430 | 500 |
| Patrol Bomber (MSM) | 20 | 10 | 136 | 122 | 389 | 317 | 0 | 0 | 0 | 0 |
| Patrol Bomber (MSY) | 423 | 203 | 690 | 512 | 836 | 441 | 0 | 0 | 0 | 0 |
| Total | 2,471 | 1,461 | 5,434 | 4,847 | 15,634 | 13,646 | 26,438 | 22,637 | 22,080 | 15,246 |
| | *TRANSPORT and UTILITY* | | | | | | | | | |
| Transport | 19 | 5 | 149 | 135 | 0 | 115[1] | 0 | 0 | 0 | 0 |
| Transport (HL) | 0 | 0 | 0 | 0 | 16 | 11 | 83 | 69 | 193 | 106 |
| Transport (ML) | 0 | 0 | 0 | 0 | 364 | 125 | 704 | 392 | 707 | 56 |
| Transport (HS) | 0 | 0 | 0 | 0 | 65 | 0 | 94 | 41 | 89 | 0 |
| Transport (MS) | 0 | 0 | 0 | 0 | 47 | 0 | 73 | 0 | 16 | 0 |
| Transport-Utility | 75 | 43 | 96 | 14 | 0 | 26[2] | 0 | 0 | 0 | 0 |
| Utility (M) | 0 | 0 | 0 | 0 | 433 | 317 | 662 | 272 | 852 | 314 |
| Utility | 168 | 69 | 231 | 87 | 151 | 35 | 829 | 212 | 1,085 | 236 |
| Transport (1 eng.) | 41 | 23 | 148 | 84 | 321 | 187 | 0 | 175[3] | 0 | 0 |
| Total | 303 | 140 | 624 | 320 | 1,397 | 816 | 2,445 | 1,161 | 2,942 | 712 |
| | *TRAINING* | | | | | | | | | |
| Scout Trainer | 727 | 647 | 0 | 0 | 4,057 | 2,871 | 4,544 | 1,479 | 4,254 | 435 |
| Scout Trainer (M) | 0 | 0 | 0 | 0 | 624 | 504 | 854 | 288 | 794 | 0 |
| Scout Trainer[3] | 0 | 0 | 142 | 143 | 0 | 0 | 0 | 0 | 0 | 0 |
| Scout Trainer[3] | 0 | 0 | 2,641 | 2,127 | 0 | 0 | 0 | 0 | 0 | 0 |
| Trainer | 1,732 | 1,251 | 2,931 | 1,418 | 3,560 | 2,252 | 2,507 | 46 | 2,340 | 0 |
| Total | 2,459 | 1,898 | 5,714 | 3,688 | 9,141 | 5,627 | 7,905 | 1,813 | 7,388 | 435 |
| Total Service Aircraft | 5,233 | 3,499 | 11,772 | 8,855 | 26,172 | 20,089 | 36,788 | 25,611 | 32,410 | 16,393 |

[1] VR to July, 1943.
[2] VJR to July, 1943.
[3] VG to May, 1944.
*Note*—M—medium, HL—heavy or 4-engine land plane, ML—medium or 2-engine land plane, HS—heavy or 4-engine seaplane, MS—medium or 2-engine seaplane, MSM—Martin seaplane, MSY—Consolidated Vultee seaplane.

## U. S. NAVY COMBAT SORTIES

### Including U. S. Marine Corps

### 1941—1945

Source: U. S. Navy Office of Public Information

Sorties by Naval and Marine Aircraft Involving Action Against Enemy Aircraft, Land Targets and Surface Shipping.

| *Year* | *Carrier-Based* | *Land-Based* | *Total* |
|---|---|---|---|
| 1941-42 | 2,673 | 2,604 | 5,277 |
| 1943 | 5,129 | 16,145 | 21,274 |
| 1944 | 68,807 | 66,915 | 135,722 |
| 1945 | 70,166 | 51,316 | 121,482 |
| Total | 146,775 | 136,980 | 283,755 |

## U. S. NAVY AIR COMBAT RECORD

### 1941—1945

### Including U. S. Marine Corps

Source: U. S. Navy Office of Public Information

| *Type of Operations and Year* | *Enemy Aircraft Destroyed in Aerial Combat* | | | *Our Losses in Aerial Combat Only* | *Ratio of Enemy Planes Shot Down to Our Losses* |
|---|---|---|---|---|---|
| | *Fighters and Float Planes* | *Bombers* | *Total* | | |
| Carrier-Based: | | | | | |
| 1941-42 | 179 | 203 | 382 | 114 | 3.4 : 1 |
| 1943 | 169 | 131 | 300 | 34 | 8.8 : 1 |
| 1944 | 2,396 | 900 | 3,296 | 184 | 17.9 : 1 |
| 1945 | 1,736 | 763 | 2,499 | 120 | 20.8 : 1 |
| Carrier Total | 4,480 | 1,997 | 6,477 | 452 | 14.3 : 1 |
| Land-Based: | | | | | |
| 1941-42 | 283 | 193 | 476 | 152 | 3.1 : 1 |
| 1943 | 762 | 177 | 939 | 199 | 4.7 : 1 |
| 1944 | 635 | 93 | 728 | 77 | 9.5 : 1 |
| 1945 | 367 | 295 | 662 | 26 | 25.5 : 1 |
| Land-Based Total | 2,047 | 758 | 2,805 | 454 | 6.2 : 1 |
| Total, All Navy and Marine: | | | | | |
| 1941-42 | 462 | 396 | 858 | 266 | 3.2 : 1 |
| 1943 | 931 | 308 | 1,239 | 233 | 5.3 : 1 |
| 1944 | 3,031 | 993 | 4,024 | 261 | 15.4 : 1 |
| 1945 | 2,103 | 1,058 | 3,161 | 146 | 21.6 : 1 |
| Grand Total | 6,527 | 2,755 | 9,282 | 906 | 10.2 : 1 |

*Note*—Land-based combat in 1943 was spread evenly throughout the year and involved F4Fs, F4Us and F6Fs, while carrier-based combat was concentrated principally in the last three months and involved largely F6Fs. Land-based combat in 1944 was principally in the Solomons in January and February, while carrier activity was spread throughout the year. Thus the apparent combat superiority of carrier-based planes may be at least partly explained by the less favorable conditions prevailing, and by the inferior plane types available at the time of the heaviest land-based operations.

## TOTAL DESTRUCTION OF ENEMY AIRCRAFT BY U. S. NAVY PLANES

### 1941—1945

### Including U. S. Marine Corps

Source: U. S. Navy Office of Public Information

| Year | By Carrier Planes | | | By Land-Based Planes | | | |
|---|---|---|---|---|---|---|---|
| | *In Aerial Combat* | *On Ground, Water, or Carrier*[1] | *Total* | *In Aerial Combat* | *On Ground, Water, or Carrier* | *Total* | *Grand Total* |
| 1941-42 | 382 | 290 | 672 | 476 | 8 | 484 | 1,156 |
| 1943 | 300 | 150 | 450 | 939 | 69 | 1,008 | 1,458 |
| 1944 | 3,296 | 2,740 | 6,036 | 728 | 127 | 855 | 6,891 |
| 1945 | 2,499 | 2,713 | 5,212 | 662 | 124 | 786 | 5,998 |
| Total | 6,477 | 5,893 | 12,370 | 2,805 | 328 | 3,133 | 15,503 |

[1] Preliminary, subject to later correction.

## AIR COMBAT RECORDS OF PRINCIPAL U. S. NAVY PLANES

### 1941—1945

Source: U. S. Navy Office of Public Information

(Includes Navy and Marine, Carrier-based and Land-based)

| *Model* | *Year* | *Enemy Planes Destroyed in Combat* | *Our Losses to Enemy Aircraft in Combat* | *Ratio of Enemy Losses to Our Losses* |
|---|---|---|---|---|
| F4F Wildcat | 1941-2 | 717 | 122 | 5.9 : 1 |
| | 1943 | 188 | 56 | 3.4 : 1 |
| FM Wildcat | 1944 | 235 | 12 | 19.6 : 1 |
| | 1945 | 187 | 1 | 187.0 : 1 |
| Total, Wildcat | | 1,327 | 191 | 6.9 : 1 |
| F4U Corsair (Including FG) | 1943 | 636 | 94 | 6.8 : 1 |
| | 1944 | 491 | 49 | 10.0 : 1 |
| | 1945 | 1,008 | 46 | 21.9 : 1 |
| Total, Corsair | | 2,135 | 189 | 11.3 : 1 |
| F6F Hellcat | 1943 | 320 | 35 | 9.1 : 1 |
| | 1944 | 3,040 | 155 | 19.6 : 1 |
| | 1945 | 1,796 | 80 | 22.5 : 1 |
| Total, Hellcat | | 5,156 | 270 | 19.1 : 1 |
| PB4Y Liberator (and Privateer) | 1943 | 39 | 10 | 3.9 : 1 |
| | 1944 | 131 | 8 | 16.4 : 1 |
| | 1945 | 134 | 7 | 19.1 : 1 |
| Total, PB4Y | | 304 | 25 | 12.2 : 1 |

## U. S. NAVY AIRCRAFT LOSSES ON ACTION SORTIES

### 1941—1945

### Including U. S. Marine Corps

Source: U. S. Navy Office of Public Information

(Excluding actions against enemy submarines)

| *Service Types and Years* | *Total Action Sorties* | *Losses on Action Sorties* | | | |
|---|---|---|---|---|---|
| | | *To Enemy Aircraft* | *To Enemy A/A* | *Operational* | *Total* |
| *Carrier-Based Fighters* | | | | | |
| 1942 | 938 | 43 | 15 | 23 | 81 |
| 1943 | 2,345 | 22 | 26 | 25 | 73 |
| 1944 | 37,805 | 161 | 305 | 214 | 680 |
| 1945 | 44,774 | 113 | 409 | 234 | 756 |
| Total | 85,862 | 339 | 755 | 496 | 1,590 |
| *Carrier-Based Bombers* | | | | | |
| 1942 | 1,735 | 71 | 32 | 45 | 148 |
| 1943 | 2,784 | 12 | 18 | 26 | 56 |
| 1944 | 31,002 | 23 | 351 | 273 | 647 |
| 1945 | 25,392 | 7 | 270 | 160 | 437 |
| Total | 60,913 | 113 | 671 | 504 | 1,288 |
| *Land-Based Fighters* | | | | | |
| 1941-2 | 1,089 | 93 | 3 | 13 | 109 |
| 1943 | 4,295 | 163 | 24 | 37 | 224 |
| 1944 | 34,048 | 55 | 114 | 77 | 246 |
| 1945 | 21,171 | 14 | 92 | 71 | 177 |
| Total | 60,603 | 325 | 233 | 198 | 756 |
| *Land-Based Dive and Torpedo Bombers* | | | | | |
| 1941-2 | 1,405 | 27 | 20 | 16 | 63 |
| 1943 | 10,971 | 22 | 54 | 33 | 109 |
| 1944 | 25,782 | 5 | 86 | 25 | 116 |
| 1945 | 21,431 | 3 | 25 | 24 | 52 |
| Total | 59,589 | 57 | 185 | 98 | 340 |
| *Patrol Bombers* | | | | | |
| 1941-2 | 110[1] | 32 | 6 | 3 | 41 |
| 1943 | 879 | 14 | 8 | 9 | 31 |
| 1944 | 7,085 | 17 | 48 | 15 | 80 |
| 1945 | 8,714 | 9 | 74 | 22 | 105 |
| Total | 16,788 | 72 | 136 | 49 | 257 |
| *All Types Combined* | | | | | |
| 1941-2 | 5,277 | 266 | 76 | 100 | 442 |
| 1943 | 21,274 | 233 | 130 | 130 | 493 |
| 1944 | 135,722 | 261 | 904 | 604 | 1,769 |
| 1945 | 121,482 | 146 | 870 | 511 | 1,527 |
| Total | 283,755 | 906 | 1,080 | 1,345 | 4,231 |

[1] Incomplete. Reports of action from some units are not available.

## U. S. NAVY AIRCRAFT CARRIER STRENGTH BY YEARS

### 1941—1945

Source: U. S. Navy Office of Public Information

| *Year and Type* | *U. S. Navy Carrier Strength* | | | *Transferred to United Kingdom* | |
|---|---|---|---|---|---|
| | *No.* | *Standard Tonnage* | *Plane Capacity*[1] | *No.* | *Tonnage* |
| **1941** | | | | | |
| Battle Carriers | 0 | 0 | 0 | 0 | 0 |
| Carriers | 7 | 147,000 | 630 | 0 | 0 |
| Light Carriers | 0 | 0 | 0 | 0 | 0 |
| Escort Carriers | 1 | 7,866 | 25 | 0 | 0 |
| Total | 8 | 154,866 | 655 | | |
| **1942** | | | | | |
| Battle Carriers | 0 | 0 | 0 | 0 | 0 |
| Carriers | 4 | 94,500 | 360 | 0 | 0 |
| Light Carriers | 0 | 0 | 0 | 0 | 0 |
| Escort Carriers | 12[3] | 110,686 | 300 | 4 | 31,200 |
| Total | 16 | 205,186 | 660 | | |
| **1943** | | | | | |
| Battle Carriers | 0 | 0 | 0 | 0 | 0 |
| Carriers | 13 | 257,100 | 1170 | 0 | 0 |
| Light Carriers | 9 | 90,000 | 360 | 0 | 0 |
| Escort Carriers | 35[4] | 204,089 | 875 | 28 | 229,593 |
| Total | 57 | 560,189 | 2405 | | |
| **1944** | | | | | |
| Battle Carriers | 0 | 0 | 0 | 0 | 0 |
| Carriers | 20 | 446,800 | 1800 | 0 | 0 |
| Light Carriers | 8 | 88,000 | 320 | 0 | 0 |
| Escort Carriers | 65[5] | 415,519 | 1625 | 5 | 41,665 |
| Total | 93 | 950,319 | 3745 | | |
| **1945**[2] | | | | | |
| Battle Carriers | 1[6] | 45,000 | 120 | 0 | 0 |
| Carriers | 23 | 528,100 | 2070 | 0 | 0 |
| Light Carriers | 8 | 88,000 | 320 | 0 | 0 |
| Escort Carriers | 72[7] | 510,050 | 1800 | 0 | 0 |
| Total | 104 | 1,171,150 | 4310 | | |

[1] Based on average number of planes by carriers.
[2] Through October, 1945.
[3] Carriers Hornet, Lexington, Yorktown and Wasp sunk during 1942.
[4] Escort carrier Liscome Bay sunk during 1943.
[5] Light carrier Princeton and escort carriers Block Island, Gambier Bay and St. Lo sunk during 1944.
[6] On February 1, 1946, the U. S. Navy had three battle carriers, Franklin D. Roosevelt, Midway and Coral Sea.
[7] Escort carriers Ommaney Bay and Bismarck Sea sunk during 1945.

# U. S. NAVY AVIATION PERSONNEL DURING WORLD WAR II

July 1, 1940—August 31, 1945
Source: Report of the Secretary of the Navy 1945
(Including Marine Corps and Coast Guard)

| Service and Type of Personnel | 1940 | | 1941 | | 1942 | | 1943 | | 1944 | | 1945 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | July 1 | Dec. 31 | June 30 | Dec. 31 | June 30 | Dec. 31 | June 30 | Dec. 31 | June 30 | Dec. 31 | Aug. 31 |
| Total Navy, Marine Corps and Coast Guard | 10,923 | 14,399 | 19,298 | 29,402 | 57,090 | 122,172 | 205,958 | 284,452 | 354,433 | 400,147 | 437,524 |
| Officers | 2,745 | 3,759 | 4,926 | 7,724 | 16,404 | 30,191 | 49,122 | 65,540 | 78,785 | 88,001 | 93,100 |
| Pilots | 2,559 | 3,268 | 3,936 | 5,900 | 10,343 | 16,269 | 25,745 | 36,862 | 47,783 | 55,294 | 60,273 |
| Non-Pilots | 186 | 491 | 990 | 1,824 | 6,061 | 13,922 | 23,377 | 28,678 | 31,002 | 32,707 | 32,827 |
| Enlisted | 8,178 | 10,640 | 14,372 | 21,678 | 40,686 | 91,981 | 156,836 | 218,912 | 275,648 | 312,146 | 344,424 |
| Pilots | 406 | 654 | 681 | 850 | 817 | 1,036 | 906 | 905 | 516 | 662 | 474 |
| Non-Pilots | 7,772 | 9,986 | 13,691 | 20,828 | 39,869 | 90,945 | 155,930 | 218,007 | 275,132 | 311,484 | 343,950 |
| Navy | 8,621 | 11,050 | 15,413 | 22,583 | 42,309 | 90,911 | 147,147 | 198,555 | 246,920 | 288,392 | 326,410 |
| Officers | 2,348 | 3,250 | 4,365 | 6,961 | 14,671 | 26,541 | 41,594 | 53,636 | 63,667 | 72,165 | 77,233 |
| Pilots | 2,203 | 2,825 | 3,422 | 5,225 | 8,977 | 13,933 | 20,728 | 28,449 | 37,181 | 44,638 | 49,615 |
| Non-Pilots | 145 | 425 | 943 | 1,736 | 5,694 | 12,608 | 20,866 | 25,187 | 26,486 | 27,527 | 27,618 |
| Enlisted | 6,273 | 7,800 | 11,048 | 15,622 | 27,638 | 64,370 | 105,553 | 144,919 | 183,253 | 216,227 | 249,177 |
| Pilots | 349 | 596 | 609 | 774 | 691 | 849 | 695 | 721 | 381 | 488 | 335 |
| Non-Pilots | 5,924 | 7,204 | 10,439 | 14,848 | 26,947 | 63,521 | 104,858 | 144,198 | 182,872 | 215,739 | 248,842 |
| Marine Corps | 2,043 | 3,057 | 3,583 | 6,467 | 14,297 | 30,553 | 57,934 | 84,530 | 106,109 | 110,245 | 109,527 |
| Officers | 321 | 427 | 480 | 679 | 1,629 | 3,483 | 7,317 | 11,678 | 14,822 | 15,469 | 15,385 |
| Pilots | 304 | 385 | 453 | 610 | 1,284 | 2,240 | 4,898 | 8,266 | 10,416 | 10,355 | 10,224 |
| Non-Pilots | 17 | 42 | 27 | 69 | 345 | 1,243 | 2,419 | 3,412 | 4,406 | 5,114 | 5,161 |
| Enlisted | 1,722 | 2,630 | 3,103 | 5,788 | 12,668 | 27,070 | 50,617 | 72,852 | 91,287 | 94,776 | 94,142 |
| Pilots | 45 | 40 | 52 | 49 | 85 | 131 | 132 | 93 | 41 | 86 | 46 |
| Non-Pilots | 1,677 | 2,590 | 3,051 | 5,739 | 12,583 | 26,939 | 50,485 | 72,759 | 91,246 | 94,690 | 94,096 |
| Coast Guard | 259 | 292 | 302 | 352 | 484 | 708 | 877 | 1,367 | 1,404 | 1,510 | 1,587 |
| Officers | 76 | 82 | 81 | 84 | 104 | 167 | 211 | 226 | 296 | 367 | 482 |
| Pilots | 52 | 58 | 61 | 65 | 82 | 96 | 119 | 147 | 186 | 301 | 434 |
| Non-Pilots | 24 | 24 | 20 | 19 | 22 | 71 | 92 | 79 | 110 | 66 | 48 |
| Enlisted | 183 | 210 | 221 | 268 | 380 | 541 | 666 | 1,141 | 1,108 | 1,143 | 1,105 |
| Pilots | 12 | 18 | 20 | 27 | 41 | 56 | 79 | 91 | 94 | 88 | 93 |
| Non-Pilots | 171 | 192 | 201 | 241 | 339 | 485 | 587 | 1,050 | 1,014 | 1,055 | 1,012 |

## U. S. NAVY AIR TRANSPORT

### 1942—1945

### Including Contract Operations

Source: U. S. Navy Office of Public Information

| *December 31, Each Year* | *1942*[1] | *1943*[2] | *1944* | *1945* |
|---|---|---|---|---|
| Number of planes in operation, peak month | 94 | 179 | 351 | 435 |
| Plane miles flown | 3,592,000 | 20,542,490 | 778,223,764 | 110,157,217 |
| Passengers loaded | 25,151 | 184,719 | 549,393 | 776,745 |
| Cargo and mail loaded (ZBNS) | 4,527 | 52,397 | 76,665 | 100,258 |
| Miles of routes (peak month) | 37,400 | 62,200 | 76,500 | 63,250 |
| Cargo and mail ton miles | 7,609,298 | 48,183,000 | 136,590,328 | 207,179,553 |
| Total ton miles | 8,927,174 | 68,900,000 | 209,473,181 | 344,668,941 |

[1] Figures for 1942 estimated because of incomplete records.
[2] Figures for 1943 include estimates for months Jan.-May inclusive because of incomplete records.

## U. S. NAVY AVIATION TRAINING

### 1942—1945

Source: U. S. Navy Office of Public Information

| | *1942* | *1943* | *1944* | *1945* |
|---|---|---|---|---|
| Pilots trained | 6,610[1] | 20,842 | 21,067 | 7,147[2] |
| Enlisted (includes only trained rated personnel) | 28,087[1] | 70,637 | 72,045 | 24,490[3] |

*Note*—In addition, 4,282 officer-navigators trained between January, 1943, and September, 1945. Figures on other ground officers not available.
[1] July 1 to December 31 only.
[2] Through August, 1945.
[3] Through October, 1945.

## 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 | — | 85,946 | 85,946 |
| 1944 | — | 96,369 | 96,369 |
| 1945 | — | 47,713 | 47,713 |

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.

## MILITARY AIRCRAFT PRODUCTION IN THE UNITED STATES

## NUMBERS AND WEIGHT[1] BY MONTHS

1941—1945

From Statistical Service, Aircraft Industries Association of America

(Weight in millions of pounds)

| *Month* | *1941*[1] | | *1942*[1] | | *1943*[2] | | *1944*[2] | | *1945*[3] | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Units* | *Weight* | *Units* | *Weight* | *Units* | *Weight* | *Units* | *Weight* | *Units* | *Weight* |
| January | 1,016 | 3.5 | 2,980 | 12.6 | 5,013 | 30.3 | 8,789 | 78.5 | 6,531 | 72.2 |
| February | 962 | 4.0 | 3,099 | 14.0 | 5,453 | 35.5 | 8,760 | 81.4 | 6,294 | 71.2 |
| March | 1,135 | 4.2 | 3,497 | 16.0 | 6,264 | 41.0 | 9,117 | 89.1 | 7,035 | 79.1 |
| April | 1,388 | 5.6 | 3,501 | 15.3 | 6,472 | 45.6 | 8,343 | 82.4 | 6,410 | 73.6 |
| May | 1,331 | 5.2 | 3,989 | 19.0 | 7,114 | 50.5 | 8,902 | 89.8 | 6,350 | 71.6 |
| June | 1,477 | 5.6 | 3,734 | 19.4 | 7,094 | 53.6 | 8,049 | 84.4 | 5,785 | 65.1 |
| July | 1,461 | 5.4 | 4,109 | 22.3 | 7,373 | 56.0 | 8,000 | 80.5 | 4,730 | 52.9 |
| August | 1,853 | 7.1 | 4,281 | 23.5 | 7,612 | 59.5 | 7,939 | 79.7 | 2,866 | 34.7 |
| September | 1,914 | 7.6 | 4,307 | 25.7 | 7,598 | 61.4 | 7,597 | 78.9 | 765 | 11.8 |
| October | 2,273 | 8.7 | 4,063 | 24.1 | 8,362 | 66.7 | 7,420 | 75.4 | 457 | 3.5 |
| November | 2,051 | 8.0 | 4,812 | 28.2 | 8,789 | 71.2 | 6,747 | 71.6 | 248 | 1.6 |
| December | 2,429 | 11.2 | 5,501 | 33.0 | 8,802 | 74.6 | 6,697 | 71.5 | 242 | 1.8 |
| Total | 19,290 | 76.1 | 47,873 | 253.1 | 85,946 | 645.9 | 96,369 | 963.2 | 47,713 | 539.3 |

[1] Excluding spare parts.
[2] Source: Aircraft Resources Control Board, Report 15.
[3] Army Air Forces, Office of Plans and Policies.

## MILITARY AIRCRAFT PRODUCTION IN THE UNITED STATES
## NUMBERS AND WEIGHT[1] BY TYPES

1941—1945

From Statistical Service, Aircraft Industries Association of America

(Weight in millions of pounds)

| | *1941* | | *1942* | | *1943* | | *1944* | | *1945* | | *Total 1941-1945* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Units* | *Weight* | *Units* | *Weight* | *Units* | *Weight* | *Units* | *Weight* | *Units* | *Weight* | *Units* | *Weight* |
| Bombers | 4,119 | 40.6 | 12,637 | 163.0 | 29,362 | 425.1 | 35,008 | 611.1 | 16,491 | 331.1 | 97,617 | 1,570.9 |
| Fighters & Naval Reconnaissance | 4,040 | 17.8 | 12,240 | 54.1 | 24,730 | 126.3 | 39,133 | 217.8 | 21,554 | 124.6 | 102,606 | 540.6 |
| Transports | 533 | 3.8 | 1,984 | 18.5 | 7,013 | 55.4 | 9,854 | 113.7 | 4,611 | 75.5 | 23,995 | 266.7 |
| Trainers | 9,366 | 18.1 | 17,632 | 39.2 | 19,942 | 47.1 | 7,578 | 19.0 | 1,309 | 3.4 | 55,827 | 126.8 |
| Naval Reconnaissance Communication & Special Purpose | 501 | .9 | 3,367 | 2.0 | 4,874 | 3.4 | 4,783 | 3.9 | 3,748 | 4.7 | 17,273 | 14.9 |
| Total All Planes | 19,459 | 81.2 | 47,860 | 276.6 | 85,930 | 657.3 | 96,356 | 965.5 | 47,713 | 539.3 | 297,318 | 2,519.9 |

[1] Airframe weight excludes spare parts.
Source: 1941-1944—Aircraft Resources Control Board, Report 15. 1945—Army Air Forces, Office of Plans and Policies.

## WAR PRODUCTION OF AIRCRAFT ENGINES
## IN THE UNITED STATES

1941—1945

From Statistical Service, Aircraft Industries Association of America

| Month | 1941 | | 1942 | | 1943 | | 1944 | | 1945 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *No. of Eng.* | *Horsepower in Thousands (incl. spares)* | *No. of Eng.* | *Horsepower in Thousands (incl. spares)* | *No. of Eng.* | *Horsepower in Thousands (incl. spares)* | *No. of Eng.* | *Horsepower in Thousands (incl. spares)* | *No. of Eng.* | *Horsepower in Thousands (incl. spares)* |
| January (est.) | 3,375 | 2,557 | 7,128 | 7,464 | 16,011 | 21,682 | 22,627 | 36,098 | 17,324 | 32,805 |
| February | 3,350 | 2,890 | 7,548 | 8,018 | 15,328 | 21,682 | 21,067 | 35,079 | 15,684 | 29,715 |
| March | 3,304 | 3,269 | 8,980 | 9,754 | 16,930 | 23,921 | 23,023 | 39,235 | 16,669 | 31,802 |
| April | 3,552 | 3,607 | 10,095 | 11,081 | 16,838 | 24,273 | 22,681 | 37,403 | 14,017 | 27,721 |
| May | 3,515 | 3,652 | 10,795 | 12,114 | 17,869 | 25,903 | 22,819 | 38,126 | 14,427 | 27,017 |
| June | 3,873 | 3,703 | 11,748 | 13,637 | 17,735 | 26,632 | 23,072 | 38,502 | 11,251 | 24,801 |
| July | 4,817 | 4,578 | 11,869 | 15,012 | 18,753 | 28,644 | 22,603 | 36,570 | 10,693 | 23,206 |
| August | 5,268 | 4,761 | 12,890 | 17,262 | 19,688 | 30,900 | 24,102 | 39,879 | 6,288 | 9,151[5] |
| September | 4,858 | 4,778 | 13,210 | 18,396 | 20,585 | 32,110 | 20,881 | 35,293 | 1,037 | 2,431[5] |
| October | 4,957 | 4,902 | 13,683 | 18,297 | 21,850 | 33,671 | 19,268 | 30,668 | 611 | 761[5] |
| November | 5,885 | 5,855 | 14,181 | 20,149 | 22,680 | 35,433 | 17,235 | 31,716 | 215 | 125[5] |
| December | 6,095 | 6,117 | 14,926 | 21,382 | 22,388 | 35,761 | 16,293 | 30,017 | 85 | 19.5[5] |
| Total | 52,633[1] | 50,747 | 136,851[2] | 172,566 | 226,561[3] | 350,538 | 256,571[4] | 428,606 | 100,201 | 200,550.5 |

[1] Plus 4,467 engines for ordnance and additional spare parts.
[2] Plus 10,597 engines for ordnance and an additional engine equivalent of 22,667 of spare parts.
[3] Plus 8,479 ordnance and an additional engine equivalent of 77,257 of spare parts.
[4] Plus 5,800 engines for ordnance and an additional engine equivalent of 58,897 spare parts.
[5] Calculated by Aircraft Industries Association on a unit basis. Does not include spares.

Source: 1941-1944—Aircraft Resources Control Office, Report 15. 1945—Army Air Forces, Office of Plans and Policies.

## PRODUCTION OF AIRCRAFT PROPELLERS IN THE UNITED STATES

1941—1945

From Statistical Service, Aircraft Industries Association of America

| *Month* | *1941* | *1942* | | | *1943* | | | *1944* | | | *1945* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Total Blade* | *Steel Blade* | *Dural Blade* | *Total Blade* | *Steel Blade* | *Dural Blade* | *Total Blade* | *Steel Blade* | *Dural Blade* | *Total Blade* | *Steel Blade* | *Dural Blade* | *Total Blade* |
| January | 2,111 | 762 | 5,826 | 6,588 | 2,079 | 10,130 | 12,209 | 1,656 | 20,847 | 22,503 | 2,401 | 13,535 | 15,936 |
| February | 1,912 | 667 | 4,578 | 5,245 | 2,149 | 10,554 | 12,703 | 1,541 | 20,822 | 22,363 | 2,417 | 12,713 | 15,130 |
| March | 2,524 | 2,456 | 4,621 | 7,077 | 2,797 | 11,616 | 14,413 | 1,697 | 20,445 | 22,142 | 3,079 | 12,745 | 15,824 |
| April | 2,419 | 1,154 | 7,220 | 8,374 | 2,938 | 12,779 | 15,717 | 2,058 | 19,375 | 21,433 | 3,089 | 11,405 | 14,494 |
| May | 2,612 | 1,503 | 7,221 | 8,724 | 2,668 | 13,279 | 15,947 | 2,099 | 19,873 | 21,972 | 2,952 | 10,267 | 13,219 |
| June | 2,829 | 1,395 | 8,231 | 9,626 | 2,272 | 14,603 | 16,875 | 2,792 | 18,988 | 21,780 | 2,546 | 7,787 | 10,333 |
| July | 2,987 | 1,079 | 8,543 | 9,622 | 2,526 | 16,784 | 19,310 | 2,725 | 16,475 | 19,200 | 2,100 | 6,373 | 8,473 |
| August | 3,434 | 1,254 | 8,337 | 9,591 | 2,494 | 17,772 | 20,266 | 2,965 | 18,035 | 21,000 | 486 | 3,893 | 4,379 |
| September | 4,171 | 1,213 | 8,697 | 9,910 | 2,234 | 18,179 | 20,413 | 2,544 | 17,102 | 19,646 | N.A. | N.A. | N.A. |
| October | 4,449 | 2,176 | 8,787 | 10,963 | 2,004 | 20,270 | 22,274 | 2,987 | 14,503 | 17,490 | N.A. | N.A. | N.A. |
| November | 4,411 | 1,586 | 8,419 | 10,005 | 1,797 | 19,548 | 21,345 | 2,867 | 14,477 | 17,344 | N.A. | N.A. | N.A. |
| December | 5,142 | 1,602 | 9,952 | 11,554 | 1,554 | 20,911 | 22,465 | 2,869 | 13,908 | 16,777 | N.A. | N.A. | N.A. |
| Total | 39,001 | 16,847 | 90,432 | 107,279 | 27,512 | 186,425 | 213,937 | 28,780 | 214,960 | 243,740 | 19,070 | 78,718 | 97,788 |

N.A. Not available.
Source: 1941-1944—Aircraft Resources Control Office, Report 15. 1945—Army Air Forces, Office of Plans and Policies.

## U. S. ARMY AIR FORCES AIRPLANE ARRIVALS OVERSEAS FROM UNITED STATES BY THEATER AND TYPE

December 1941—August 1945

Source: U. S. Army Air Forces Office of Statistical Control

| Theater and Type of Airplane | Total | 1941 (Dec.) | 1942 | 1943 | 1944 | 1945 (Jan.-Aug.) |
|---|---|---|---|---|---|---|
| *All Theaters—Total* | 76,076 | 212 | 5,374 | 16,149 | 37,018 | 17,323 |
| Very Heavy Bombers | 1,751 | — | — | — | 539 | 1,212 |
| Heavy Bombers | 18,774 | 18 | 955 | 4,289 | 10,740 | 2,772 |
| Medium & Light Bombers | 8,982 | — | 749 | 2,492 | 4,247 | 1,494 |
| Fighters | 31,273 | 190 | 2,812 | 6,729 | 14,113 | 7,429 |
| Transports | 6,895 | 4 | 474 | 1,453 | 3,464 | 1,500 |
| Reconnaissance | 3,138 | — | 168 | 729 | 1,311 | 930 |
| Communications | 5,263 | — | 216 | 457 | 2,604 | 1,986 |
| *European Theater—Total* | 31,359 | — | 1,414 | 5,881 | 18,613 | 5,451 |
| Heavy Bombers | 10,587 | — | 632 | 2,682 | 6,304 | 1,239 |
| Medium & Light Bombers | 2,991 | — | 161 | 551 | 1,838 | 441 |
| Fighters | 12,333 | — | 577 | 2,083 | 7,123 | 2,550 |
| Transports | 2,567 | — | 183 | 247 | 1,789 | 348 |
| Reconnaissance | 928 | — | 59 | 236 | 469 | 164 |
| Communications | 1,953 | — | 72 | 82 | 1,090 | 709 |
| *Mediterranean Theater—Total* | 16,290 | — | 618 | 4,916 | 8,538 | 2,218 |
| Heavy Bombers | 4,907 | — | 87 | 720 | 3,377 | 723 |
| Medium & Light Bombers | 2,473 | — | 132 | 1,054 | 1,046 | 241 |
| Fighters | 6,727 | — | 324 | 2,334 | 3,098 | 971 |
| Transports | 990 | — | 52 | 565 | 266 | 107 |
| Reconnaissance | 484 | — | 23 | 166 | 245 | 50 |
| Communications | 709 | — | — | 77 | 506 | 126 |
| *Pacific Ocean Areas—Total* | 4,344 | 142 | 418 | 495 | 1,310 | 1,979 |
| Heavy Bombers | 705 | 18 | 167 | 138 | 222 | 160 |
| Medium & Light Bombers | 364 | — | 33 | 91 | 90 | 150 |
| Fighters | 2,466 | 120 | 198 | 231 | 726 | 1,191 |
| Transports | 269 | 4 | 9 | 20 | 86 | 150 |
| Reconnaissance | 165 | — | — | — | 55 | 110 |
| Communications | 375 | — | 11 | 15 | 131 | 218 |
| *Far East Air Forces—Total* | 12,844 | 70 | 1,652 | 2,948 | 4,209 | 3,965 |
| Heavy Bombers | 1,715 | — | 171 | 473 | 591 | 480 |
| Medium & Light Bombers | 2,149 | — | 259 | 562 | 861 | 467 |
| Fighters | 5,515 | 70 | 1,070 | 1,232 | 1,648 | 1,495 |
| Transports | 1,486 | — | 76 | 437 | 539 | 434 |
| Reconnaissance | 816 | — | 36 | 142 | 252 | 386 |
| Communications | 1,163 | — | 40 | 102 | 318 | 703 |
| *China & India-Burma—Total* | 6,842 | — | 375 | 1,147 | 3,306 | 2,014 |
| Heavy Bombers | 589 | — | 54 | 237 | 170 | 128 |
| Medium & Light Bombers | 724 | — | 55 | 105 | 370 | 194 |
| Fighters | 3,054 | — | 190 | 517 | 1,378 | 969 |
| Transports | 1,187 | — | 63 | 94 | 622 | 408 |
| Reconnaissance | 468 | — | 13 | 60 | 258 | 137 |
| Communications | 820 | — | — | 134 | 508 | 178 |
| *Alaska—Total* | 915 | — | 447 | 222 | 106 | 140 |
| Heavy Bombers | 100 | — | 54 | 24 | 13 | 9 |
| Medium & Light Bombers | 152 | — | 77 | 43 | 32 | — |
| Fighters | 493 | — | 249 | 111 | 18 | 115 |
| Transports | 109 | — | 43 | 35 | 19 | 12 |
| Reconnaissance | 22 | — | 9 | 4 | 5 | 4 |
| Communications | 39 | — | 15 | 5 | 19 | — |
| *Twentieth Air Force—Total* | 1,986 | — | — | — | 676 | 1,310 |
| Very Heavy Bombers | 1,751 | — | — | — | 539 | 1,212 |
| Heavy Bombers | 33 | — | — | — | 14 | 19 |
| Medium & Light Bombers | — | — | — | — | — | — |
| Fighters | — | — | — | — | — | — |
| Transports | 118 | — | — | — | 102 | 16 |
| Reconnaissance | 84 | — | — | — | 21 | 63 |
| Communications | — | — | — | — | — | — |
| *Other Overseas—Total* | 1,496 | — | 450 | 540 | 260 | 246 |
| Heavy Bombers | 138 | — | 60 | 15 | 49 | 14 |
| Medium & Light Bombers | 129 | — | 32 | 86 | 10 | 1 |
| Fighters | 685 | — | 204 | 221 | 122 | 138 |
| Transports | 169 | — | 48 | 55 | 41 | 25 |
| Reconnaissance | 171 | — | 28 | 121 | 6 | 16 |
| Communications | 204 | — | 78 | 42 | 32 | 52 |

## USE OF TRANSPORT AIRPLANES BY AIR TRANSPORT COMMAND U. S. ARMY AIR FORCES

October 1943—August 1945

Source: U. S. Army Air Forces Office of Statistical Control

| Year and Month | Average Number of Airplanes Assigned[1] | Thousands of Hours Flown | Average Hours Flown Per Airplane Per Day | Percent of Total Hours Flown: In Transport Operations | In Training Operations | In Other Operations |
|---|---|---|---|---|---|---|
| | | | TOTAL AIRPLANES | | | |
| 1943 | | | | | | |
| Oct. | 873 | 109.5 | 4.0 | 74 | 21 | 5 |
| Nov. | 1,267 | 125.6 | 3.3 | 61 | 31 | 8 |
| Dec. | 1,334 | 129.9 | 3.1 | 70 | 21 | 9 |
| 1944 | | | | | | |
| Jan. | 1,448 | 138.6 | 3.1 | 70 | 21 | 9 |
| Feb. | 1,549 | 147.2 | 3.3 | 72 | 23 | 5 |
| Mar. | 1,642 | 167.7 | 3.3 | 68 | 25 | 7 |
| April | 1,723 | 173.5 | 3.3 | 69 | 25 | 6 |
| May | 1,878 | 206.5 | 3.5 | 67 | 27 | 6 |
| June | 2,041 | 234.0 | 3.8 | 64 | 29 | 7 |
| July | 2,161 | 269.7 | 4.0 | 68 | 26 | 6 |
| Aug. | 2,287 | 289.6 | 4.1 | 73 | 21 | 6 |
| Sept. | 2,272 | 286.7 | 4.2 | 74 | 19 | 7 |
| Oct. | 2,342 | 318.7 | 4.4 | 74 | 20 | 6 |
| Nov. | 2,519 | 312.5 | 4.1 | 77 | 18 | 5 |
| Dec. | 2,614 | 314.9 | 3.9 | 78 | 17 | 5 |
| 1945 | | | | | | |
| Jan. | 2,658 | 339.4 | 4.1 | 79 | 16 | 5 |
| Feb. | 2,684 | 331.2 | 4.4 | 79 | 15 | 6 |
| Mar. | 2,735 | 398.0 | 4.7 | 79 | 16 | 5 |
| April | 2,820 | 418.6 | 4.9 | 79 | 16 | 5 |
| May | 2,830 | 435.3 | 4.9 | 77 | 18 | 5 |
| June | 3,129 | 453.3 | 4.8 | 76 | 19 | 5 |
| July | 3,275 | 514.8 | 5.1 | 76 | 19 | 5 |
| Aug. | 3,354 | 492.6 | 4.7 | 77 | 18 | 5 |
| | | | MAJOR TRANSPORTS | | | |
| 1943 | | | | | | |
| Oct. | 715 | 102.1 | 4.6 | 79 | 18 | 3 |
| Nov. | 730 | 99.3 | 4.5 | 77 | 15 | 8 |
| Dec. | 727 | 107.0 | 4.7 | 83 | 8 | 9 |
| 1944 | | | | | | |
| Jan. | 787 | 114.4 | 4.7 | 84 | 8 | 8 |
| Feb. | 832 | 120.5 | 5.0 | 86 | 10 | 4 |
| Mar. | 886 | 134.0 | 4.9 | 83 | 11 | 6 |
| April | 869 | 136.9 | 5.3 | 85 | 9 | 6 |
| May | 1,014 | 164.0 | 5.2 | 82 | 13 | 5 |
| June | 1,167 | 186.6 | 5.3 | 79 | 15 | 6 |
| July | 1,258 | 221.2 | 5.7 | 81 | 15 | 4 |
| Aug. | 1,446 | 252.7 | 5.6 | 83 | 13 | 4 |
| Sept. | 1,524 | 253.5 | 5.5 | 84 | 12 | 4 |
| Oct. | 1,608 | 286.7 | 5.8 | 83 | 14 | 3 |
| Nov. | 1,825 | 286.1 | 5.2 | 84 | 13 | 3 |
| Dec. | 1,950 | 292.2 | 4.8 | 83 | 13 | 4 |
| 1945 | | | | | | |
| Jan. | 2,013 | 318.3 | 5.1 | 84 | 12 | 4 |
| Feb. | 2,086 | 313.2 | 5.4 | 84 | 12 | 4 |
| Mar. | 2,151 | 375.0 | 5.6 | 84 | 13 | 3 |
| April | 2,239 | 393.8 | 5.9 | 84 | 13 | 3 |
| May | 2,291 | 405.4 | 5.7 | 82 | 14 | 4 |
| June | 2,394 | 426.9 | 5.5 | 81 | 16 | 3 |
| July | 2,708 | 486.1 | 5.8 | 81 | 16 | 3 |
| Aug. | 2,789 | 468.4 | 5.4 | 81 | 16 | 3 |

[1] Excludes airplanes enroute.

## TOTAL TRANSPORT OPERATIONS
## AIR TRANSPORT COMMAND
## U. S. ARMY AIR FORCES

July 1942—August 1945

Source: U. S. Army Air Forces Office of Statistical Control

| Year and Month | Number of Passengers | Tons Carried | | | | Millions of Ton Miles | Millions of Passenger Miles | Millions of Airplane Miles | Thousands of Hours Flown |
|---|---|---|---|---|---|---|---|---|---|
| | | Total | Passengers | Mail | Other Cargo | | | | |
| Grand Total | 2,957,454[1] | 1,407,661[1] | 314,585[1] | 92,597[1] | 1,000,479[1] | 2,369.4 | 6,937.3 | 935.0 | 5,638.2 |
| *Annually* | | | | | | | | | |
| 1942 (July-Dec.) | | Not Available | | | | 64.4 | 157.7 | 31.3 | 191.5 |
| 1943 | | | | | | 320.4 | 883.5 | 128.6 | 775.2 |
| 1944 | 1,256,714 | 575,624 | 136,072 | 41,478 | 398,074 | 857.5 | 2,439.7 | 340.7 | 2,053.6 |
| 1945 (Jan.-Aug.) | 1,700,740 | 832,037 | 178,513 | 51,119 | 602,405 | 1,127.1 | 3,456.4 | 434.4 | 2,617.9 |
| *Monthly* | | | | | | | | | |
| 1942 | | | | | | | | | |
| July | | | | | | 6.5 | 15.7 | 4.6 | 28.0 |
| Aug. | | | | | | 8.1 | 18.5 | 4.7 | 29.3 |
| Sept. | | | | | | 8.4 | 16.8 | 4.4 | 26.7 |
| Oct. | | | | | | 12.5 | 30.5 | 5.9 | 35.8 |
| Nov. | | | | | | 13.5 | 33.3 | 5.7 | 34.8 |
| Dec. | | | | | | 15.4 | 42.9 | 6.0 | 36.9 |
| 1943 | | | | | | | | | |
| Jan. | | | | | | 15.5 | 40.3 | 6.7 | 41.0 |
| Feb. | | | | | | 17.1 | 44.6 | 7.5 | 45.6 |
| Mar. | | | | | | 21.8 | 51.9 | 8.5 | 52.0 |
| April | | | | | | 23.3 | 59.3 | 8.8 | 52.9 |
| May | | | | | | 25.6 | 68.8 | 9.7 | 58.7 |
| June | | Not Available | | | | 27.0 | 82.2 | 10.5 | 63.6 |
| July | | | | | | 30.9 | 80.2 | 11.2 | 67.6 |
| Aug. | | | | | | 30.8 | 83.5 | 11.6 | 69.6 |
| Sept. | | | | | | 31.0 | 90.0 | 12.5 | 74.6 |
| Oct. | | | | | | 31.2 | 89.9 | 13.3 | 81.4 |
| Nov. | | | | | | 30.3 | 93.5 | 13.1 | 77.2 |
| Dec. | | | | | | 35.9 | 99.3 | 15.2 | 91.0 |
| 1944 | | | | | | | | | |
| Jan. | 55,633 | 28,258 | 5,776 | 1,664 | 20,818 | 39.6 | 111.1 | 16.2 | 97.5 |
| Feb. | 51,697 | 27,897 | 5,978 | 1,787 | 20,132 | 42.9 | 117.2 | 17.6 | 106.1 |
| Mar. | 54,682 | 28,354 | 6,268 | 1,934 | 20,152 | 48.0 | 122.9 | 19.4 | 114.1 |
| April | 84,037 | 34,082 | 8,990 | 2,226 | 22,866 | 48.7 | 140.3 | 19.4 | 117.1 |
| May | 78,252 | 34,383 | 8,824 | 3,074 | 22,485 | 56.1 | 161.9 | 22.6 | 137.9 |
| June | 90,091 | 42,076 | 9,609 | 3,131 | 29,336 | 61.8 | 166.3 | 24.9 | 150.6 |
| July | 101,858 | 47,854 | 11,029 | 3,537 | 33,288 | 74.2 | 198.8 | 30.6 | 182.4 |
| Aug. | 125,685 | 61,069 | 13,647 | 3,798 | 43,624 | 88.5 | 247.4 | 35.2 | 210.9 |
| Sept. | 145,627 | 59,937 | 15,790 | 3,864 | 40,283 | 88.4 | 267.9 | 35.6 | 214.7 |
| Oct. | 152,971 | 67,091 | 16,830 | 4,861 | 45,400 | 100.7 | 304.6 | 39.3 | 237.6 |
| Nov. | 153,482 | 74,190 | 16,424 | 5,129 | 52,637 | 104.2 | 296.7 | 40.1 | 240.6 |
| Dec. | 162,719 | 70,433 | 16,907 | 6,473 | 47,053 | 104.4 | 304.6 | 39.8 | 244.1 |
| 1945 | | | | | | | | | |
| Jan. | 162,544 | 90,111 | 18,091 | 6,539 | 65,481 | 111.1 | 293.5 | 43.8 | 268.7 |
| Feb. | 144,908 | 76,863 | 15,896 | 5,248 | 55,719 | 107.8 | 302.1 | 41.7 | 261.8 |
| Mar. | 183,232 | 107,705 | 18,905 | 6,077 | 82,723 | 131.7 | 369.5 | 50.5 | 314.4 |
| April | 195,650 | 106,035 | 20,202 | 6,274 | 79,559 | 141.9 | 378.1 | 53.6 | 330.6 |
| May | 247,385 | 109,920 | 25,100 | 6,590 | 78,230 | 143.1 | 413.4 | 54.6 | 331.4 |
| June | 235,139 | 111,353 | 24,943 | 6,831 | 79,579 | 154.6 | 485.3 | 57.9 | 340.9 |
| July | 274,934 | 124,638 | 28,922 | 6,863 | 88,853 | 175.1 | 618.6 | 67.5 | 393.0 |
| Aug. | 256,948 | 105,412 | 26,454 | 6,697 | 72,261 | 161.8 | 595.9 | 64.8 | 377.1 |

[1] Figures are for Jan. 1944 to Aug. 1945.

## DOMESTIC TRANSPORT OPERATIONS
## AIR TRANSPORT COMMAND
## U. S. ARMY AIR FORCES

July 1942—August 1945

Source: U. S. Army Air Forces Office of Statistical Control

| Year and Month | Number of Passengers | Tons Carried | | | | Millions of Ton Miles | Millions of Passenger Miles | Millions of Airplane Miles | Thousands of Hours Flown | Percent Actual to Available Ton Miles |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | Passengers | Mail | Other Cargo | | | | | |
| Grand Total | 330,822[1] | 84,195[1] | 32,317[1] | 120[1] | 51,758[1] | 187.3 | 576.5 | 114.0 | 735.9 | |
| *Annually* | | | | | | | | | | |
| 1942 (July-Dec.) | | Not Available | | | | 14.5 | 9.7 | 9.6 | 60.0 | |
| 1943 | | | | | | 46.4 | 35.9 | 24.6 | 157.5 | |
| 1944 | 104,905 | 40,112 | 10,490 | 79 | 29,543 | 69.0 | 253.8 | 45.6 | 298.1 | |
| 1945 (Jan.-Aug.) | 225,917 | 44,083 | 21,827 | 41 | 22,215 | 57.4 | 277.1 | 34.2 | 220.3 | |
| *Monthly* | | | | | | | | | | |
| 1942 | | | | | | | | | | |
| July | | | | | | 1.4 | 1.9 | 1.3 | 7.9 | Not Available |
| Aug. | | | | | | 2.7 | 2.1 | 1.9 | 12.0 | |
| Sept. | | | | | | 2.2 | 1.4 | 1.5 | 9.6 | |
| Oct. | | | | | | 3.1 | 1.4 | 1.9 | 11.6 | |
| Nov. | | | | | | 2.8 | 1.5 | 1.6 | 10.1 | |
| Dec. | | | | | | 2.3 | 1.4 | 1.4 | 8.8 | |
| 1943 | | | | | | | | | | |
| Jan. | | | | | | 2.7 | 1.6 | 1.3 | 9.3 | |
| Feb. | | Not Available | | | | 3.2 | 2.2 | 1.7 | 10.4 | |
| Mar. | | | | | | 3.9 | 2.6 | 1.8 | 11.6 | |
| April | | | | | | 4.4 | 3.2 | 1.9 | 12.0 | |
| May | | | | | | 4.3 | 2.3 | 1.9 | 12.2 | |
| June | | | | | | 4.4 | 1.9 | 1.9 | 12.6 | |
| July | | | | | | 5.0 | 2.5 | 2.1 | 13.8 | |
| Aug. | | | | | | 4.8 | 2.2 | 2.1 | 14.0 | |
| Sept. | | | | | | 4.4 | 2.9 | 2.5 | 16.2 | |
| Oct. | | | | | | 3.3 | 4.3 | 2.6 | 17.4 | |
| Nov. | | | | | | 2.7 | 4.7 | 2.4 | 13.6 | 49 |
| Dec. | | | | | | 2.9 | 5.5 | 2.2 | 14.2 | 57 |
| 1944 | | | | | | | | | | |
| Jan. | 3,975 | 2,382 | 398 | 7 | 1,977 | 3.2 | 4.5 | 2.4 | 16.1 | 56 |
| Feb. | 3,575 | 2,395 | 358 | 9 | 2,028 | 3.7 | 8.6 | 2.8 | 18.0 | 60 |
| Mar. | 4,750 | 2,928 | 475 | 7 | 2,446 | 4.8 | 12.8 | 3.5 | 22.2 | 57 |
| April | 7,250 | 2,942 | 725 | 9 | 2,208 | 4.8 | 15.0 | 3.3 | 22.0 | 65 |
| May | 6,546 | 2,920 | 655 | 8 | 2,257 | 5.5 | 23.0 | 4.0 | 26.3 | 64 |
| June | 8,280 | 3,423 | 828 | 8 | 2,587 | 6.0 | 18.9 | 3.8 | 25.6 | 61 |
| July | 8,506 | 3,820 | 850 | 1 | 2,969 | 6.5 | 23.4 | 4.6 | 30.0 | 56 |
| Aug. | 10,250 | 3,976 | 1,025 | 8 | 2,943 | 7.6 | 29.7 | 4.9 | 31.8 | 59 |
| Sept. | 10,450 | 3,734 | 1,045 | 6 | 2,683 | 7.6 | 31.8 | 4.6 | 30.3 | 64 |
| Oct. | 14,006 | 4,257 | 1,400 | 6 | 2,851 | 7.6 | 33.7 | 4.7 | 29.7 | 61 |
| Nov. | 12,681 | 3,923 | 1,268 | 6 | 2,649 | 6.5 | 27.7 | 3.7 | 24.6 | 66 |
| Dec. | 14,636 | 3,412 | 1,463 | 4 | 1,945 | 5.2 | 24.7 | 3.3 | 21.5 | 61 |
| 1945 | | | | | | | | | | |
| Jan. | 17,706 | 4,100 | 1,771 | 4 | 2,325 | 5.3 | 23.8 | 3.4 | 22.9 | 62 |
| Feb. | 17,714 | 4,146 | 1,771 | 4 | 2,371 | 5.5 | 83.6 | 3.4 | 22.4 | 69 |
| Mar. | 23,271 | 5,600 | 2,327 | 5 | 3,268 | 7.8 | 32.4 | 4.5 | 28.3 | 70 |
| April | 23,072 | 5,323 | 2,307 | 5 | 3,011 | 7.5 | 31.1 | 4.4 | 27.9 | 68 |
| May | 26,937 | 6,402 | 2,694 | 5 | 3,703 | 7.6 | 34.3 | 4.5 | 28.7 | 67 |
| June | 32,451 | 5,776 | 3,245 | 6 | 2,525 | 7.0 | 37.1 | 4.1 | 27.1 | 65 |
| July | 45,998 | 7,320 | 4,600 | 6 | 2,714 | 8.4 | 46.4 | 4.9 | 31.3 | 65 |
| Aug. | 38,768 | 5,416 | 3,112 | 6 | 2,298 | 8.3 | 48.4 | 5.0 | 31.7 | 60 |

[1] Figures are for Jan. 1944 to Aug. 1945.

## FOREIGN TRANSPORT OPERATIONS
## AIR TRANSPORT COMMAND
## U. S. ARMY AIR FORCES

July 1942—August 1945

| Year and Month | Number of Passengers | Tons Carried | | | | Millions of Ton Miles | Millions of Passenger Miles | Millions of Airplane Miles | Thousands of Hours Flown | Percent Actual to Available Ton Miles | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | Passengers | Mail | Other Cargo | | | | | Outbound | Inbound |
| Grand Total | 2,626,632[1] | 1,323,466[1] | 282,268[1] | 92,477[1] | 948,721[1] | 2,182.1 | 6,360.8 | 821.0 | 4,902.3 | | |
| *Annually* | | | | | | | | | | | |
| 1942 (July-Dec.) | | Not Available | | | | 49.9 | 148.0 | 21.7 | 131.5 | | |
| 1943 | | | | | | 274.0 | 847.6 | 104.0 | 617.7 | | |
| 1944 | 1,151,809 | 535,512 | 125,582 | 41,399 | 368,531 | 788.5 | 2,185.9 | 295.1 | 1,755.5 | | |
| 1945 (Jan.-Aug.) | 1,474,823 | 787,954 | 156,686 | 51,078 | 580,190 | 1,069.7 | 3,179.3 | 400.2 | 2,397.6 | | |
| *Monthly* | | | | | | | | | | | |
| 1942 | | | | | | | | | | | |
| July | | | | | | 5.1 | 13.8 | 3.3 | 20.1 | | |
| Aug. | | | | | | 5.4 | 16.4 | 2.8 | 17.3 | | |
| Sept. | | | | | | 6.2 | 15.4 | 2.9 | 17.1 | | |
| Oct. | | | | | | 9.4 | 29.1 | 4.0 | 24.2 | Not Available | Not Available |
| Nov. | | | | | | 10.7 | 31.8 | 4.1 | 24.7 | | |
| Dec. | | | | | | 13.1 | 41.5 | 4.6 | 28.1 | | |
| 1943 | | | | | | | | | | | |
| Jan. | | Not Available | | | | 12.8 | 38.7 | 5.2 | 31.5 | | |
| Feb. | | | | | | 13.9 | 42.4 | 5.8 | 35.2 | | |
| Mar. | | | | | | 17.9 | 49.3 | 6.7 | 40.4 | | |
| April | | | | | | 18.9 | 56.1 | 6.9 | 40.9 | | |
| May | | | | | | 21.1 | 66.5 | 7.8 | 46.5 | | |
| June | | | | | | 22.6 | 80.3 | 8.6 | 51.0 | | |
| July | | | | | | 25.9 | 77.7 | 9.1 | 53.8 | | |
| Aug. | | | | | | 26.0 | 81.3 | 9.5 | 55.6 | | |
| Sept. | | | | | | 26.6 | 87.1 | 10.1 | 58.4 | | |
| Oct. | | | | | | 27.7 | 85.6 | 10.7 | 64.0 | | |
| Nov. | | | | | | 27.6 | 88.8 | 10.7 | 63.6 | | |
| Dec. | | | | | | 33.0 | 93.8 | 13.0 | 76.8 | | |
| 1944 | | | | | | | | | | | |
| Jan. | 51,658 | 25,876 | 5,378 | 1,657 | 18,841 | 36.4 | 106.6 | 13.8 | 81.4 | 91 | 65 |
| Feb. | 48,122 | 25,502 | 5,620 | 1,778 | 18,104 | 39.2 | 108.6 | 14.8 | 88.1 | 94 | 61 |
| Mar. | 49,932 | 25,426 | 5,793 | 1,927 | 17,706 | 43.2 | 110.1 | 15.9 | 91.9 | 92 | 60 |
| April | 76,787 | 31,140 | 8,265 | 2,217 | 20,658 | 43.9 | 125.3 | 16.1 | 95.1 | 92 | 63 |
| May | 71,706 | 31,463 | 8,169 | 3,066 | 20,228 | 50.6 | 138.9 | 18.6 | 111.6 | 91 | 61 |
| June | 81,811 | 38,653 | 8,781 | 3,123 | 26,749 | 55.8 | 147.4 | 21.1 | 125.0 | 92 | 50 |
| July | 93,332 | 44,034 | 10,179 | 3,536 | 30,319 | 67.7 | 175.4 | 26.0 | 152.4 | 92 | 49 |
| Aug. | 115,435 | 57,093 | 12,622 | 3,790 | 40,681 | 80.9 | 217.7 | 30.3 | 179.1 | 91 | 57 |
| Sept. | 135,177 | 56,203 | 14,745 | 3,858 | 37,600 | 80.8 | 236.1 | 31.0 | 184.4 | 92 | 48 |
| Oct. | 138,965 | 62,834 | 15,430 | 4,855 | 42,549 | 93.1 | 270.9 | 34.6 | 207.9 | 90 | 51 |
| Nov. | 140,801 | 70,267 | 15,156 | 5,123 | 49,988 | 97.7 | 269.0 | 36.4 | 216.0 | 92 | 47 |
| Dec. | 148,083 | 67,021 | 15,444 | 6,469 | 45,108 | 99.2 | 279.9 | 36.5 | 222.6 | 92 | 48 |
| 1945 | | | | | | | | | | | |
| Jan. | 144,838 | 86,011 | 16,320 | 6,535 | 63,156 | 105.8 | 269.7 | 40.4 | 245.8 | 92 | 42 |
| Feb. | 127,194 | 72,717 | 14,125 | 5,244 | 53,348 | 102.3 | 278.5 | 38.3 | 239.4 | 91 | 42 |
| Mar. | 159,961 | 102,105 | 16,578 | 6,072 | 79,455 | 123.9 | 337.1 | 46.0 | 286.1 | 92 | 43 |
| April | 172,578 | 100,712 | 17,895 | 6,269 | 76,548 | 134.4 | 347.0 | 49.2 | 302.7 | 90 | 42 |
| May | 220,448 | 103,518 | 22,406 | 6,585 | 74,527 | 135.5 | 379.1 | 50.1 | 302.7 | 85 | 45 |
| June | 202,688 | 105,577 | 21,698 | 6,825 | 77,054 | 147.6 | 448.2 | 53.8 | 313.8 | 84 | 45 |
| July | 228,936 | 117,318 | 24,322 | 6,857 | 86,139 | 166.7 | 572.2 | 62.6 | 361.7 | 78 | 48 |
| Aug. | 218,180 | 99,996 | 23,342 | 6,691 | 69,963 | 153.5 | 547.5 | 59.8 | 345.4 | NA | NA |

[1] Figures are for Jan. 1944 to Aug. 1945.

## INDIA-CHINA OPERATIONS

## AIR TRANSPORT COMMAND

## U. S. ARMY AIR FORCES

(Over the Hump)

January 1943—August 1945

Source: U. S. Army Air Forces Office of Statistical Control

| Year and Month | Tons of Cargo Carried Eastbound | | | Number of Trips Flown Eastbound | Assigned Airplanes | | Tons Carried | | Trips | | Airplanes Lost | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | Gasoline and Oil | Other Cargo | | Average Number | Per-cent in Service | Per Airplane Assigned | Per Airplane in Service | Per Airplane Assigned | Per Airplane in Service | Number | Per-cent of Airplanes Assigned | Per 1,000 Trips Eastbound |
| Grand Total | 685,304 | 392,362 | 292,942 | 156,977[1] | | | | | | | 373[1] | | |
| *Annually* | | | | | | | | | | | | | |
| 1943 | 52,366 | 26,421 | 29,945 | 3,138[2] | | | | | | | 20[2] | | |
| 1944 | 231,219 | 136,476 | 94,743 | 54,926 | | | | | | | 184 | | |
| 1945 (Jan-Aug) | 401,719 | 229,465 | 172,254 | 98,913 | | | | | | | 169 | | |
| *Monthly* | | | | | | | | | | | | | |
| 1943 | | | | | | | | | | | | | |
| Jan. | 1,263 | 600 | 663 | | | | | | | | | | |
| Feb. | 2,855 | 1,149 | 1,706 | | | | | | | | | | |
| Mar. | 2,278 | 760 | 1,518 | | | | | | | | | | |
| April | 1,910 | 777 | 1,133 | | | | | | | | | | |
| May | 2,334 | 1,522 | 812 | | | | | | | | | | |
| June | 2,382 | 1,518 | 864 | | | | | Not Available | | | | | |
| July | 3,451 | 1,856 | 1,595 | | | | | | | | | | |
| Aug. | 4,447 | 2,606 | 1,841 | | | | | | | | | | |
| Sept. | 5,125 | 3,640 | 1,485 | | | | | | | | | | |
| Oct. | 7,240 | 3,701 | 3,539 | | | | | | | | | | |
| Nov. | 6,491 | 3,477 | 3,014 | | | | | | | | | | |
| Dec. | 12,590 | 4,815 | 7,775 | 3,138 | 165 | 57 | 76 | 134 | 19 | 33 | 20 | 12 | 6 |
| 1944 | | | | | | | | | | | | | |
| Jan. | 13,399 | 3,673 | 9,726 | 3,166 | 180 | 61 | 74 | 123 | 18 | 29 | 26 | 14 | 8 |
| Feb. | 12,920 | 5,089 | 7,831 | 3,035 | 195 | 66 | 66 | 100 | 16 | 24 | 16 | 8 | 5 |
| Mar. | 9,587 | 6,761 | 2,826 | 2,271 | 164 | 58 | 59 | 101 | 14 | 24 | 12 | 7 | 5 |
| April | 11,555 | 6,631 | 4,924 | 2,617 | 153 | 49 | 76 | 153 | 17 | 35 | 2 | 1 | 1 |
| May | 11,383 | 5,688 | 5,695 | 2,663 | 166 | 49 | 69 | 141 | 16 | 33 | 12 | 7 | 5 |
| June | 15,845 | 11,792 | 4,053 | 3,702 | 148 | 71 | 107 | 152 | 25 | 35 | 14 | 10 | 4 |
| July | 18,975 | 11,873 | 7,102 | 4,431 | 147 | 74 | 129 | 176 | 30 | 41 | 16 | 11 | 4 |
| Aug. | 23,676 | 12,950 | 10,726 | 5,600 | 172 | 79 | 138 | 174 | 33 | 41 | 15 | 9 | 3 |
| Sept. | 22,315 | 13,461 | 8,854 | 5,680 | 187 | 78 | 119 | 154 | 30 | 39 | 16 | 9 | 3 |
| Oct. | 24,715 | 18,463 | 6,252 | 5,879 | 199 | 84 | 124 | 148 | 29 | 35 | 20 | 10 | 3 |
| Nov. | 34,914 | 21,309 | 13,605 | 8,270 | 285 | 82 | 123 | 149 | 29 | 35 | 17 | 6 | 2 |
| Dec. | 31,935 | 18,786 | 13,149 | 7,612 | 318 | 60 | 100 | 167 | 24 | 40 | 18 | 6 | 2 |
| 1945 | | | | | | | | | | | | | |
| Jan. | 44,099 | 28,760 | 15,339 | 10,817 | 368 | 67 | 120 | 180 | 29 | 44 | 17 | 5 | 2 |
| Feb. | 40,677 | 22,150 | 18,527 | 10,194 | 411 | 66 | 99 | 150 | 25 | 37 | 21 | 5 | 2 |
| Mar. | 46,545 | 22,937 | 23,608 | 11,346 | 421 | 69 | 111 | 160 | 27 | 39 | 32 | 8 | 3 |
| April | 44,254 | 22,047 | 22,207 | 10,776 | 405 | 67 | 109 | 163 | 27 | 40 | 22 | 5 | 2 |
| May | 46,394 | 25,483 | 20,911 | 11,196 | 404 | 66 | 115 | 173 | 28 | 42 | 22 | 5 | 2 |
| June | 55,386 | 35,166 | 20,220 | 13,194 | 513 | 71 | 108 | 153 | 26 | 36 | 23 | 5 | 2 |
| July | 71,042 | 39,629 | 31,413 | 17,204 | 640 | NA | 111 | NA | 27 | NA | 20 | 3 | 1 |
| Aug. | 53,322 | 33,293 | 20,029 | 14,186 | 624 | NA | 85 | NA | 23 | NA | 12 | 2 | 1 |

[1] Figures for Dec. 1943 to Aug. 1945.
[2] Figures for Dec. 1943 only.

## FERRYING OPERATIONS BY AIR TRANSPORT COMMAND U. S. ARMY AIR FORCES

January 1942—August 1945

Source: U. S. Army Air Forces Office of Statistical Control

Because an airplane can be delivered domestically, picked up again, and then delivered to a foreign destination, it may be included in both domestic and foreign deliveries.

| Year and Month | TOTAL | | | | DOMESTIC | | | | INTERNATIONAL | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Plane Deliveries | Thousands Mi. Flown | Thousands Hrs. Flown | Planes Lost | Plane Deliveries[2] | Thousands Mi. Flown | Thousands Hrs. Flown | Planes Lost | Plane Deliveries | Thousands Mi. Flown | Thousands Hrs. Flown | Planes Lost |
| Grand Total | 268,905 | 616,348 | 3,981 | 1,013[3] | 219,144 | 286,786 | 1,933 | 419[3] | 49,761 | 329,562 | 2,048 | 594[3] |
| *Annually* | | | | | | | | | | | | |
| 1942 | 30,395 | 57,913 | 422 | 84[4] | 26,805 | 38,027 | 298 | 16 | 3,590 | 19,886 | 124 | 68[4] |
| 1943 | 72,316 | 150,015 | 999 | 402 | 59,586 | 80,065 | 562 | 147 | 12,730 | 69,950 | 437 | 255 |
| 1944 | 108,653 | 254,219 | 1,615 | 368 | 85,601 | 107,994 | 694 | 156 | 23,052 | 146,225 | 921 | 212 |
| 1945 (Jan.-Aug.) | 57,541 | 154,201 | 945 | 159 | 47,152 | 60,700 | 379 | 100 | 10,389 | 93,501 | 566 | 59 |
| *Monthly* | | | | | | | | | | | | |
| 1942 | | | | | | | | | | | | |
| Jan. | 926 | 1,569 | 12 | NA | 896 | 1,250 | 10 | NA | 30 | 319 | 2 | NA |
| Feb. | 1,707 | 2,903 | 19 | NA | 1,661 | 2,395 | 16 | NA | 46 | 508 | 3 | NA |
| Mar. | 2,726 | 3,815 | 29 | NA | 2,650 | 3,380 | 26 | NA | 76 | 435 | 3 | NA |
| April | 2,107 | 3,256 | 26 | NA | 1,995 | 2,624 | 22 | NA | 112 | 632 | 4 | NA |
| May | 2,626 | 4,839 | 46 | NA | 2,431 | 3,281 | 36 | NA | 195 | 1,558 | 10 | NA |
| June | 2,644 | 4,206 | 31 | NA | 2,471 | 3,144 | 24 | NA | 173 | 1,062 | 7 | NA |
| July | 2,347 | 4,701 | 34 | 21 | 2,070 | 3,287 | 25 | — | 277 | 1,414 | 9 | 21 |
| Aug. | 3,101 | 6,458 | 49 | 7 | 2,495 | 3,193 | 29 | 1 | 606 | 3,265 | 20 | 6 |
| Sept. | 3,054 | 6,000 | 37 | 10 | 2,597 | 4,186 | 26 | 3 | 457 | 1,814 | 11 | 7 |
| Oct. | 2,870 | 6,312 | 44 | 10 | 2,236 | 3,230 | 25 | 4 | 634 | 3,082 | 19 | 6 |
| Nov. | 2,950 | 6,588 | 45 | 16 | 2,499 | 4,062 | 29 | 4 | 451 | 2,526 | 16 | 12 |
| Dec. | 3,337 | 7,266 | 50 | 20 | 2,804 | 3,995 | 30 | 4 | 533 | 3,271 | 20 | 16 |
| 1943 | | | | | | | | | | | | |
| Jan. | 4,026 | 7,182 | 50 | 22 | 3,522 | 4,566 | 34 | 7 | 504 | 2,616 | 16 | 15 |
| Feb. | 4,275 | 8,743 | 57 | 29 | 3,730 | 5,272 | 35 | 12 | 545 | 3,471 | 22 | 17 |
| Mar. | 5,187 | 12,201 | 78 | 48 | 4,362 | 5,912 | 39 | 14 | 825 | 6,289 | 39 | 34 |
| April | 5,505 | 12,941 | 82 | 41 | 4,409 | 6,109 | 39 | 10 | 1,096 | 6,832 | 43 | 31 |
| May | 5,955 | 15,793 | 105 | 41 | 4,455 | 5,981 | 44 | 12 | 1,500 | 9,812 | 61 | 29 |
| June | 6,409 | 13,869 | 93 | 52 | 4,863 | 6,399 | 46 | 15 | 1,546 | 7,470 | 47 | 37 |
| July | 6,614 | 11,703 | 81 | 24 | 5,407 | 6,420 | 48 | 5 | 1,207 | 5,283 | 33 | 19 |
| Aug. | 5,868 | 11,341 | 80 | 16 | 4,857 | 6,806 | 52 | 7 | 1,011 | 4,535 | 28 | 9 |
| Sept. | 5,810 | 10,642 | 75 | 28 | 4,860 | 6,639 | 50 | 17 | 950 | 4,003 | 25 | 11 |
| Oct. | 8,127 | 14,470 | 93 | 33 | 6,925 | 9,372 | 61 | 18 | 1,202 | 5,098 | 32 | 15 |
| Nov. | 7,275 | 14,395 | 95 | 27 | 6,234 | 8,571 | 59 | 17 | 1,041 | 5,824 | 36 | 10 |
| Dec. | 7,265 | 16,735 | 110 | 41 | 5,962 | 8,018 | 55 | 13 | 1,303 | 8,717 | 55 | 28 |
| 1944 | | | | | | | | | | | | |
| Jan. | 8,401 | 23,192 | 142 | 36 | 6,640 | 10,196 | 61 | 14 | 1,761 | 12,996 | 81 | 22 |
| Feb. | 8,011 | 22,023 | 137 | 37 | 6,274 | 8,989 | 56 | 13 | 1,737 | 13,034 | 81 | 24 |
| Mar. | 10,059 | 30,756 | 190 | 54 | 7,621 | 10,917 | 66 | 20 | 2,438 | 19,839 | 124 | 34 |
| April | 10,045 | 29,150 | 184 | 37 | 7,456 | 9,650 | 62 | 10 | 2,589 | 19,500 | 122 | 27 |
| May | 9,512 | 27,275 | 183 | 33 | 6,989 | 9,250 | 70 | 9 | 2,523 | 18,025 | 113 | 24 |
| June | 8,425 | 16,957 | 111 | 29 | 6,812 | 8,250 | 57 | 12 | 1,613 | 8,707 | 54 | 17 |
| July | 10,432 | 21,311 | 128 | 30 | 8,055 | 9,750 | 56 | 18 | 2,377 | 11,561 | 72 | 12 |
| Aug. | 10,919 | 22,018 | 136 | 29 | 8,729 | 10,150 | 62 | 14 | 2,190 | 11,868 | 74 | 15 |
| Sept. | 10,766 | 16,184 | 118 | 23 | 9,201 | 10,067 | 73 | 17 | 1,565 | 6,117 | 45 | 6 |
| Oct. | 8,724 | 17,089 | 109 | 19 | 7,106 | 8,375 | 55 | 12 | 1,618 | 8,714 | 54 | 7 |
| Nov. | 7,079 | 14,968 | 95 | 21 | 5,687 | 6,400 | 38 | 6 | 1,392 | 8,568 | 57 | 15 |
| Dec. | 6,280 | 13,296 | 82 | 20 | 5,031 | 6,000 | 38 | 11 | 1,249 | 7,296 | 44 | 9 |
| 1945 | | | | | | | | | | | | |
| Jan. | 7,882 | 17,045 | 99 | 21 | 6,255 | 7,700 | 44 | 10 | 1,627 | 9,345 | 55 | 11 |
| Feb. | 6,303 | 16,803 | 96 | 33 | 4,734 | 6,000 | 37 | 22 | 1,569 | 10,803 | 59 | 11 |
| Mar. | 8,047 | 19,060 | 114 | 23 | 6,215 | 8,200 | 51 | 16 | 1,832 | 10,860 | 63 | 7 |
| April | 7,491 | 18,028 | 100 | 10 | 5,882 | 8,100[5] | 44 | 4 | 1,609 | 9,928 | 56 | 6 |
| May | 7,643 | 19,750 | 114 | 13 | 6,354 | 8,500[5] | 49 | 10 | 1,289 | 11,250 | 65 | 3 |
| June | 8,651 | 25,165 | 177 | 21 | 7,537 | 9,200[5] | 59 | 14 | 1,114 | 15,965 | 118 | 7 |
| July | 7,441 | 26,653 | 167 | 20 | 6,502 | 8,200[5] | 63 | 10 | 939 | 18,453 | 104 | 10 |
| Aug. | 4,083 | 11,697 | 78 | 18 | 3,673 | 4,800[5] | 32 | 14 | 410 | 6,897 | 46 | 4 |

[1] Hours flown in airplanes returning to Continental U. S. not included prior to Sept. 1944. [2] Includes only deliveries to final domestic destinations. Excluded are deliveries to modification centers and installation points. [3] Figures are for July 1942 to Aug. 1945. [4] Figures are for July to Dec. 1942. [5] Estimated.

## SUMMARY OF AIR CARRIER OPERATIONS

### Air Lines in the United States

Compiled by the Office of Aviation Information, Civil Aeronautics Administration

Calendar Years

| *Year* | *Operators* | *Planes in Service* | *Revenue Miles Flown* | *Total Passengers Carried* | *Total Passenger Miles Flown* | *Express Carried (pounds)* | *Mail Ton-Miles Flown*[1] |
|---|---|---|---|---|---|---|---|
| 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. | 249,634 | N.A. |
| 1930 | 38 | 497 | 31,092,634 | 374,935 | 84,014,572 | 359,523 | N.A. |
| 1931 | 35 | 490 | 42,755,417 | 469,981 | 106,442,375 | 788,059 | 3,140,205 |
| 1932 | 29 | 456 | 45,606,354 | 474,279 | 127,038,708 | 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 | 40,955,396 | 461,743 | 187,858,629 | 2,133,191 | 2,461,411 |
| 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] | 1,343,427 | 557,719,268 | 7,335,967 | 7,422,860 |
| 1939 | 17 | 265 | 82,571,523 | 1,876,051 | 749,787,096 | 9,514,229 | 8,584,891 |
| 1940 | 16 | 358 | 108,800,436 | 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 | 12,999,405 |
| 1942 | 16 | 179 | 110,102,860 | 3,551,833 | 1,481,076,329 | 30,068,785 | 21,066,627 |
| 1943 | 16 | 194 | 103,601,443 | 3,454,040 | 1,642,596,640 | 57,543,501 | 35,027,042 |
| 1944 | 16 | 270 | 142,234,034 | 4,668,466 | 2,264,282,453 | 66,011,669 | 50,022,016 |
| 1945 | 17 | 411 | 214,959,855 | 7,502,538 | 3,300,102,057 | 85,024,000 | 64,055,466 |

N.A.: Not available.

[1] Mail ton-miles flown are for domestic services and Hawaiian Airlines, Ltd., which company holds a domestic air mail contract.

## STATUS OF AIR CARRIER OPERATIONS

Compiled by Office of Aviation Information, Civil Aeronautics Administration

January 1, 1946

| | | |
|---|---|---|
| Miles of Airways Operated | | 51,433 |
| With U. S. Mail | 51,433 | |
| With Passengers | 50,505 | |
| With Express | 51,433 | |
| Airplane Miles Scheduled Daily (Average) | | 713,682 |
| With U. S. Mail | 713,682 | |
| With Passengers | 667,670 | |
| With Express | 713,682 | |
| Number of Services in Operation | | 258 |
| With U. S. Mail | 258 | |
| With Passengers | 242 | |
| With Express | 258 | |
| Number of Domestic Air Carriers | | 17 |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The Boeing Stratocruiser—incorporating all the aerodynamic advancements proved in the B-29 Superfortress—brings to air travel the same skill and experience in research, design, engineering and manufacture that gave America the B-29, the staunch B-17 Flying Fortress, the ocean-spanning Clippers, the Stratoliners and other great Boeing airplanes.
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## MONTHLY AIR CARRIER OPERATIONS

Domestic Air Lines in the United States

Compiled by the Office of Aviation Information, Civil Aeronautics Administration

| *1943* | *Revenue Miles Flown* | *Total Passengers Carried*[1] | *Total Passenger Miles* | *Mail Ton-Miles*[2] | *Express Tons Carried* |
|---|---|---|---|---|---|
| January | 7,508,260 | 208,380 | 101,410,602 | 2,328,991 | 1,811 |
| February | 7,585,465 | 233,049 | 110,982,551 | 2,463,504 | 1,824 |
| March | 8,126,495 | 263,175 | 124,256,467 | 2,698,820 | 2,160 |
| April | 8,288,177 | 280,913 | 132,984,531 | 2,864,335 | 2,408 |
| May | 8,314,154 | 282,103 | 133,266,615 | 2,754,976 | 2,275 |
| June | 8,410,461 | 297,760 | 140,745,710 | 2,775,542 | 2,417 |
| July | 8,880,864 | 320,096 | 150,013,387 | 3,014,585 | 2,631 |
| August | 9,303,103 | 338,059 | 156,873,457 | 3,106,498 | 2,668 |
| September | 9,214,834 | 321,616 | 153,980,314 | 3,177,225 | 2,692 |
| October | 9,510,543 | 322,059 | 155,855,938 | 3,420,899 | 2,585 |
| November | 9,307,585 | 301,253 | 145,104,815 | 3,487,803 | 2,555 |
| December | 9,151,502 | 283,537 | 137,122,253 | 3,743,864 | 2,740 |
| Total | 103,601,443 | 3,454,040 | 1,642,596,640 | 35,027,042 | 28,772 |
| *1944* | | | | | |
| January | 9,342,804 | 285,283 | 141,474,106 | 3,522,323 | 2,459 |
| February | 8,507,500 | 260,754 | 125,088,621 | 3,293,362 | 2,039 |
| March | 9,505,470 | 293,523 | 142,834,165 | 3,669,378 | 2,388 |
| April | 9,002,042 | 318,560 | 155,159,351 | 3,504,624 | 2,161 |
| May | 11,219,214 | 369,649 | 181,038,023 | 4,039,027 | 2,268 |
| June | 11,674,188 | 389,123 | 193,288,705 | 4,189,537 | 2,666 |
| July | 12,769,199 | 441,341 | 211,703,804 | 4,335,708 | 2,878 |
| August | 13,555,054 | 476,808 | 227,350,700 | 4,803,371 | 3,365 |
| September | 13,369,602 | 464,536 | 225,471,945 | 4,622,430 | 3,075 |
| October | 14,595,700 | 497,664 | 239,022,033 | 4,896,008 | 3,381 |
| November | 13,942,022 | 455,907 | 217,338,262 | 4,776,201 | 3,101 |
| December | 13,651,239 | 415,318 | 204,512,740 | 5,270,047 | 3,224 |
| Total | 142,754,034 | 4,668,466 | 2,264,282,453 | 50,022,016 | 33,005 |
| *1945* | | | | | |
| January | 14,294,179 | 430,115 | 209,288,931 | 5,042,108 | 3,423 |
| February | 12,989,154 | 401,563 | 190,324,414 | 4,763,253 | 3,407 |
| March | 16,136,567 | 532,286 | 251,170,561 | 5,843,627[3] | 4,324 |
| April | 15,969,098 | 543,755 | 256,892,372 | 5,371,666[3] | 3,858 |
| May | 17,606,790 | 612,912 | 289,846,496 | 5,922,196[3] | 4,154 |
| June | 18,041,644 | 659,861 | 306,872,654 | 5,998,262[3] | 3,987 |
| July | 19,409,918 | 713,382 | 331,639,158 | 5,926,678[4] | 3,839 |
| August | 20,238,043 | 753,147 | 343,928,310 | 6,019,230[4] | 3,355 |
| September | 19,643,629 | 714,562 | 329,276,363 | 5,598,992[4] | 2,469 |
| October | 20,887,773 | 770,190 | 353,526,547 | 5,467,970[4] | 3,015 |
| November | 20,103,236 | 723,247 | 328,599,828 | 4,600,384[4] | 2,555 |
| December | 19,639,824 | 647,518 | 308,736,423 | 4,401,100[4] | 3,136 |
| Total | 214,959,855 | 7,502,538 | 3,500,102,057 | 64,955,466 | 41,512 |

[1] Revenue and non-revenue.
[2] Includes Hawaiian Air Lines, Ltd.
[3] Preliminary Post Office data.
[4] Estimated from CAB 2780 reports.

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## CONSOLIDATED VULTEE AIRCRAFT CORPORATION

San Diego, California • Downey, California • Wayne, Michigan (Stinson Division)
Fort Worth, Texas • Nashville, Tennessee

## UNITED STATES AIR TRANSPORT ROUTES

January 1, 1946

Compiled by Information and Statistics Service, Civil Aeronautics Administration

| | | | |
|---|---|---|---|
| Total Domestic Routes | 51,433 miles | Express Service | 51,433 miles |
| Passenger Service | 50,505 miles | Mail Service | 51,433 miles |

| Domestic Routes | Airway Miles | Type of Service | Daily Schedule (round trips) | Daily Mileage |
|---|---|---|---|---|
| **All American Aviation, Inc.** | | | | |
| Pittsburgh-Huntington via Elkins and Charleston | 333 | ME | 2 | 1,332 |
| Pittsburgh-Huntington via Parkersburg | 338 | ME | 2 | 1,352 |
| Pittsburgh-Philadelphia | 398 | ME | 2 | 1,592 |
| Pittsburgh-Williamsport | 202 | ME | 2 | 808 |
| Pittsburgh-Jamestown | 178 | ME | 2 | 712 |
| **American Airlines, Inc.** | | | | |
| Boston-New York | 184 | MPE | 16½ | 6,072 |
| Boston-New York via Hartford and/or Bridgeport | 186 | MPE | 4½ | 1,674 |
| Boston-New York via Providence | 192 | MPE | 4 | 1,536 |
| Boston-New York via Springfield | 208 | MPE | 1 | 416 |
| Boston-New York via Providence and Hartford | 204 | MPE | 1 | 408 |
| Hartford-New York | 92 | MPE | 1 | 184 |
| Providence-New York | 143 | MPE | 1 | 286 |
| New York-Washington | 215 | MPE | 21 | 9,030 |
| New York-Los Angeles | 2,678 | ME | 1 | 5,356 |
| Washington-Los Angeles via Nashville and El Paso | 2,465 | MPE | 3 | 14,790 |
| Washington-Los Angeles via Knoxville | 2,536 | MPE | 1 | 5,072 |
| Washington-Los Angeles via Memphis and Dallas | 2,466 | MPE | 1 | 4,932 |
| Washington-Los Angeles via El Paso | 2,514 | MPE | 3 | 15,084 |
| Washington-Los Angeles via Knoxville and Nashville | 2,488 | MPE | 1 | 4,976 |
| Washington-Los Angeles via Memphis and San Diego | 2,566 | MPE | 2 | 10,264 |
| Nashville-Memphis | 200 | MPE | 1 | 400 |
| Nashville-Los Angeles | 1,931 | MPE | 2 | 7,724 |
| El Paso-Los Angeles | 734 | MPE | 4½ | 6,606 |
| El Paso-Los Angeles via Douglas | 823 | MPE | ½ | 823 |
| Dallas or Ft. Worth-El Paso | 556 | MPE | 2 | 2,224 |
| Tulsa-El Paso | 675 | MPE | 1 | 1,350 |
| Oklahoma City-El Paso | 564 | MPE | 1 | 1,128 |
| New York-Chicago (direct) | 724 | MPE | 1 | 1,448 |
| New York-Chicago via Detroit | 734 | MPE | 1½ | 2,202 |
| New York-Chicago via Detroit and Buffalo | 760 | MPE | 8½ | 12,920 |
| New York-Detroit | 760 | ME | 1 | 1,520 |
| New York-Buffalo | 328 | MPE | 3 | 1,968 |
| New York-Cleveland | 521 | MPE | 1 | 1,042 |
| Windsor-Chicago | 257 | MPE | 1 | 514 |
| Chicago-Detroit | 248 | MPE | 2 | 992 |
| Chicago-Tulsa | 602 | MPE | 1 | 1,204 |
| Chicago-Oklahoma City | 723 | MPE | 1 | 1,446 |
| Chicago-Ft. Worth | 928 | MPE | 4 | 7,424 |
| Tulsa-Oklahoma City | 111 | MPE | 2 | 444 |
| Chicago-Washington | 665 | MPE | 4 | 5,320 |
| Cleveland-Nashville | 499 | MPE | 3 | 2,994 |
| Ft. Worth-San Antonio | 259 | MPE | 1 | 518 |
| Buffalo-Toronto | 69 | MPE | 3 | 414 |
| **Braniff Airways, Inc.** | | | | |
| Chicago-Nuevo Laredo | 1,265 | MPE | 1 | 2,530 |
| Chicago-Dallas via Kansas City | 857 | MPE | 2 | 3,428 |
| Chicago-Dallas via Oklahoma City | 917 | MPE | 2 | 3,668 |
| Chicago-Dallas via Wichita | 945 | MPE | 2 | 3,780 |
| Denver-Dallas via Oklahoma City | 784 | MPE | 1 | 1,568 |
| Denver-Dallas | 702 | MPE | 2 | 2,808 |
| Dallas-Amarillo via Lubbock | 405 | MPE | 1 | 810 |
| Dallas-Amarillo via Wichita Falls | 340 | MPE | 1 | 680 |
| Dallas-Brownsville | 543 | MPE | 1 | 1,086 |

*United States Air Transport Routes (January 1, 1946)*—Continued

| Domestic Routes | Airway Miles | Type of Service | Daily Schedule (round trips) | Daily Mileage |
|---|---|---|---|---|
| **Braniff Airways, Inc.—Cont.** | | | | |
| Dallas-Galveston | 279 | MPE | 1½ | 837 |
| Dallas-Galveston via Waco | 345 | MPE | ½ | 345 |
| Dallas-Tulsa | 292 | MPE | 1 | 584 |
| Dallas-Corpus Christi | 415 | MPE | 2½ | 2,075 |
| Dallas-Corpus Christi via Waco and Houston | 626 | MPE | ½ | 626 |
| Dallas-San Antonio via Waco | 281 | MPE | 1 | 562 |
| Dallas-San Antonio via Austin and Houston | 463 | MPE | ½ | 463 |
| Dallas-San Antonio via Austin | 255 | MPE | ½ | 255 |
| Memphis-Amarillo | 708 | MPE | 1 | 1,416 |
| **Chicago & Southern Airlines, Inc.** | | | | |
| Chicago-Houston | 994 | MPE | 1 | 1,988 |
| Chicago-Houston via Little Rock | 1,038 | MPE | 2 | 4,152 |
| Chicago-New Orleans | 857 | MPE | 3 | 5,142 |
| Detroit-Houston | 1,164 | MPE | 1 | 2,328 |
| Detroit-New Orleans | 992 | MPE | 1 | 1,984 |
| Chicago-St. Louis (direct) | 251 | MPE | 1 | 502 |
| Chicago-St. Louis via Peoria | 311 | MPE | 1 | 622 |
| Detroit-Memphis | 649 | MPE | 1 | 1,298 |
| Detroit-Evansville | 396 | MPE | 1 | 792 |
| Chicago-Memphis | 508 | MPE | 1 | 1,016 |
| **Continental Air Lines, Inc.** | | | | |
| Denver-Kansas City | 592 | MPE | 1 | 1,184 |
| Denver-Kansas City via Hutchinson | 553 | MPE | 2 | 2,212 |
| Denver-Tulsa | 694 | MPE | 1 | 1,388 |
| Denver-Albuquerque | 350 | MPE | 1½ | 1,050 |
| Denver-Albuquerque via Santa Fe | 394 | MPE | 1½ | 1,182 |
| Albuquerque-San Antonio via El Paso | 740 | MPE | 1 | 1,480 |
| Albuquerque-San Antonio via Big Spring | 1,005 | MPE | ½ | 1,005 |
| Albuquerque-San Antonio via Hobbs | 632 | MPE | ½ | 632 |
| Albuquerque-El Paso (direct) | 224 | MPE | 1 | 448 |
| El Paso-San Antonio (direct) | 498 | MPE | ½ | 498 |
| El Paso-San Antonio via Hobbs | 556 | MPE | ½ | 556 |
| **Delta Air Corporation** | | | | |
| Chicago-Miami via Atlanta | 1,327 | MPE | 1 | 2,654 |
| Chicago-Miami via Asheville | 1,292 | MPE | 1 | 2,584 |
| Atlanta-Ft. Worth | 772 | MPE | 4 | 6,176 |
| Atlanta-Ft. Worth via Meridian | 783 | MPE | 2 | 3,132 |
| Cincinnati-Atlanta (direct) | 377 | MPE | ½ | 377 |
| Cincinnati-Atlanta via Knoxville | 380 | MPE | 2½ | 1,900 |
| Ft. Worth-New Orleans | 478 | MPE | 1 | 956 |
| Ft. Worth-New Orleans via Shreveport | 497 | MPE | 3 | 2,982 |
| Atlanta-Savannah | 251 | MPE | 2 | 1,004 |
| Atlanta-Charleston | 301 | MPE | 2 | 1,204 |
| **Eastern Air Lines, Inc.** | | | | |
| Boston-New York | 184 | MPE | 7 | 2,576 |
| New York-Miami via Jacksonville | 1,188 | MPE | 5 | 11,880 |
| New York-Miami via Columbia or Charleston | 1,223 | MPE | 2 | 4,892 |
| New York-Miami via Atlanta | 1,488 | MPE | 1 | 2,976 |
| New York-Miami via Tallahassee | 1,401 | MPE | 2 | 5,604 |
| New York-Miami | 1,185 | ME | 1 | 2,370 |
| New York-Jacksonville | 855 | MPE | 1 | 1,710 |
| Atlanta-Jacksonville | 277 | MPE | 1 | 554 |
| Atlanta-Miami | 608 | MPE | 3 | 3,648 |
| Atlanta-Miami via Macon | 762 | MPE | 1 | 1,524 |
| Atlanta-Miami via West Palm Beach | 616 | MPE | 1 | 1,232 |
| New York-Washington (direct) | 215 | MPE | 11½ | 4,045 |

*United States Air Transport Routes (January 1, 1946)*—Continued

| Domestic Routes | Airway Miles | Type of Service | Daily Schedule (round trips) | Daily Mileage |
|---|---|---|---|---|
| **Eastern Air Lines, Inc.—Cont.** | | | | |
| New York-Washington via Philadelphia and/or Baltimore | 216 | MPE | 5½ | 2,376 |
| Atlanta-Washington (direct) | 547 | MPE | ½ | 547 |
| Atlanta-Washington via Spartanburg | 551 | MPE | ½ | 551 |
| Atlanta-Washington | 555 | MPE | 2½ | 2,775 |
| Atlanta-Washington via Charlotte | 578 | MPE | 2½ | 2,890 |
| Atlanta-Washington via Greenville and Richmond | 580 | MPE | 1 | 1,160 |
| Washington-St. Louis | 734 | MPE | 3 | 4,404 |
| Atlanta-New Orleans (direct) | 414 | MPE | 2 | 1,656 |
| Atlanta-New Orleans via Montgomery and Birmingham | 490 | MPE | 1 | 980 |
| Atlanta-New Orleans via Mobile and Birmingham | 468 | MPE | 2 | 1,872 |
| Atlanta-New Orleans via Columbus, Georgia | 442 | MPE | 1 | 884 |
| Atlanta-New Orleans via Birmingham | 445 | MPE | 1 | 890 |
| New Orleans-Brownsville | 631 | MPE | 2 | 2,524 |
| New Orleans-San Antonio | 509 | MPE | 1 | 1,018 |
| New Orleans-San Antonio via Baton Rouge | 523 | MPE | 1 | 1,046 |
| New Orleans-Houston | 317 | MPE | 1 | 634 |
| Chicago-Atlanta | 642 | MPE | 5 | 6,420 |
| Chicago-Miami | 1,355 | MPE | 1 | 2,710 |
| St. Louis-Miami | 1,134 | MPE | 1 | 2,268 |
| Memphis-Miami | 887 | MPE | 1 | 1,774 |
| Atlanta-St. Louis | 516 | MPE | 1 | 1,032 |
| Atlanta-Memphis | 346 | MPE | 1 | 692 |
| Atlanta-Birmingham | 134 | MPE | 1 | 268 |
| Richmond-Washington | 95 | MPE | 2 | 380 |
| Detroit-Miami | 1,224 | MPE | 3 | 7,344 |
| **Essair, Inc.** | | | | |
| Houston-Amarillo | 683 | MPE | 2 | 2,732 |
| **Inland Air Lines, Inc.** | | | | |
| Denver-Cheyenne | 96 | MPE | 7 | 1,344 |
| Cheyenne-Great Falls | 567 | MPE | 2 | 2,268 |
| Cheyenne-Huron | 486 | MPE | 2 | 1,944 |
| Rapid City-Spearfish | 40 | ME | 2 | 160 |
| **Mid-Continent Airlines, Inc.** | | | | |
| Minneapolis-Kansas City via Watertown | 678 | MPE | 1½ | 2,034 |
| Minneapolis-Kansas City via Sioux Falls | 526 | MPE | 2½ | 2,630 |
| Minneapolis-Kansas City via Des Moines | 428 | MPE | 3 | 2,568 |
| Des Moines-St. Louis | 258 | MPE | 3 | 1,548 |
| Kansas City-Tulsa | 238 | MPE | 1 | 476 |
| Kansas City-New Orleans | 799 | MPE | 2 | 3,196 |
| **National Airlines, Inc.** | | | | |
| New York-Jacksonville (direct) | 839 | MPE | 2 | 3,356 |
| New York-Jacksonville via Charleston | 851 | MPE | 2 | 3,404 |
| Jacksonville-Miami (direct) | 330 | MPE | 1 | 660 |
| Jacksonville-Miami via Tampa | 378 | MPE | 3 | 2,268 |
| Jacksonville-Miami via St. Petersburg | 510 | MPE | 1 | 1,020 |
| Jacksonville-Miami via Orlando | 475 | MPE | 1 | 950 |
| Jacksonville-New Orleans via Mobile | 511 | MPE | 2 | 2,044 |
| Jacksonville-New Orleans via Pensacola and/or Tallahassee | 505 | MPE | 2 | 2,020 |
| Miami-Key West | 127 | MPE | 3 | 762 |
| **Northeast Airlines, Inc.** | | | | |
| New York-Boston | 184 | MPE | 16 | 5,888 |
| Boston-Bangor | 208 | MPE | 2 | 832 |
| Boston-Presque Isle | 353 | MPE | 1 | 706 |

*United States Air Transport Routes (January 1, 1946)*—Continued

| Domestic Routes | Airway Miles | Type of Service | Daily Schedule (round trips) | Daily Mileage |
|---|---|---|---|---|
| NORTHEAST AIRLINES, INC.—Cont. | | | | |
| Boston-Moncton | 425 | MPE | 1 | 850 |
| Boston-Montreal | 259 | MPE | 2 | 1,036 |
| NORTHWEST AIRLINES, INC. | | | | |
| New York-Minneapolis | 1,035 | MPE | 5 | 10,350 |
| Chicago-Minneapolis (direct) | 350 | MPE | 8 | 5,600 |
| Chicago-Minneapolis via Rochester and/or Milwaukee | 391 | MPE | 3 | 2,346 |
| Chicago-Rochester | 285 | MPE | 1 | 570 |
| Minneapolis-Winnipeg | 431 | MPE | 1 | 862 |
| Minneapolis-Duluth | 144 | MPE | 2 | 576 |
| Minneapolis-Billings via Bismarck | 765 | MPE | 4 | 6,120 |
| Minneapolis-Billings via Bismarck and Fargo | 788 | MPE | 2 | 3,152 |
| Minneapolis-Billings via Fargo and Miles City | 790 | MPE | 1 | 1,580 |
| Billings-Spokane via Butte | 451 | MPE | 2 | 1,804 |
| Billings-Spokane via Helena | 437 | MPE | 2 | 1,748 |
| Billings-Spokane via Great Falls | 465 | MPE | 2 | 1,860 |
| Billings-Spokane (direct) | 437 | MPE | 1 | 874 |
| Spokane-Portland | 290 | MPE | 3 | 1,740 |
| Spokane-Seattle (direct) | 233 | MPE | 5 | 2,330 |
| Spokane-Seattle via Yakima | 277 | MPE | 1 | 554 |
| Spokane-Seattle via Wenatchee | 234 | MPE | 1 | 468 |
| PENNSYLVANIA-CENTRAL AIRLINES CORP. | | | | |
| New York-Pittsburgh | 320 | MPE | 4 | 2,560 |
| Newark-Pittsburgh | 304 | MPE | 2 | 1,216 |
| Norfolk-Washington | 143 | MPE | 11 | 3,146 |
| Washington-Chicago via Detroit | 645 | MPE | 4 | 5,160 |
| Washington-Chicago via Pittsburgh and Detroit | 690 | MPE | 5 | 6,900 |
| Baltimore-Chicago via Cleveland and Detroit | 657 | MPE | 1 | 1,314 |
| Detroit-Chicago (direct) | 247 | MPE | 6½ | 3,211 |
| Detroit-Chicago via Flint | 298 | MPE | ½ | 298 |
| Pittsburgh-Detroit | 216 | MPE | 3 | 1,296 |
| Cleveland-Detroit | 91 | MPE | 3 | 546 |
| Washington-Milwaukee | 674 | MPE | 5 | 6,740 |
| Detroit-Milwaukee | 259 | MPE | 2 | 1,036 |
| Washington-Pittsburgh | 186 | MPE | 1 | 372 |
| Washington-Detroit | 422 | MPE | 3 | 2,532 |
| Chicago-Grand Rapids | 132 | MPE | 1 | 264 |
| Pittsburgh-Birmingham via Knoxville | 610 | MPE | 2 | 2,440 |
| Pittsburgh-Birmingham via Knoxville and Huntsville | 648 | MPE | 1 | 1,296 |
| Norfolk-Knoxville via Greensboro | 463 | MPE | 1 | 926 |
| Norfolk-Knoxville via Greensboro and Asheville | 500 | MPE | 1 | 1,000 |
| Buffalo-Pittsburgh via Erie | 215 | MPE | 1 | 430 |
| Buffalo-Washington via Harrisburg | 376 | MPE | 1 | 752 |
| Buffalo-Washington via Rochester | 352 | MPE | 1 | 704 |
| Buffalo-Washington via Erie | 451 | MPE | ½ | 451 |
| Buffalo-Washington (direct) | 330 | MPE | ½ | 330 |
| TRANSCONTINENTAL & WESTERN AIR, INC. | | | | |
| Boston-Kansas City via Dayton | 1,292 | MPE | 1 | 2,584 |
| Boston-Pittsburgh via Williamsport | 504 | MPE | 1 | 1,008 |
| New York-Pittsburgh | 320 | MPE | 5 | 3,200 |
| New York-Pittsburgh via Philadelphia | 350 | MPE | 4 | 2,800 |
| New York-Pittsburgh via Reading and Harrisburg | 334 | MPE | 2 | 1,336 |
| New York-Pittsburgh | 320 | ME | 1 | 640 |
| New York-Pittsburgh via Philadelphia | 346 | ME | 1 | 692 |
| New York-San Francisco via Chicago, Kansas City and Los Angeles | 2,816 | MPE | 2 | 11,264 |
| Washington-San Francisco via Kansas City | 2,757 | MPE | 1 | 5,514 |
| Pittsburgh-Kansas City via Chicago | 825 | MPE | 4 | 6,600 |
| Pittsburgh-Kansas City via Dayton and St. Louis | 817 | MPE | 10 | 16,340 |

*United States Air Transport Routes (January 1, 1946)*—Continued

| Domestic Routes | Airway Miles | Type of Service | Daily Schedule (round trips) | Daily Mileage |
|---|---|---|---|---|
| TRANSCONTINENTAL & WESTERN AIR, INC.—Cont. | | | | |
| Pittsburgh-Chicago | 447 | MPE | 1 | 894 |
| Washington-Chicago via Dayton | 628 | MPE | 1 | 1,256 |
| Washington-Kansas City via Chicago | 1,022 | MPE | 1 | 2,044 |
| Washington-Kansas City via Dayton and St. Louis | 962 | MPE | 1 | 1,924 |
| Detroit-Kansas City | 692 | MPE | 1 | 1,384 |
| Pittsburgh-Dayton | 230 | MPE | 1 | 460 |
| Detroit-Cincinnati | 242 | MPE | 3 | 1,452 |
| Cincinnati-Kansas City via Chicago | 704 | MPE | ½ | 704 |
| Cincinnati-Kansas City via St. Louis | 550 | MPE | ½ | 550 |
| Pittsburgh-San Francisco via Chicago and Kansas City | 2,544 | ME | 2 | 10,176 |
| Chicago-Los Angeles via Kansas City and Albuquerque | 1,814 | ME | 1 | 3,628 |
| Kansas City-San Francisco via Albuquerque and Los Angeles | 1,787 | MPE | 5 | 17,870 |
| Kansas City-Los Angeles via Albuquerque | 1,437 | MPE | 4 | 11,496 |
| UNITED AIR LINES, INC. | | | | |
| New York-Chicago via Cleveland | 732 | MPE | 11 | 16,104 |
| New York-Chicago via Detroit | 783 | MPE | 2 | 3,132 |
| New York-Chicago via Cleveland | 740 | ME | 3 | 4,440 |
| Boston-Chicago via Hartford and Cleveland | 877 | MPE | 2 | 3,508 |
| Washington-Chicago via Toledo | 610 | MPE | 3 | 3,660 |
| Chicago-San Francisco via Denver and Salt Lake City | 1,910 | MPE | 3 | 11,460 |
| Chicago-San Francisco via Omaha and Denver | 1,874 | MPE | 2 | 7,496 |
| Chicago-San Francisco via Cheyenne and Salt Lake City | 1,885 | MPE | 2 | 7,540 |
| Chicago-San Francisco via Cheyenne and Elko | 1,880 | MPE | 1 | 3,760 |
| Chicago-San Francisco via Omaha | 1,859 | MPE | 3 | 11,154 |
| Chicago-San Francisco via Omaha and Salt Lake City | 1,889 | ME | 1 | 3,778 |
| Chicago-San Francisco via Omaha and Denver or Cheyenne | 1,864 | ME | 2 | 7,456 |
| Chicago-Seattle via Denver and Boise | 2,194 | MPE | 1 | 4,388 |
| Chicago-Seattle via Denver and Salt Lake City | 2,094 | MPE | 1 | 4,188 |
| Chicago-Seattle via Cheyenne and Boise | 1,993 | MPE | 2 | 7,072 |
| Chicago-Spokane via Denver and Salt Lake City | 1,952 | MPE | 1 | 3,904 |
| Chicago-Salt Lake City via Denver | 1,307 | MPE | 1 | 2,614 |
| Chicago-Salt Lake City via Cheyenne | 1,263 | MPE | 1 | 2,526 |
| Cheyenne-Denver | 96 | MPE | 2 | 384 |
| San Diego-Los Angeles | 123 | MPE | 3 | 738 |
| Los Angeles-San Francisco (direct) | 327 | MPE | 12 | 7,848 |
| Los Angeles-San Francisco via Oakland | 338 | MPE | 1 | 676 |
| Los Angeles-San Francisco via Bakersfield and Fresno | 350 | MPE | 2 | 1,400 |
| Los Angeles-San Francisco via Santa Barbara and Monterey | 352 | MPE | 1 | 704 |
| Los Angeles-San Francisco via Fresno and Sacramento | 426 | MPE | 1 | 852 |
| San Francisco-Seattle via Sacramento and Medford | 715 | MPE | 1 | 1,430 |
| San Francisco-Seattle via Medford and Salem or Red Bluff | 695 | MPE | 3 | 4,170 |
| San Francisco-Seattle via Sacramento and Eugene | 719 | MPE | 1 | 1,438 |
| San Francisco-Seattle via Oakland and Eugene | 697 | MPE | 1 | 1,394 |
| San Francisco-Sacramento | 79 | MPE | 1 | 158 |
| Seattle-Vancouver | 125 | MPE | 2 | 500 |
| Portland-Seattle | 135 | MPE | 2 | 540 |
| WESTERN AIR LINES, INC. | | | | |
| Los Angeles-San Francisco | 327 | MPE | 12 | 7,848 |
| San Diego-Los Angeles | 123 | MPE | 4 | 984 |
| Los Angeles-Great Falls via Salt Lake City | 1,075 | MPE | 1 | 2,150 |
| Los Angeles-Lethbridge via Salt Lake City | 1,238 | MPE | 1 | 2,476 |
| Los Angeles-Pocatello via Salt Lake City | 741 | MPE | 1 | 1,482 |
| Los Angeles-Salt Lake City via Las Vegas | 590 | MPE | 3 | 3,540 |
| Los Angeles-Las Vegas | 235 | MPE | 1 | 470 |

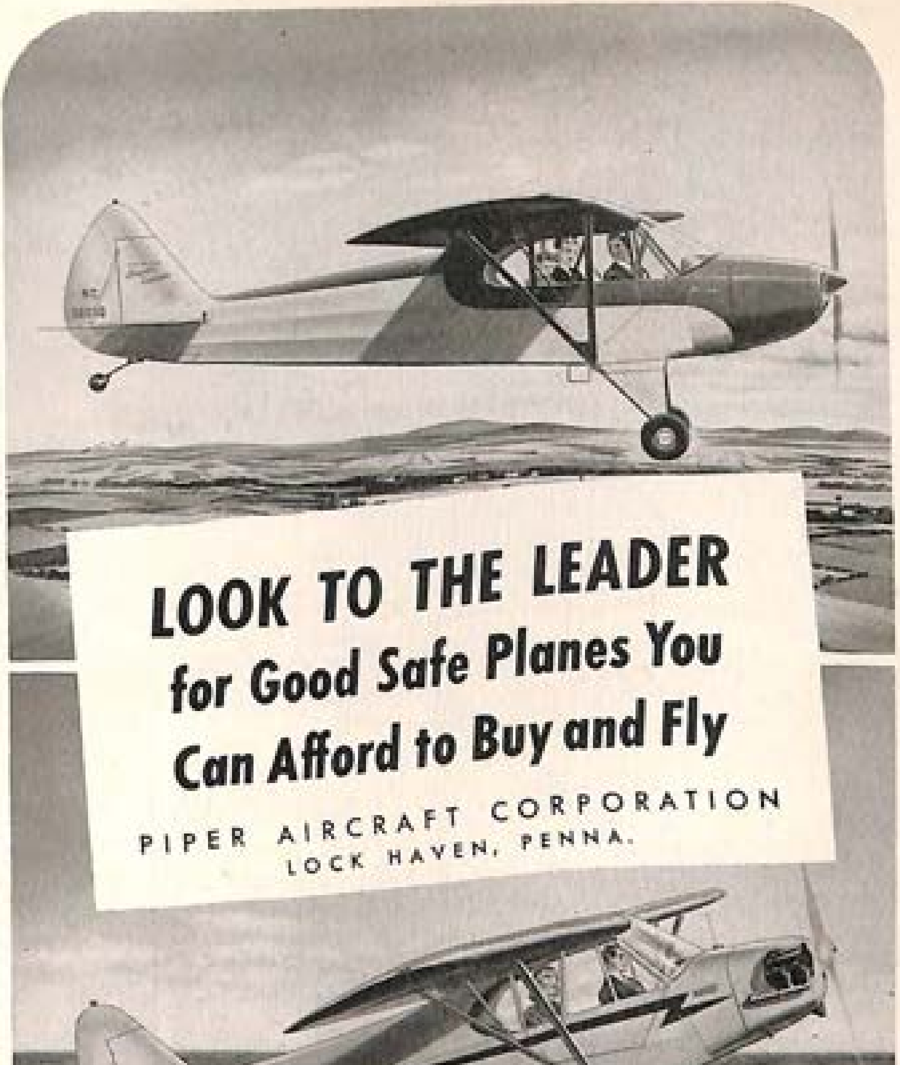
MPE — Mail, Passengers, Express.

## PROGRESS OF CIVIL AERONAUTICS IN THE UNITED STATES

(All statistics are as of Dec. 31 each year)

Compiled by the Office of Aviation Information, U. S. Civil Aeronautics Administration

| | 1943 | 1944 | 1945 |
|---|---|---|---|
| **DOMESTIC AIR CARRIER OPERATIONS** | | | |
| Operators (number of) | 16 | 16 | 17 |
| Airplanes (in service and reserve) | 194 | 279 | 411 |
| Air Carrier Route Mileage (unduplicated) | 36,982 | 40,392 | 51,433 |
| Express service | 36,982 | 40,392 | 51,433 |
| Mail service | 36,982 | 40,392 | 51,433 |
| Passenger service | 34,803 | 39,251 | 50,505 |
| Miles Flown: | | | |
| Daily average | 283,840 | 388,618 | 588,931 |
| Revenue miles | 103,601,443 | 142,234,034 | 214,959,855 |
| Passenger Traffic: | | | |
| Passengers carried | 3,454,040 | 4,668,466 | 7,502,538 |
| Revenue[1] | 3,351,537 | 4,575,852 | 7,383,025 |
| Non revenue | 102,503 | 92,614 | 119,513 |
| Passenger Miles Flown (1 passenger carried 1 mile) | 1,642,596,640 | 2,264,282,453 | 3,500,102,057 |
| Revenue | 1,606,119,468 | 2,229,571,113 | 3,452,687,355 |
| Non revenue | 36,477,172 | 34,711,340 | 47,414,702 |
| Passenger Seat Miles Flown | 1,824,849,802 | 2,492,893,507 | 3,915,770,090 |
| Passenger Load Factor (%) | | | |
| Revenue | 88.01 | 89.44 | 88.17 |
| Revenue and Non revenue | 90.01 | 90.83 | 89.38 |
| Passenger Fare per Mile | $0.0535 | $0.0514 | $0.0450 |
| Mail Ton Miles[2] | 35,927,042 | 50,022,016 | 64,955,466 |
| Express and Freight: | | | |
| Ton miles | 15,117,025 | 17,094,029 | 22,632,618 |
| Tons carried[1] | 28,772 | 33,005 | 41,512 |
| Accidents: | | | |
| Number of accidents | 24 | 28 | 43 |
| Revenue miles flown per accident | 4,316,727 | 5,079,816 | 4,999,066 |
| Number fatal accidents | 2 | 5 | 8 |
| Revenue miles flown per fatal accident | 51,800,722 | 28,446,967 | 26,869,982 |
| Fatal accidents per million revenue miles flown | 0.02 | 0.04 | 0.04 |
| Pilot fatalities | 2 | 5 | 5 |
| Revenue miles flown per pilot fatality | 51,800,722 | 28,446,967 | 42,991,971 |
| Copilot fatalities | 2 | 3 | 4 |
| Crew fatalities (other than pilot or copilot) | 4 | 2 | 3 |
| Passenger fatalities | 22 | 48 | 76 |
| Total passenger miles flown per passenger fatality | 74,663,484 | 47,172,551 | 46,053,974 |
| Passenger fatalities per 100,000,000 passenger miles flown | 1.34 | 2.12 | 2.17 |
| Ground crew and third party fatalities | 0 | 0 | 0 |
| Total fatalities | 30 | 58 | 88 |
| Fatalities per million revenue miles flown | 0.29 | 0.41 | 0.41 |
| **PRIVATE FLYING OPERATIONS** (All domestic) | | | |
| Airplanes in Operation | 22,323[3] | 21,212 | 28,347 |
| **AIRPORTS AND LANDING FIELDS** | | | |
| Total Airports in Operation | 2,769 | 3,427 | 4,026 |
| Commercial | 801 | 1,027 | 1,509 |
| Municipal | 914 | 1,067 | 1,220 |
| Intermediate CAA—lighted | 230[4] | 228 | 215[4] |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## PROGRESS OF CIVIL AERONAUTICS IN THE UNITED STATES (Continued)

| | 1943 | 1944 | 1945 |
|---|---|---|---|
| AIRPORTS AND LANDING FIELDS (Continued) | | | |
| Intermediate CAA—unlighted | 1 | 1 | 1 |
| Army, Navy, Marine Corps, National Guard, reserve, private and miscellaneous | 814 | 1,104 | 1,081 |
| Lighted, total | 859 | 964 | 1,007 |
| FEDERAL AIRWAYS SYSTEM AND AIDS TO AIR NAVIGATION | | | |
| Federal Airways: | | | |
| Mileage | 33,403 | 34,424 | 35,561 |
| Mileage under Construction at close of year | 1,493 | 275 | 3,839 |
| Communications: | | | |
| Total Radio Range stations | 291 | 297 | 304 |
| With scheduled broadcasts | 108 | 285 | 293 |
| With nonscheduled broadcasts | 166 | 2 | 1 |
| Without voice | 17 | 10 | 10 |
| Radio Marker Beacons | 63 | 84 | 83 |
| Weather reporting airport and airway stations: | | | |
| Weather Bureau and CAA operated long-line teletypewriter equipped | 365 | 535 | 533 |
| Traffic control stations teletypewriter equipped | 36 | 371 | 373 |
| Miles of weather reporting teletypewriter service | 52,800 | 62,545 | 62,835 |
| Miles of traffic control teletypewriter service | 10,372 | 36,755 | 32,807 |
| Weather Bureau first order stations (does not include airport stations) | 120 | 118 | 164 |
| Airway lighting: | | | |
| Beacons | | | |
| Revolving | 2,035 | 2,037 | 2,025 |
| Flashing | 143 | 123 | 121 |
| Beacons privately owned and certified | 1,201 | 1,347 | 1,454 |
| Intermediate landing fields, lighted | 236 | 228 | 207 |
| CERTIFICATES | | | |
| Certificated Aircraft: | | | |
| Airplanes | 22,927 | 21,893 | 29,214 |
| Gliders | 124 | 144 | 240 |
| Certificated Airmen: | | | |
| Pilots, airplane, total | 122,884 | 132,432 | .... |
| Airline transport | 2,315 | 3,046 | .... |
| Commercial | 20,587 | 22,059 | .... |
| Private | 99,982 | 107,327 | .... |
| Pilots, gliders (private and commercial) | 1,435 | 2,412 | 2,438 |
| Pilots, gliders (student) | 1,137 | 1,211 | 1,301 |
| Mechanics | 20,805[6] | 25,157 | 27,272 |
| Parachute technicians | 473 | 930 | 1,020 |
| Ground Instructors | 12,739 | 14,647 | 15,195 |
| Airplane student pilot certificates issued during year | 36,802 | 51,618 | 74,058 |

[1] Totals shown for passengers and express carried are not unduplicated figures, as the same passengers and express may be counted for more than one route.

[2] The mail ton-miles flown by Hawaiian Airlines, Ltd., are included with the domestic mail ton-miles as this company holds a domestic air mail contract. All other operations statistics for this carrier are included with foreign and territorial statistics. 1945 total is preliminary.

[3] Includes DPC aircraft assigned by CAA to WTS operators.

[4] Includes 3 fields which were constructed but not commissioned on Jan. 1, 1944.

[5] Includes 8 fields no longer classed as CAA intermediate but not reclassified as of January 1, 1946.

[6] Includes 473 parachute technicians.


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The side-by-side Taylorcraft is the obvious answer to the personal plane requirements of sportsmen, professionals, farmers, and family men. Unbelievably safe and easy-to-fly . . . inexpensive to own and operate. Years of pre-war experience with side-by-side planes and the successful fulfillment of exacting war contracts have made Taylorcraft your "BEST BUY IN THE SKY."
Taylorcraft
TAYLORCRAFT AVIATION • ALLIANCE, OHIO
WORLD'S LARGEST BUILDERS OF SIDE-BY-SIDE AIRPLANES

## AIRPORTS AND LANDING FIELDS IN THE UNITED STATES

January 1, 1946

Compiled by Information and Statistics Service, Civil Aeronautics Administration

| *State* | *Total* | *Commercial* | *Municipal* | *CAA Intermediate* | *All Others*[1] | *Total Lighted* |
|---|---|---|---|---|---|---|
| Total | 4,026 | 1,509 | 1,220 | 216 | 1,081 | 1,007 |
| Alabama | 71 | 17 | 12 | 3 | 39 | 20 |
| Arizona | 95 | 24 | 24 | 10 | 37 | 32 |
| Arkansas | 60 | 28 | 14 | 2 | 16 | 9 |
| California | 298 | 96 | 59 | 12 | 131 | 91 |
| Colorado | 70 | 28 | 29 | 2 | 11 | 13 |
| Connecticut | 23 | 13 | 7 | 1 | 2 | 7 |
| Delaware | 10 | 4 | 1 | 0 | 5 | 3 |
| District of Columbia | 3 | 0 | 0 | 0 | 3 | 3 |
| Florida | 205 | 23 | 39 | 4 | 139 | 51 |
| Georgia | 92 | 22 | 17 | 9 | 44 | 40 |
| Idaho | 63 | 11 | 33 | 5 | 14 | 15 |
| Illinois | 125 | 71 | 18 | 6 | 30 | 21 |
| Indiana | 94 | 45 | 17 | 3 | 29 | 18 |
| Iowa | 83 | 49 | 26 | 4 | 4 | 15 |
| Kansas | 127 | 38 | 45 | 3 | 41 | 25 |
| Kentucky | 23 | 10 | 7 | 2 | 4 | 9 |
| Louisiana | 53 | 16 | 13 | 4 | 20 | 21 |
| Maine | 41 | 15 | 20 | 0 | 6 | 18 |
| Maryland | 37 | 23 | 3 | 1 | 10 | 5 |
| Massachusetts | 58 | 34 | 12 | 0 | 12 | 11 |
| Michigan | 159 | 46 | 91 | 2 | 20 | 20 |
| Minnesota | 67 | 29 | 34 | 2 | 2 | 9 |
| Mississippi | 63 | 16 | 23 | 6 | 18 | 18 |
| Missouri | 87 | 38 | 23 | 8 | 18 | 20 |
| Montana | 95 | 12 | 53 | 13 | 17 | 27 |
| Nebraska | 66 | 23 | 25 | 5 | 13 | 16 |
| Nevada | 44 | 12 | 10 | 8 | 14 | 18 |
| New Hampshire | 18 | 6 | 11 | 0 | 1 | 6 |
| New Jersey | 53 | 38 | 6 | 0 | 9 | 11 |
| New Mexico | 76 | 17 | 22 | 10 | 27 | 24 |
| New York | 164 | 98 | 41 | 4 | 21 | 34 |
| North Carolina | 100 | 50 | 21 | 1 | 28 | 16 |
| North Dakota | 42 | 7 | 28 | 7 | 0 | 12 |
| Ohio | 132 | 89 | 28 | 7 | 8 | 25 |
| Oklahoma | 135 | 48 | 42 | 4 | 41 | 26 |
| Oregon | 65 | 19 | 24 | 5 | 17 | 26 |
| Pennsylvania | 149 | 100 | 37 | 3 | 9 | 30 |
| Rhode Island | 7 | 3 | 0 | 0 | 4 | 2 |
| South Carolina | 61 | 15 | 21 | 2 | 23 | 15 |
| South Dakota | 33 | 8 | 18 | 2 | 5 | 6 |
| Tennessee | 38 | 12 | 13 | 7 | 6 | 18 |
| Texas | 378 | 136 | 102 | 22 | 118 | 100 |
| Utah | 40 | 5 | 23 | 7 | 5 | 18 |
| Vermont | 12 | 3 | 9 | 0 | 0 | 4 |
| Virginia | 79 | 36 | 19 | 4 | 20 | 18 |
| Washington | 92 | 21 | 37 | 3 | 31 | 29 |
| West Virginia | 33 | 19 | 11 | 2 | 1 | 6 |
| Wisconsin | 68 | 31 | 32 | 3 | 2 | 10 |
| Wyoming | 39 | 5 | 20 | 8 | 6 | 16 |

[1] Includes military.

## EMPLOYEES IN THE AIRCRAFT INDUSTRY

1941—1945

From Statistical Service, Aircraft Industries Association of America

| *At End of Month* | *Total Employees of All Prime Contractors* | *Airframes* | *Engines* | *Propellers* |
|---|---|---|---|---|
| 1941 | | | | |
| December | 425,027 | 313,207 | 96,746 | 12,084 |
| 1942 | | | | |
| January | 460,356 | 341,603 | 104,156 | 14,597 |
| February | 501,753 | 368,669 | 116,804 | 16,280 |
| March | 538,060 | 399,078 | 120,387 | 18,595 |
| April | 572,616 | 412,927 | 138,974 | 20,715 |
| May | 611,272 | 439,188 | 148,738 | 23,346 |
| June | 653,033 | 470,765 | 156,964 | 25,304 |
| July | 695,359 | 505,274 | 162,893 | 27,192 |
| August | 753,425 | 553,840 | 170,080 | 29,505 |
| September | 796,954 | 589,503 | 176,597 | 30,854 |
| October | 852,862 | 635,056 | 185,387 | 32,419 |
| November | 910,932 | 680,535 | 195,869 | 34,528 |
| December | 970,359 | 729,995 | 204,177 | 36,187 |
| 1943[1] | | | | |
| January | 1,027,914 | 770,471 | 219,084 | 38,359 |
| February | 1,072,573 | 800,055 | 232,186 | 40,332 |
| March | 1,106,664 | 819,848 | 244,434 | 42,382 |
| April | 1,139,018 | 839,349 | 255,547 | 44,122 |
| May | 1,166,555 | 856,244 | 263,684 | 46,627 |
| June | 1,203,470 | 881,130 | 273,798 | 48,542 |
| July | 1,233,385 | 900,584 | 282,944 | 49,857 |
| August | 1,257,427 | 907,098 | 297,329 | 53,000 |
| September | 1,290,181 | 924,872 | 310,573 | 54,736 |
| October | 1,311,765 | 931,109 | 325,916 | 54,740 |
| November | 1,326,345 | 936,466 | 336,128 | 53,751 |
| December | 1,310,799 | 922,859 | 333,303 | 54,637 |
| 1944 | | | | |
| January | 1,307,953 | 913,091 | 337,698 | 57,164 |
| February | 1,295,701 | 898,865 | 339,833 | 57,003 |
| March | 1,267,057 | 875,423 | 335,014 | 56,620 |
| April | 1,247,182 | 856,325 | 334,458 | 56,399 |
| May | 1,227,724 | 840,351 | 332,149 | 55,224 |
| June | 1,197,074 | 811,623 | 331,367 | 54,084 |
| July | 1,180,866 | 796,976 | 329,620 | 54,270 |
| August | 1,130,919 | 760,282 | 317,346 | 53,291 |
| September | 1,095,198 | 741,129 | 300,451 | 53,618 |
| October | 1,062,900 | 721,449 | 289,563 | 51,888 |
| November | 1,050,320 | 715,421 | 284,356 | 50,543 |
| December | 1,045,635 | 713,081 | 283,548 | 49,006 |
| 1945 | | | | |
| January | 1,058,236 | 723,850 | 286,233 | 48,153 |
| February | 1,053,089 | 720,384 | 285,406 | 47,299 |
| March | 1,031,363 | 704,053 | 280,443 | 46,867 |
| April | 996,356 | 679,039 | 270,821 | 46,496 |
| May | 920,441 | 622,039 | 255,359 | 43,043 |
| June | 843,946 | 565,921 | 237,685 | 40,340 |
| July | 792,430 | 531,977 | 224,600 | 35,853 |
| August | 345,900 | 255,037 | 80,457 | 10,406 |
| September | 242,652 | 176,409 | 59,041 | 7,202 |

[1] Beginning with January 1943 and thereafter figures differ generally from those previously released due to a shift in reporting from a net to a gross basis. The effect of this change is an increase of approximately 9,500 over the total and airframe employment previously reported for January 1943. The engine and propeller figures were not affected until later in 1943 and the change is of insufficient magnitude to impair the employment trend.

Source: U. S. Department of Labor, Bureau of Labor Statistics, Division of Construction and Public Employment. The Bureau discontinued this series after September, 1945.

## WAGES AND HOURS IN THE AIRCRAFT INDUSTRY

From Statistical Service, Aircraft Industries Association of America

AVERAGE HOURS AND EARNINGS OF WAGE EARNERS IN AIRFRAME, ENGINE AND PROPELLER PLANTS

| | *Airframe Plants* | | | *Engine Plants* | | | *Propeller Plants* | | |
|---|---|---|---|---|---|---|---|---|---|
| | *Weekly Hours* | *Average Weekly Earnings* | *Hourly Earnings* | *Weekly Hours* | *Average Weekly Earnings* | *Hourly Earnings* | *Weekly Hours* | *Average Weekly Earnings* | *Hourly Earnings* |
| 1941 | | | | | | | | | |
| Dec. | 45.8 | $41.53 | $ .91 | 48.3 | $55.63 | $1.15 | 53.2 | $63.95 | $1.20 |
| 1942 | | | | | | | | | |
| Jan. | 48.9 | 46.12 | .94 | 50.6 | 62.09 | 1.23 | 52.0 | 59.10 | 1.14 |
| Feb. | 47.5 | 44.35 | .93 | 49.7 | 59.34 | 1.19 | 49.7 | 54.15 | 1.09 |
| Mar. | 47.6 | 44.33 | .93 | 49.3 | 60.93 | 1.23 | 50.1 | 56.42 | 1.13 |
| Apr. | 47.4 | 44.62 | .94 | 48.5 | 58.90 | 1.21 | 50.9 | 58.04 | 1.14 |
| May | 46.7 | 44.52 | .95 | 48.3 | 58.43 | 1.21 | 51.5 | 59.51 | 1.16 |
| June | 46.1 | 44.65 | .97 | 48.2 | 58.07 | 1.21 | 51.0 | 59.58 | 1.17 |
| July | 45.6 | 44.49 | .97 | 48.0 | 59.61 | 1.24 | 52.1 | 59.01 | 1.13 |
| Aug. | 46.0 | 44.78 | .97 | 48.3 | 60.21 | 1.25 | 48.9 | 57.47 | 1.18 |
| Sept. | 45.8 | 45.34 | .99 | 47.6 | 61.00 | 1.28 | 47.7 | 59.44 | 1.25 |
| Oct. | 45.7 | 44.35 | .97 | 48.8 | 61.14 | 1.25 | 48.3 | 60.18 | 1.24 |
| Nov. | 46.1 | 44.91 | .97 | 47.3 | 59.25 | 1.25 | 46.2 | 56.38 | 1.22 |
| Dec. | 46.4 | 45.59 | .98 | 47.1 | 58.92 | 1.25 | 48.9 | 59.89 | 1.22 |
| 1943 | | | | | | | | | |
| Jan. | 46.3 | 45.82 | .99 | 47.2 | 59.84 | 1.27 | 49.0 | 59.62 | 1.22 |
| Feb. | 45.9 | 45.89 | 1.00 | 47.8 | 60.21 | 1.26 | 47.4 | 58.05 | 1.23 |
| Mar. | 46.1 | 46.48 | 1.01 | 48.5 | 61.33 | 1.26 | 47.7 | 58.18 | 1.22 |
| Apr. | 47.1 | 48.90 | 1.04 | 48.0 | 60.40 | 1.26 | 48.2 | 60.14 | 1.25 |
| May | 46.7 | 49.21 | 1.05 | 48.8 | 62.10 | 1.27 | 48.2 | 60.27 | 1.25 |
| June | 46.4 | 49.47 | 1.07 | 46.7 | 59.03 | 1.26 | 48.3 | 60.56 | 1.25 |
| July | 45.4 | 48.31 | 1.06 | 46.7 | 59.40 | 1.27 | 48.3 | 60.94 | 1.26 |
| Aug. | 45.6 | 48.97 | 1.07 | 47.1 | 59.70 | 1.27 | 49.0 | 61.27 | 1.25 |
| Sept. | 46.5 | 51.58 | 1.11 | 47.7 | 62.25 | 1.30 | 49.0 | 64.11 | 1.31 |
| Oct. | 46.6 | 51.30 | 1.10 | 47.7 | 61.14 | 1.28 | 47.0 | 58.89 | 1.25 |
| Nov. | 46.6 | 51.84 | 1.11 | 47.4 | 61.14 | 1.29 | 47.6 | 59.75 | 1.26 |
| Dec. | 45.6 | 51.12 | 1.12 | 46.2 | 58.47 | 1.26 | 47.2 | 59.89 | 1.27 |
| 1944 | | | | | | | | | |
| Jan. | 47.7 | 54.03 | 1.13 | 47.7 | 61.69 | 1.29 | 48.7 | 61.71 | 1.27 |
| Feb. | 47.3 | 53.65 | 1.13 | 46.9 | 60.66 | 1.29 | 47.4 | 59.52 | 1.26 |
| Mar. | 46.8 | 53.52 | 1.14 | 47.1 | 60.07 | 1.29 | 46.5 | 58.26 | 1.26 |
| Apr. | 46.4 | 53.32 | 1.15 | 47.1 | 61.15 | 1.30 | 46.7 | 59.10 | 1.26 |
| May | 46.8 | 54.30 | 1.16 | 46.0 | 59.49 | 1.29 | 46.4 | 58.16 | 1.25 |
| June | 46.9 | 54.37 | 1.16 | 46.7 | 61.00 | 1.31 | 47.3 | 60.61 | 1.28 |
| July | 46.5 | 53.90 | 1.16 | 42.2 | 55.23 | 1.31 | 44.3 | 57.00 | 1.29 |
| Aug. | 46.8 | 54.36 | 1.16 | 45.4 | 59.19 | 1.30 | 48.2 | 62.70 | 1.30 |
| Sept. | 45.7 | 53.99 | 1.18 | 44.3 | 58.44 | 1.32 | 45.0 | 59.30 | 1.32 |
| Oct. | 46.5 | 54.51 | 1.17 | 45.9 | 59.75 | 1.30 | 47.5 | 62.62 | 1.32 |
| Nov. | 47.0 | 55.28 | 1.18 | 44.9 | 59.05 | 1.31 | 46.2 | 61.07 | 1.32 |
| Dec. | 47.3 | 55.64 | 1.18 | 46.3 | 61.16 | 1.32 | 46.7 | 62.34 | 1.33 |
| 1945 | | | | | | | | | |
| Jan. | 48.1 | 57.41 | 1.19 | 45.6 | 61.39 | 1.35 | 44.1 | 58.30 | 1.32 |
| Feb. | 47.1 | 55.46 | 1.18 | 47.1 | 62.43 | 1.32 | 46.1 | 61.77 | 1.34 |
| Mar. | 47.0 | 55.58 | 1.18 | 46.8 | 61.71 | 1.32 | 46.8 | 62.94 | 1.35 |
| Apr. | 46.8 | 55.24 | 1.18 | 45.7 | 59.44 | 1.30 | 46.7 | 65.51 | 1.34 |
| May | 46.8 | 55.31 | 1.18 | 45.1 | 58.88 | 1.31 | 45.9 | 60.52 | 1.32 |
| June | 47.3 | 56.38 | 1.19 | 44.2 | 57.25 | 1.30 | 44.7 | 57.90 | 1.30 |
| July | 46.2 | 55.17 | 1.19 | 43.8 | 56.70 | 1.29 | 44.6 | 57.67 | 1.29 |
| Aug. | 40.0 | 47.37 | 1.19 | 34.6 | 44.07 | 1.27 | 39.4 | 50.70 | 1.29 |
| Sept. | 37.8 | 44.54 | 1.18 | 37.8 | 46.01 | 1.22 | 42.4 | 52.33 | 1.23 |

Source: U. S. Dept. of Labor, Bureau of Labor Statistics. The series was discontinued after September, 1945.

# AMERICAN AIRCRAFT IN SERVICE OR IN RESERVE

AIR FORCES OF THE UNITED STATES

January 1, 1946

| Designer | Model | | Approved Name |
|---|---|---|---|
| | U. S. Army | U. S. Navy | |
| *Bombers* | | | |
| Boeing | B-17 | PB | Flying Fortress |
| Douglas | B-19 | | Hemisphere Defender |
| Consolidated Vultee | B-24 | PB4Y-1 | Liberator |
| North American | B-25 | PBJ | Mitchell |
| Martin | B-26 | | Marauder |
| Boeing | B-29 | | Superfortress |
| Consolidated Vultee | B-32 | | Dominator |
| Lockheed | B-34 | | Ventura |
| Northrop | B-35 | | (No name) |
| Consolidated Vultee | B-36 | | (No name) |
| Boeing | B-39 | | Superfortress |
| Boeing | B-44 | | Superfortress |
| North American | B-45 | | (No name) |
| Douglas | A-20 | | Havoc |
| Douglas | A-24 | SBD | Dauntless |
| Curtiss | A-25 | SB2C | Helldiver |
| Douglas | A-26 | | Invader |
| Consolidated Vultee | A-31, A-35 | | Vengeance |
| Consolidated Vultee | A-44 | | (No name) |
| Curtiss | | BT2C | (No name) |
| Douglas | | BT2D | (No name) |
| Martin | | BTM | Mauler |
| Curtiss | | SBF | Helldiver |
| Curtiss | | SBW | Helldiver |
| Grumman | | TBF | Avenger |
| Grumman | | TBM | Avenger |
| Vought | | TBY | Seawolf |
| Lockheed | | P2V | Neptune |
| Consolidated Vultee | | PB4Y-2 | Privateer |
| Lockheed | | PV-1 | Ventura |
| Lockheed | | PV-2 | Harpoon |
| Consolidated Vultee | | PB2Y | Coronado |
| Consolidated Vultee | | PBY | Catalina |
| Martin | | PBM | Mariner |
| *Fighters* | | | |
| Lockheed | P-38 | | Lightning |
| Republic | P-47 | | Thunderbolt |
| North American | P-51 | | Mustang |
| Bell | P-59 | | Airacomet |
| Northrop | P-61 | F2T | Black Widow |
| Bell | P-63 | | Kingcobra |
| General Motors (Fisher) | P-75 | | (No name) |
| Lockheed | P-80 | | Shooting Star |
| Consolidated Vultee | P-81 | | (No name) |
| North American | P-82 | | (No name) |
| Bell | P-83 | | (No name) |
| Republic | P-84 | | (No name) |
| North American | P-86 | | (No name) |
| McDonnell | | FD | Phantom |
| Boeing | | F8B | (No name) |
| Goodyear | | F2G | (No name) |
| Grumman | | FM | Wildcat |
| Vought | | F4U, F3A, FG | Corsair |
| Grumman | | F6F | Hellcat |
| Grumman | | F8F | Bearcat |
| Ryan | | FR | Fireball |
| Grumman | | F7F | Tigercat |
| *Observation* | | | |
| Beech | F-2 | | Expeditor |
| Lockheed | F-5 | | Lightning |
| North American | F-6 | | Mustang |
| Consolidated Vultee | F-7 | | Liberator |
| Boeing | F-9 | | Flying Fortress |
| North American | F-10 | | Mitchell |
| Republic | F-12 | | (No name) |
| Boeing | F-13 | | Superfortress |
| Lockheed | F-14 | | Shooting Star |
| Northrop | F-15 | | Black Widow |
| Consolidated Vultee | OA-10 | | Catalina |


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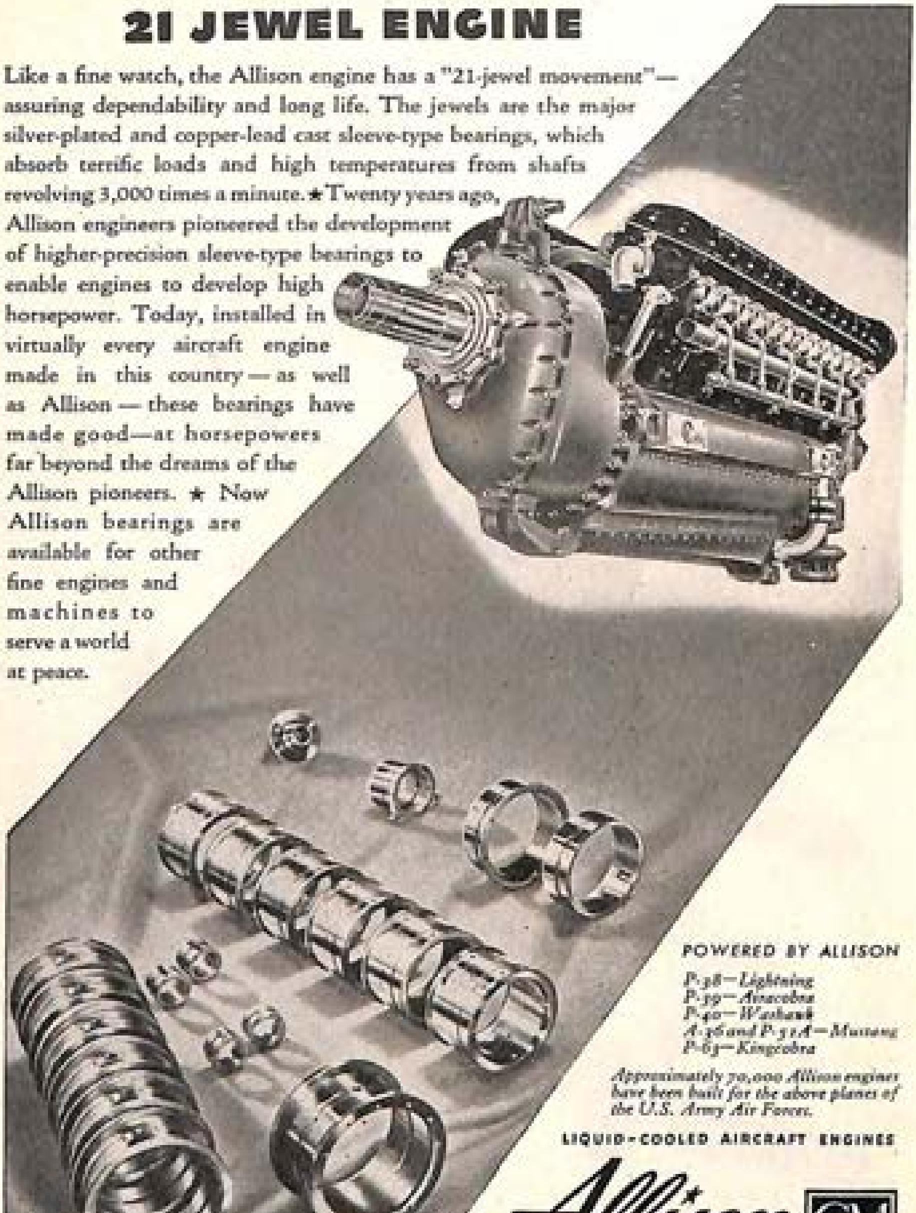
LOCKHEED P-80 POWERED BY GENERAL ELECTRIC

## AMERICAN AIRCRAFT IN SERVICE OR IN RESERVE
(Continued)

| Designer | Model: U. S. Army | Model: U. S. Navy | Approved Name |
|---|---|---|---|
| *Observation, cont'd.* | | | |
| Curtiss | | SC | Seahawk |
| Vought | | OS2U, OS2N | Kingfisher |
| Consolidated Vultee | | OY | Sentinel |
| *Transports* | | | |
| Beech | C-45 | | Expeditor |
| Curtiss | C-46 | R5C | Commando |
| Douglas | C-47 | R4D | Skytrain |
| Douglas | C-54 | R5D | Skymaster |
| Noorduyn | C-64 | JA | Norseman |
| Lockheed | C-69 | | Constellation |
| Douglas | C-74 | | Globemaster |
| Fairchild | C-82 | | Packet |
| Boeing | C-97 | | (No name) |
| Douglas | C-117 | | Skytrain |
| Beech | UC-45 | GB | Traveller |
| Fairchild | UC-61 | GK | Forwarder |
| Consolidated Vultee | | RY | Liberator |
| Lockheed | | XR60 | (No name) |
| Douglas | | R4D | Skytrooper |
| Lockheed | | R50 | Lodestar |
| Lockheed | | R30 | (No name) |
| Consolidated Vultee | | PB2Y | Coronado |
| Martin | | JRM | Mars |
| Sikorsky | | JR2S | Excalibur |
| Boeing | | B-314 | Clipper |
| Martin | | PBM | Mariner |
| *Trainers* | | | |
| North American | AT-6 | SNJ | Texan |
| Beech | AT-7 | SNB | Navigator |
| Beech | AT-11 | SNB | Kansan |
| Boeing | PT-13, 17 | N2S | Kaydet |
| Fairchild | PT-19 | | Cornell |
| Curtiss | | SNC | Falcon |
| Consolidated Vultee | | SNV | Valiant |
| Howard | | NH | Nightingale |
| Ryan | | NR | Recruit |
| *Utility* (Navy Classification) | | | |
| Douglas | | BD | Havoc |
| Douglas | | JD | Invader |
| Beech | | JRB | Expeditor |
| Cessna | | JRC | Bobcat |
| Grumman | | JRF | Goose |
| Martin | | JM | Marauder |
| Grumman | | J4F | Widgeon |
| Lockheed | | JO | (No name) |
| Piper | | AE, NE | Grasshopper |
| Fairchild | | GK | Forwarder |
| Beech | | GB | Traveller |
| Howard | | GH | Nightingale |
| Noorduyn | | JA | Norseman |
| Grumman | | J2F | Duck |
| *Liaison* | | | |
| Piper | L-4 | AE, NE, HE | Grasshopper |
| Consolidated Vultee | L-5 | OY | Sentinel |
| Consolidated Vultee | L-13 | | (No name) |
| Piper | L-14 | | (No name) |
| *Rotary Wing* | | | |
| Sikorsky | R-4 | HNS | (No name) |
| Sikorsky | R-5 | HO2S | (No name) |
| Nash Kelvinator | R-6 | HOS | (No name) |
| Bell | R-12 | | (No name) |
| Bell | R-13 | | (No name) |
| Kellett | O-60 | | (No name) |

Source: U. S. Army Airplanes, Office of Plans and Policies, AAF; U. S. Navy Airplanes, Office of the Chief of Public Relations, Navy Department.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# Directory

## U. S. ARMY AIR FORCES

Washington, D. C.

February 1, 1946

Robert W. Patterson, Secretary of War
W. Stuart Symington, Asst. Secretary of War for Air

| | |
|---|---|
| Commanding General, Army Air Forces | Gen. Carl Spaatz |
| Deputy Commander, AAF and Chief of Air Staff | Lt. Gen. Ira C. Eaker |
| Deputy Chief of Air Staff | Major Gen. C. C. Chauncey |
| Deputy Chief of Air Staff | Brig. Gen. R. C. Hood |
| Deputy Chief of Air Staff for Research and Development | Major Gen. C. E. LeMay |
| Assistant Chief of Air Staff—1 | Major Gen. F. L. Anderson |
| Assistant Chief of Air Staff—2 | Brig. Gen. G. C. McDonald |
| Assistant Chief of Air Staff—3 | Major Gen. E. E. Partridge |
| Assistant Chief of Air Staff—4 | Major Gen. E. M. Powers |
| Assistant Chief of Air Staff—5 | Major Gen. L. Norstad |
| AAF Personnel Distribution Command | Major Gen. John D. F. Barker |
| AAF Training Command (Acting) | Major Gen. J. P. Hodges |
| Air Transport Command | Lt. Gen. H. L. George |
| Air Technical Service Command | Lt. Gen. N. F. Twining |
| AAF Center | Major Gen. Donald Wilson |
| Continental Air Forces: | Commanding General, Gen. Carl Spaatz |
| | Deputy, Major Gen. St. Clair Streett |
| Fifth Air Force (Acting) | Major Gen. Kenneth B. Wolfe |
| Sixth Air Force | Major Gen. Hubert R. Harmon |
| Seventh Air Force | Brig. Gen. Thomas D. White |
| Eighth Air Force | Brig. Gen. Patrick W. Timberlake |
| Thirteenth Air Force | Major Gen. Paul D. Wurtsmith |
| Twentieth Air Force | Major Gen. James E. Parker |
| Alaskan Air Command | Brig. Gen. Edmund C. Lynch |
| Air Inspector | Major Gen. J. W. Jones |
| Budget and Fiscal | Colonel E. H. White |
| Special Assistant for Anti-Aircraft | Major Gen. H. R. Oldfield |

## CIVIL AERONAUTICS ADMINISTRATION
## U. S. DEPARTMENT OF COMMERCE

Washington, D. C.

Henry A. Wallace, Secretary of Commerce
William A. M. Burden, Assistant Secretary of Commerce

| | |
|---|---|
| Administrator of Civil Aeronautics | T. P. Wright |
| Deputy Administrator | Charles I. Stanton |
| Assistant Administrator, Field Operations | A. S. Koch |
| Assistant Administrator, Business Management | A. E. Stockburger |
| Assistant Administrator, Aviation Information | Ben Stern |
| Assistant Administrator, Safety Regulation | Fred Lanter |
| Assistant Administrator, Airports | C. B. Donaldson |
| Executive Assistant to Administrator | Edward Sturhahn |
| Assistant to the Administrator, Personal Flying Development | John Geisse |
| Assistant to the Administrator, Research | Dean R. Brimhall |
| Assistant to the Administrator, State Relations | E. J. Robins |
| Manager, Washington National Airport | Hervey Law |

### Regional Managers

| | | |
|---|---|---|
| Region I | New York, N. Y. | W. E. Kline |
| Region II | Atlanta, Ga. | W. M. Robertson |
| Region III | Chicago, Ill. | George W. Vest |
| Region IV | Fort Worth, Tex. | L. C. Elliott |
| Region V | Kansas City, Mo. | L. W. Jurden |
| Region VI | Santa Monica, Calif. | Joseph S. Marriott |
| Region VII | Seattle, Wash. | R. D. Bedinger |
| Region VIII | Anchorage, Alaska | W. P. Plett |
| Region IX | Honolulu, T. H. | John M. Beardslee |

## U. S. NAVAL AVIATION

Washington, D. C.

March 15, 1946

James Forrestal, Secretary of the Navy

| | |
|---|---|
| Chief of Naval Operations | Fleet Admiral Chester W. Nimitz |
| Vice Chief of Naval Operations | Vice Admiral deWitt C. Ramsey |
| Deputy Chief of Naval Operations (Air) | Vice Admiral Arthur W. Radford |
| Director, Marine Aviation | Major General Field Harris |
| Director, Naval Air Transport Service | Rear Admiral John W. Reeves, Jr. |
| Director, Aviation Training | Captain John P. W. Vest |
| Director, Aviation Planning | Captain Lucian A. Moebus |
| Director, Aviation Personnel | Captain John P. Heath |
| Director, Flight Division | Captain James R. Dudley |
| Assistant Chief of Naval Operations (Air) | Rear Admiral R. E. Jennings |
| Commander, Air Force Pacific | Vice Admiral A. A. Montgomery |
| Commander, Air Force Atlantic | Vice Admiral Gerald F. Bogan |
| Commander, Fleet Air West Coast | Rear Admiral W. K. Harrill |
| Commander, Fleet Air Alameda | Rear Admiral John D. Price |
| Commander, Fleet Air Quonset | Rear Admiral George R. Henderson |
| Chief, Naval Aviation Training | Rear Admiral F. D. Wagner |
| Chief, Naval Aviation Advanced Training | Rear Admiral Ralph Davison |
| Chief, Naval Aviation Basic Training | Rear Admiral J. J. Clark |
| Chief, Naval Aviation Technical Training | Rear Admiral Felix Stump |
| Chief, Naval Aviation Reserve Training | Rear Admiral Edward C. Ewen |

### Bureau of Aeronautics

| | |
|---|---|
| Chief, Bureau of Aeronautics | Rear Admiral Harold B. Sallada |
| Assistant Chief, Bureau of Aeronautics | Rear Admiral Lawrence B. Richardson |
| Director, Military Requirements | Captain Robert E. Dixon |
| Director, Procurement | Captain Joseph W. Antonides |
| Director, Engineering | Captain Theodore C. Lonnquest |
| Director, Production | Captain Leland D. Webb |

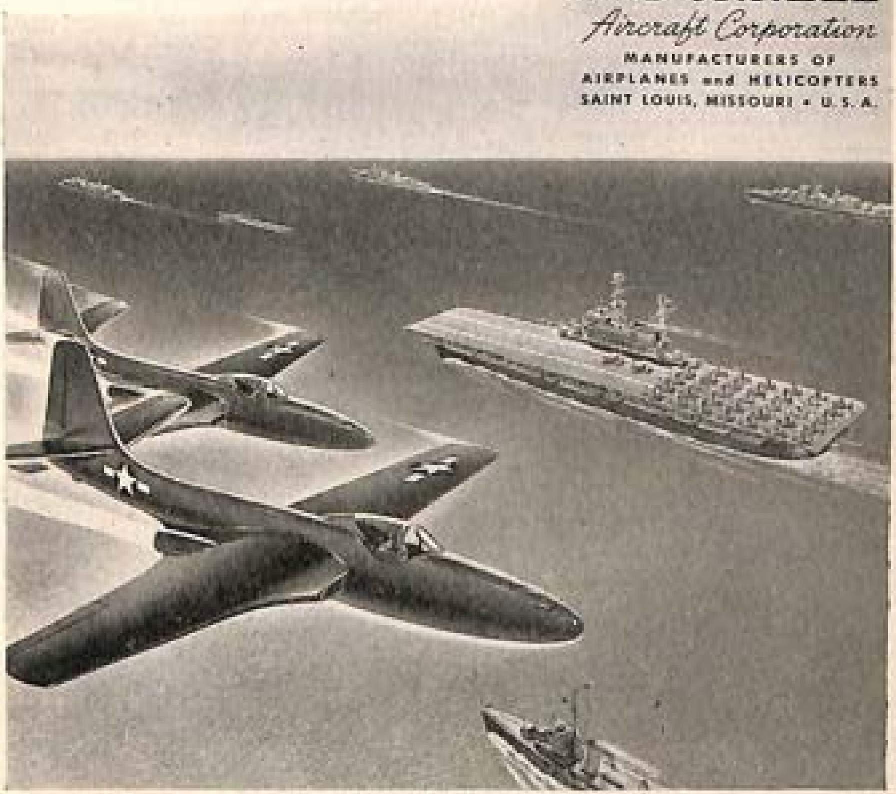
## CIVIL AERONAUTICS BOARD

| | |
|---|---|
| L. Welch Pogue | Chairman |
| Harllee Branch | Member |
| Oswald Ryan | Member |
| Josh Lee | Member |
| Clarence M. Young | Member |
| Fred A. Toombs | Secretary |
| George C. Neal | General Counsel |
| Francis W. Brown | Chief Examiner |
| Russell B. Adams | Director, Economic Bureau |
| Joseph B. Duckworth | Director, Safety Bureau |

## POST OFFICE DEPARTMENT AIR MAIL SERVICE

Washington, D. C.

| | |
|---|---|
| Postmaster General | Robert E. Hannegan |
| Second Assistant Postmaster General | Gael E. Sullivan |
| Deputy Second Assistant Postmaster General | Roy M. Martin |
| Domestic Air Mail Service: | |
| Superintendent | Robert S. Burgess |
| Regional Superintendent, New York, N. Y. | W. H. Nichols |
| Regional Superintendent, Chicago, Ill. | R. E. Pollard |
| Regional Superintendent, Atlanta, Ga. | J. L. Fulghum |
| Regional Superintendent, Fort Worth, Tex. | A. C. Hodges |
| Regional Superintendent, San Francisco, Calif. | A. O. Willoughby |
| Director of International Postal Service | S. M. Weber |
| Assistant Director of International Postal Service | V. B. Waters |
| Assistant Director of International Postal Service | E. J. Mahoney |



## NATIONAL ASSOCIATION OF STATE AVIATION OFFICIALS

### Officers

PRESIDENT

Wm. L. Anderson, Executive Director
Pennsylvania Aeronautics Commission
Harrisburg State Airport
New Cumberland, Pennsylvania

1st VICE-PRESIDENT

C. F. Cornish, Director
Indiana Aeronautics Commission
Board of Trade Building
Indianapolis 4, Indiana

2nd VICE-PRESIDENT

David M. Giltinan
West Virginia Board of Aeronautics
201 Atlas Building
Charleston 5, West Virginia

3rd VICE-PRESIDENT

Leo G. Devaney, Director
Oregon State Board of Aeronautics
507 Lumbermen's Building
Portland, Oregon

SECRETARY-TREASURER

Edward F. Knapp, Director
Vermont Aeronautics Commission
State House
Montpelier, Vermont

LEGAL COUNSEL

George B. Logan
506 Olive Street
St. Louis 1, Missouri

### Regional Directors

Region 1:
Arthur H. Tully, Jr., Director
Massachusetts Aeronautics Commission
100 Nashua Street
Boston 9, Massachusetts

Region 2:
Asa Rountree, Jr., Director
Alabama Department of Aeronautics
711 High Street
Montgomery 5, Alabama

Region 3:
L. L. Schroeder
Commissioner of Aeronautics
2429 University Avenue
St. Paul 4, Minnesota

Region 4:
Robert A. Adams
Chief of Aeronautics
Department of Public Works
Baton Rouge, Louisiana

Region 5:
I. V. Packard, Director
Nebraska Aeronautics Commission
State Capitol
Lincoln, Nebraska

Region 6:
Joseph Bergin, Director
Utah State Aeronautics Commission
430 Capitol Building
Salt Lake City 3, Utah

Region 7:
Wm. G. Ferguson, Secretary
State Aeronautics Commission
Helena, Montana

### State Officials

| | |
|---|---|
| ALABAMA: | Asa Rountree, Jr., Alabama Department of Aeronautics<br>711 High Street, Montgomery 5, Ala. |
| COLORADO: | Marvin N. Jackson<br>202 So. 7th St., Grand Junction, Colo. |
| CONNECTICUT: | Kenneth H. Ringrose, Commissioner, Department of Aeronautics<br>P. O. Box 537, Hartford, Conn. |
| IDAHO: | A. A. Bennett, Director of Aeronautics, Department of Public Works<br>P. O. Box 879, Room 907, State House, Boise, Idaho |
| INDIANA: | Clarence F. Cornish, Director, Indiana Aeronautics Commission<br>2nd Floor, Board of Trade Building, Indianapolis 4, Ind. |
| KENTUCKY: | Al Near, Director, Kentucky Aeronautics Commission<br>1st Floor, Old Capitol Annex, Frankfort, Ky. |
| LOUISIANA: | Robert A. Adams, Chief of Aeronautics, Department of Public Works<br>Baton Rouge, La. |
| MAINE: | John E. Wiley, Chairman, Maine Aeronautics Commission<br>State Airport, Augusta, Me. |
| MARYLAND: | Edw. R. Fennimore, Director, State Aviation Commission<br>728 Muncey Building, Baltimore, Md. |
| MASSACHUSETTS: | Arthur H. Tully, Jr., Director, Massachusetts Aeronautics Commission<br>Room 805, 100 Nashua Street, Boston 9, Mass. |
| MICHIGAN: | Sheldon B. Steers, Director, Michigan Department of Aeronautics<br>Capital City Airport, P. O. Box 358, Lansing 2, Mich. |
| MINNESOTA: | L. L. Schroeder, Commissioner, Department of Aeronautics<br>2429 University Avenue, St. Paul 4, Minn. |

## U. S. NAVAL AVIATION

Washington, D. C.

March 15, 1946

James Forrestal, Secretary of the Navy

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| Chief of Naval Operations | Fleet Admiral Chester W. Nimitz |
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| Director, Aviation Training | Captain John P. W. Vest |
| Director, Aviation Planning | Captain Lucian A. Moebus |
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| Harllee Branch | Member |
| Oswald Ryan | Member |
| Josh Lee | Member |
| Clarence M. Young | Member |
| Fred A. Toombs | Secretary |
| George C. Neal | General Counsel |
| Francis W. Brown | Chief Examiner |
| Russell B. Adams | Director, Economic Bureau |
| Joseph B. Duckworth | Director, Safety Bureau |

## POST OFFICE DEPARTMENT AIR MAIL SERVICE

Washington, D. C.

| | |
|---|---|
| Postmaster General | Robert E. Hannegan |
| Second Assistant Postmaster General | Gael E. Sullivan |
| Deputy Second Assistant Postmaster General | Roy M. Martin |
| Domestic Air Mail Service: | |
| Superintendent | Robert S. Burgess |
| Regional Superintendent, New York, N. Y. | W. H. Nichols |
| Regional Superintendent, Chicago, Ill. | R. E. Pollard |
| Regional Superintendent, Atlanta, Ga. | J. L. Fulghum |
| Regional Superintendent, Fort Worth, Tex. | A. C. Hodges |
| Regional Superintendent, San Francisco, Calif. | A. O. Willoughby |
| Director of International Postal Service | S. M. Weber |
| Assistant Director of International Postal Service | V. B. Waters |
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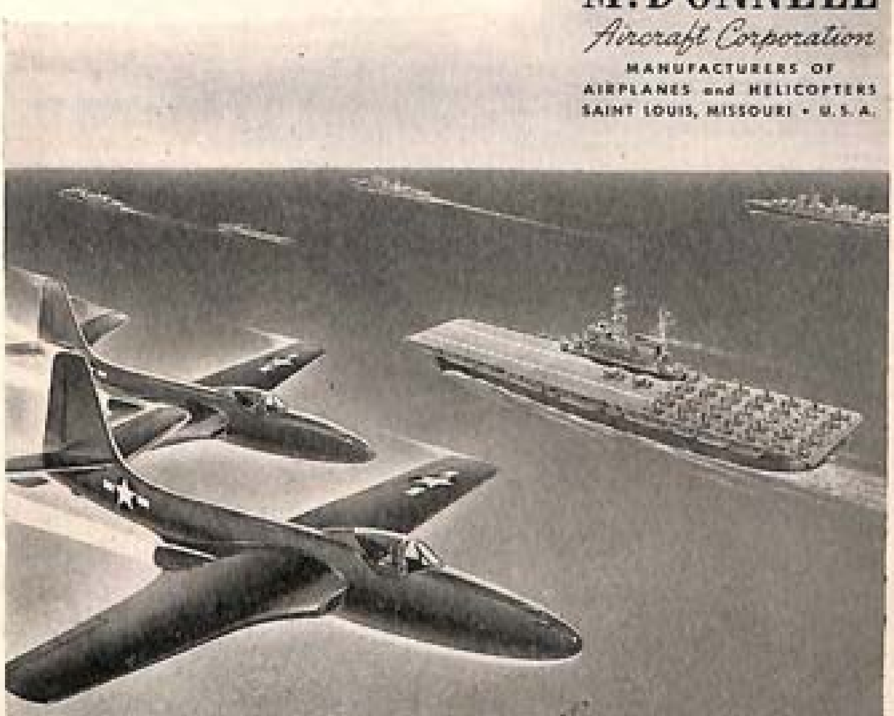

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| MICHIGAN: | Sheldon B. Steers, Director, Michigan Department of Aeronautics<br>Capital City Airport, P. O. Box 358, Lansing 2, Mich. |
| MINNESOTA: | L. L. Schroeder, Commissioner, Department of Aeronautics<br>2429 University Avenue, St. Paul 4, Minn. |

## NATIONAL ASSOCIATION OF STATE AVIATION OFFICIALS
(Continued)

| | |
|---|---|
| MISSOURI: | Eugene V. Fryhoff, Director, Aviation Division, State Department of Resources & Development<br>State Office Building, Jefferson City, Mo. |
| MONTANA: | Wm. G. Ferguson, Secretary, State Aeronautics Commission<br>Helena, Mont. |
| NEBRASKA: | S. Paul Kitrell, Secretary, Nebraska Aeronautics Commission<br>Lincoln, Nebr. |
| NEW HAMPSHIRE: | Russell Hilliard, Director, New Hampshire Aeronautics Commission<br>State House, Concord, N. H. |
| NEW JERSEY: | Gill Robb Wilson, Director, New Jersey Department of Aviation<br>Trenton, N. J. |
| NEW YORK: | Wm. E. Cullinan, Jr., Director, New York Bureau of Aviation, Department of Commerce<br>112 State Street, Albany 1, N. Y. |
| NORTH DAKOTA: | Wesley E. Keller, Chairman, North Dakota Division of Aeronautics<br>Minot, N. D. |
| OREGON: | Major Leo G. Devaney, Director, Oregon State Board of Aeronautics<br>507 Lumbermen's Building, Portland, Ore. |
| PENNSYLVANIA: | Wm. L. Anderson, Director, Pennsylvania Aeronautics Commission, Department of Commerce<br>Harrisburg Airport, New Cumberland, Pa. |
| RHODE ISLAND: | Willard M. Fletcher, Administrator of Aeronautics, Division of Aeronautics, Department of Public Works<br>Theodore Francis Greene Airport, Hillsgrove, R. I. |
| SOUTH CAROLINA: | Dexter C. Martin, Director, South Carolina Aeronautics Commission<br>Columbia, S. C. |
| SOUTH DAKOTA: | Major John Moodie, Executive Secretary, South Dakota Aeronautics Commission<br>Pierre, S. D. |
| TENNESSEE: | Herbert Fox, Executive Director, Tennessee Bureau of Aeronautics<br>Berry Field, Nashville, Tenn. |
| UTAH: | Joseph Bergin, Director, Utah State Aeronautics Commission<br>439 Capitol Building, Salt Lake City 3, Utah |
| VERMONT: | Edw. F. Knapp, Director, Vermont Aeronautics Commission<br>State House, Montpelier, Vt. |
| VIRGINIA: | Lt. Col. Allen Perkinson, Director, Virginia State Corporation Commission<br>907 Travelers Building, Richmond 19, Va. |
| WEST VIRGINIA: | Hubert A. Stark, Director, W. Va. Board of Aeronautics<br>201 Atlas Building, Charleston 5, W. Va. |
| WYOMING: | Wilfred O'Leary, Aeronautical Commissioner, Wyoming Department of Aviation<br>Majestic Building, Cheyenne, Wyo. |

## FEDERAL COMMUNICATIONS COMMISSION

Washington, D. C.

### Commissioners

Paul A. Porter, Chairman

| | |
|---|---|
| Paul A. Walker | Ewell K. Jett |
| Ray C. Wakefield | Charles R. Denny |
| Clifford J. Durr | William H. Wills |

### Legal Department

Rosel H. Hyde, General Counsel
Jeremiah Courtney, Chief, Safety & Special Services Division
Raymond Sawyer, Chief of Aviation Section, Marine and Experimental Services

### Engineering Department

George P. Adair, Chief Engineer
William N. Krebs, Chief, Safety & Special Services Branch
E. L. White, Chief of Aviation Division

### Accounting Department

William J. Norfleet, Chief Accountant

## CONGRESSIONAL COMMITTEES INTERESTED IN AVIATION

Standing Committees of the 79th Congress

### Senate

#### Appropriations

| | | | |
|---|---|---|---|
| Carter Glass | (D) | Burnet R. Maybank | (D) |
| Kenneth McKellar | (D) | Abe Murdock | (D) |
| Carl Hayden | (D) | Styles Bridges | (R) |
| Elmer Thomas | (D) | Wallace H. White | (R) |
| Millard E. Tydings | (D) | Chan Gurney | (R) |
| Richard B. Russell | (D) | C. Wayland Brooks | (R) |
| Pat McCarran | (D) | Clyde M. Reed | (R) |
| John H. Overton | (D) | Joseph H. Ball | (R) |
| John H. Bankhead | (D) | Raymond E. Willis | (R) |
| Joseph C. O'Mahoney | (D) | Homer Ferguson | (R) |
| Theodore Francis Green | (D) | Kenneth S. Wherry | (R) |
| Dennis Chavez | (D) | Guy Cordon | (R) |
| James M. Mead | (D) | | |

#### Interstate Commerce

| | | | |
|---|---|---|---|
| Burton K. Wheeler | (D) | Frank P. Briggs | (D) |
| Alben W. Barkley | (D) | James W. Huffman | (D) |
| Edwin C. Johnson | (D) | Wallace H. White, Jr. | (R) |
| Tom Stewart | (D) | Warren R. Austin | (R) |
| James M. Tunnell | (D) | Henrik Shipstead | (R) |
| Ernest W. McFarland | (D) | Charles W. Tobey | (R) |
| Clyde R. Hoey | (D) | Clyde M. Reed | (R) |
| Olin D. Johnston | (D) | Albert W. Hawkes | (R) |
| Francis J. Myers | (D) | E. H. Moore | (R) |
| Brien McMahon | (D) | Homer E. Capehart | (R) |
| Hugh B. Mitchell | (D) | | |

#### Military Affairs

| | | | |
|---|---|---|---|
| Elbert D. Thomas | (D) | Burnet R. Maybank | (D) |
| Edwin C. Johnson | (D) | Frank P. Briggs | (D) |
| Lister Hill | (D) | Warren R. Austin | (R) |
| Sheridan Downey | (D) | Styles Bridges | (R) |
| Harley M. Kilgore | (D) | Chan Gurney | (R) |
| James E. Murray | (D) | Chapman Revercomb | (R) |
| Joseph C. O'Mahoney | (D) | George A. Wilson | (R) |
| Robert F. Wagner | (D) | H. Alexander Smith | (R) |
| Tom Stewart | (D) | Thomas C. Hart | (R) |

#### Naval Affairs

| | | | |
|---|---|---|---|
| David I. Walsh | (D) | Francis J. Myers | (D) |
| Millard E. Tydings | (D) | Hiram W. Johnson | (R) |
| Richard B. Russell | (D) | Charles W. Tobey | (R) |
| Harry Flood Byrd | (D) | Raymond E. Willis | (R) |
| Peter G. Gerry | (D) | C. Wayland Brooks | (R) |
| Charles O. Andrews | (D) | Owen Brewster | (R) |
| Allen J. Ellender | (D) | Edward V. Robertson | (R) |
| John L. McClellan | (D) | Leverett Saltonstall | (R) |
| James O. Eastland | (D) | Wayne Morse | (R) |
| Warren G. Magnuson | (D) | | |

#### Post Offices and Post Roads

| | | | |
|---|---|---|---|
| Kenneth McKellar | (D) | Glen H. Taylor | (D) |
| Carl Hayden | (D) | E. P. Carville | (D) |
| Josiah W. Bailey | (D) | Clyde M. Reed | (R) |
| Dennis Chavez | (D) | William Langer | (R) |
| Allen J. Ellender | (D) | C. Douglass Buck | (R) |
| James M. Mead | (D) | Bourke B. Hickenlooper | (R) |
| W. Lee O'Daniel | (D) | Forrest C. Donnell | (R) |
| James O. Eastland | (D) | Milton R. Young | (R) |
| John L. McClellan | (D) | William A. Stanfill | (R) |

## CONGRESSIONAL COMMITTEES INTERESTED IN AVIATION (Continued)

### House of Representatives

#### Appropriations

| | | | |
|---|---|---|---|
| Clarence Cannon | (D) | George W. Andrews | (D) |
| Louis Ludlow | (D) | John J. Rooney | (D) |
| Malcolm C. Tarver | (D) | Herman P. Kopplemann | (D) |
| Jed Johnson | (D) | John Taber | (R) |
| J. Buell Snyder | (D) | Richard B. Wigglesworth | (R) |
| Emmet O'Neal | (D) | Charles A. Plumley | (R) |
| Louis C. Rabaut | (D) | Everett M. Dirksen | (R) |
| John H. Kerr | (D) | Albert J. Engel | (R) |
| George H. Mahon | (D) | Karl Stefan | (R) |
| Harry R. Sheppard | (D) | Francis Case | (R) |
| Butler B. Hare | (D) | Frank B. Keefe | (R) |
| Albert Thomas | (D) | Noble J. Johnson | (R) |
| Joe Hendricks | (D) | Robert F. Jones | (R) |
| Michael J. Kirwan | (D) | Ben F. Jensen | (R) |
| John M. Coffee | (D) | H. Carl Andersen | (R) |
| W. F. Norrell | (D) | Henry C. Dworshak | (R) |
| Albert Gore | (D) | Walter C. Ploeser | (R) |
| Jamie L. Whitten | (D) | Harve Tibbott | (R) |
| Thomas J. O'Brien | (D) | Walt Horan | (R) |
| James M. Curley | (D) | Dean M. Gillespie | (R) |
| Thomas D'Alesandro, Jr. | (D) | Gordon Canfield | (R) |

#### Interstate and Foreign Commerce

| | | | |
|---|---|---|---|
| Clarence F. Lea | (D) | Dwight L. Rogers | (D) |
| Robert Crosser | (D) | Benjamin J. Rabin | (D) |
| Alfred L. Bulwinkle | (D) | Vito Marcantonio | (A.L.) |
| Virgil Chapman | (D) | Charles A. Wolverton | (R) |
| Lyle H. Boren | (D) | Pehr G. Holmes | (R) |
| Lindley Beckworth | (D) | B. Carroll Reece | (R) |
| J. Percy Priest | (D) | Charles A. Halleck | (R) |
| Oren Harris | (D) | Carl Hinshaw | (R) |
| George G. Sadowski | (D) | Clarence J. Brown | (R) |
| Richard F. Harless | (D) | Evan Howell | (R) |
| John W. Murphy | (D) | Leonard W. Hall | (R) |
| Edward A. Kelly | (D) | Thomas D. Winter | (R) |
| Luther Patrick | (D) | Joseph P. O'Hara | (R) |
| John B. Sullivan | (D) | Wilson D. Gillette | (R) |

#### Military Affairs

| | | | |
|---|---|---|---|
| Andrew J. May | (D) | Melvin Price | (D) |
| R. Ewing Thomason | (D) | Walter G. Andrews | (R) |
| Overton Brooks | (D) | Dewey Short | (R) |
| John J. Sparkman | (D) | Leslie C. Arends | (R) |
| Paul J. Kilday | (D) | Charles R. Clason | (R) |
| Carl T. Durham | (D) | J. Parnell Thomas | (R) |
| John Edward Sheridan | (D) | Paul W. Shafer | (R) |
| Robert Sikes | (D) | Thomas E. Martin | (R) |
| Philip J. Philbin | (D) | Charles H. Elston | (R) |
| Paul Stewart | (D) | Forest A. Harness | (R) |
| Arthur Winstead | (D) | Ivor D. Fenton | (R) |
| Chet Holifield | (D) | J. Leroy Johnson | (R) |
| James A. Roe | (D) | Clare Boothe Luce | (R) |

#### Naval Affairs

| | | | |
|---|---|---|---|
| Carl Vinson | (D) | Ed. V. Izac | (D) |
| Patrick H. Drewry | (D) | Lansdale G. Sasscer | (D) |
| Lyndon B. Johnson | (D) | James J. Heffernan | (D) |
| Michael J. Bradley | (D) | L. Mendel Rivers | (D) |

## CONGRESSIONAL COMMITTEES INTERESTED IN AVIATION
(Continued)

### Naval Affairs (Continued)

| | | | |
|---|---|---|---|
| F. Edward Hébert | (D) | George J. Bates | (R) |
| John E. Fogarty | (D) | William E. Hess | (R) |
| Emory H. Price | (D) | Jack Z. Anderson | (R) |
| William A. Rowan | (D) | James Wolfenden | (R) |
| Ray J. Madden | (D) | William W. Blackney | (R) |
| Franck R. Havenner | (D) | Robert A. Grant | (R) |
| Hugh De Lacy | (D) | Margaret Chase Smith | (R) |
| Andrew J. Biemiller | (D) | Harry L. Towe | (R) |
| W. Sterling Cole | (R) | C. W. Bishop | (R) |

### Post Offices and Post Roads

| | | | |
|---|---|---|---|
| Thomas G. Burch | (D) | J. Vaughan Gary | (D) |
| George D. O'Brien | (D) | Fred A. Hartley, Jr. | (R) |
| Charles E. McKenzie | (D) | Noah M. Mason | (R) |
| Tom Murray | (D) | John C. Butler | (R) |
| James H. Torrens | (D) | William C. Cole | (R) |
| Matthew M. Neely | (D) | Harold C. Hagen | (R) |
| Philip A. Traynor | (D) | William H. Stevenson | (R) |
| Edward J. Gardner | (D) | Walter E. Brehm | (R) |
| Frank T. Starkey | (D) | Robert J. Corbett | (R) |
| Ned R. Healy | (D) | John W. Heselton | (R) |
| John E. Lyle | (D) | Edward J. Elsaesser | (R) |
| Dudley G. Roe | (D) | James I. Dolliver | (R) |

## INSTITUTE OF THE AERONAUTICAL SCIENCES

2 East 64th St.

New York 21, N. Y.

### Officers for 1946

| | |
|---|---|
| President | Arthur E. Raymond |
| Vice President | Preston R. Bassett |
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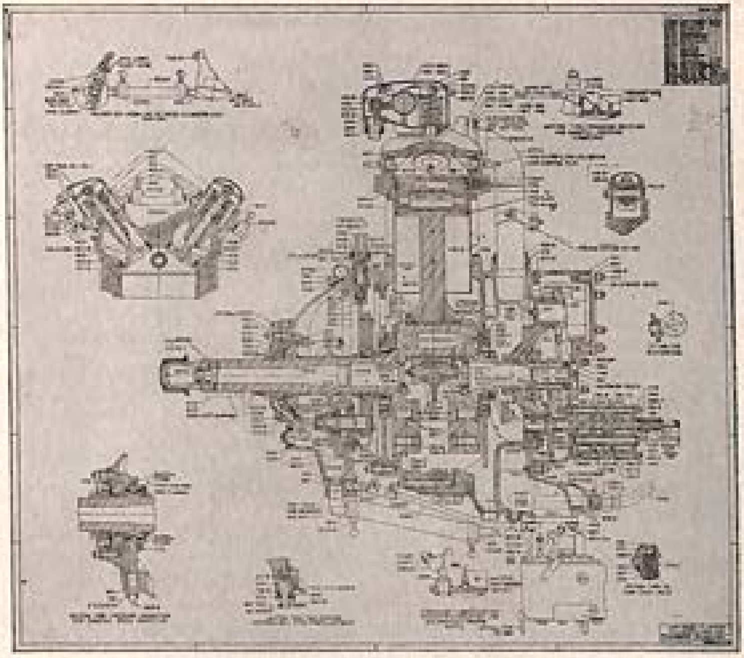

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### Committees (Continued)

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Charles Saygoe........................................Hughes Aircraft Company
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Walter H. Kirff, Standards Engineer........................Lockheed Aircraft Corporation
W. S. Clark, Chief Draftsman........................Luscombe Airplane Corporation
J. T. Thompson, Standards Coordinator........................The Glenn L. Martin Company
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Dale Armstrong, Asst. to General Manager........................Northrop Aircraft, Inc.
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### Committees (Continued)

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R. L. Hamilton, Traffic Manager.......Bendix Aviation Corporation, Scintilla Magneto Div.
W. W. Garrett, Traffic Superintendent
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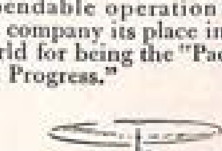
THE MODERN  MAGIC CARPET*

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## AIRCRAFT PARTS

Agawam Aircraft Products, Inc.
Air-Parts, Inc.
All American Aircraft Products, Inc.
American Tube Bending Co., Inc.
Bellanca Aircraft Corp.
Farmingdale Aircraftsmen Manufacturing Corp.
Guiberson Corp.
Heath Co.
Jarvis Manufacturing Co.
Kaiser Cargo, Inc., Fleetwings Div.
Liberty Aircraft Products Corp.
Luscombe Airplane Corp.
Newton-New Haven Co.
Precision Products, Inc.
Saxl Instrument Co.
Scott Aviation Corp.
Taylorcraft Aviation Div., Detroit Air-Craft Products, Inc.
Teleoptic Co.
Thompson Products, Inc.
United Aircraft Products, Inc.
Western Mfg. Supply Co.

### Aluminum

Ace Manufacturing Corp.
Acme Aluminum Alloys Inc.
Adel Precision Products Corp., Huntington Precision Products Div.
Advance Aluminum Castings Corp.
Aero Supply Mfg. Co. Inc.
Agawam Aircraft Products, Inc.
Agerstrand Corp.
All American Aircraft Products, Inc.
Anderson Die Casting & Engineering Corp.
D. L. Auld Co.
B. H. Aircraft Co., Inc.
Bellanca Aircraft Corp.
Breeze Corporations, Inc.
Buhl Manufacturing Co.
Chas. W. Carll Sons
Colgate Aircraft Corp.
Conco Engineering Works
Connecticut Precision Hardware Co.
Dunkirk Die & Machine Works
Eclipse-Pioneer Div., Bendix Aviation Corp.
Edo Aircraft Corp.
Farmingdale Aircraftsmen Manufacturing Corp.
Feick Mfg. Co., Div. of Detroit Aircraft Products
Floorola Products, Inc.
Guiberson Corp.
Frederick Hart & Co., Inc.
International Aviation Corp.

**(Aluminum)** *Continued*
Jarvis Manufacturing Co.
Kaiser Cargo, Inc., Fleetwings Div.
Kellett Aircraft Corp.
Koehler Aircraft Products Co.
Liberty Aircraft Products Corp.
Luscombe Airplane Corp.
Luscombe Engineering Co., Inc.
Machine Products Div., Armstrong Furnace Co.
Irvin W. Masters Inc.
Mercury Aircraft Inc.
Meyers Aircraft Co.
Newton-New Haven Co.
Pacific Aviation, Inc., Los Angeles Div.
Pacific Div., Bendix Aviation Corp.
Poulsen & Nardon, Inc.
Precision Products, Inc.
Reynolds Metals Co.
Rocky Mountain Steel Products, Inc.
Rohr Aircraft Corp.
Ryan Aeronautical Co.
Schweizer Aircraft Corp.
Scott Aviation Corp.
Skydyne, Inc.
Spartan Aircraft Co.
Taylorcraft Aviation Div., Detroit Air-Craft Products, Inc.
Teicher Manufacturing Corp.
Teleoptic Co.
Thompson Products, Inc.
United Aircraft Products, Inc.
Vimalert Co., Ltd.
Waco Aircraft Co.
Worcester Pressed Steel Co.
Wyman-Gordon Co.

### Cork

Adel Precision Products Corp., Huntington Precision Products Div.
Gasket Manufacturing Co.
Meyers Aircraft Co.
United Aircraft Products, Inc.

### Felt

Acadia Synthetic Products Div. Western Felt Works
American Hair & Felt Co.
Gasket Manufacturing Co.

### Fibre

Ace Manufacturing Corp.
Adel Precision Products Corp., Huntington Precision Products Div.
Continental-Diamond Fibre Co.
Gasket Manufacturing Co.
International Aviation Corp.
National Vulcanized Fibre Co.
Pacific Aviation, Inc., Los Angeles Div.
Wells Aircraft Parts Co.

### Leather

Gasket Manufacturing Co.

### Magnesium

Agawam Aircraft Products, Inc.
All American Aircraft Products, Inc.
D. L. Auld Co.
B. H. Aircraft Co., Inc.
Colgate Aircraft Corp.
Connecticut Precision Hardware Co.
Eclipse-Pioneer Div., Bendix Aviation Corp.
International Aviation Corp.
Kaiser Cargo, Inc., Fleetwings Div.
Machine Products Div., Armstrong Furance Co.
Newton-New Haven Co.
Pacific Aviation, Inc., Los Angeles Div.
Precision Products, Inc
Rocky Mountain Steel Products, Inc
Scott Aviation Corp.
Spartan Aircraft Co.
Thompson Products, Inc.
Vimalert Co., Ltd.
Worcester Pressed Steel Co.
Wyman-Gordon Co.

### Plastic

Acadia Synthetic Products Div. Western Felt Works
Agerstrand Corp.
Bellanca Aircraft Corp.
Commercial Plastics Co.
Connecticut Precision Hardware Co.
Continental-Diamond Fibre Co.
Duramold Div. of Fairchild Engine & Airplane Corp.
Formica Insulation Co.
Heath Co.
International Aviation Corp.
Molded Insulation Co.
Scintilla Magneto Div., Bendix Aviation Corp.
Snapvent Co.
United States Plywood Corp.
Universal Moulded Products Corp.
Waco Aircraft Co.
Westinghouse Electric Corp.


AEROPRODUCTS
DIVISION

### Plywood

Air-Parts, Inc.
D. L. Auld Co.
Bellanca Aircraft Corp.
Duramold Div. of Fairchild Engine & Airplane Corp.
Hardman, Peck & Co.
Heath Co.
Hughes Aircraft Co.
International Aviation Corp.
Kilgen Aircraft Div. of Kilgen Organ Co.
Meyers Aircraft Co.
Schweizer Aircraft Corp.
Skydyne, Inc.
Spartan Aircraft Co.
United States Plywood Corp.
Universal Moulded Products Corp.
Waco Aircraft Co.

### Rubber

Adel Precision Products Corp., Huntington Precision Products Div.
Connecticut Hard Rubber Co., Inc.
General Tire & Rubber Co.
Guiberson Corp.
Lord Manufacturing Co.
Miller Products Co., Inc.
Nukraft Manufacturing Co., Inc.
Scintilla Magneto Div., Bendix Aviation Corp.
United States Rubber Co.

### Steel

Ace Manufacturing Corp.
Adel Precision Products Corp., Huntington Precision Products Div.
Aero Supply Mfg. Co. Inc.
Agawam Aircraft Products, Inc.
Air-Parts, Inc.
All American Aircraft Products, Inc.
B. H. Aircraft Co., Inc.
Bellanca Aircraft Corp.
Chas. W. Carll Sons
Cleveland Pneumatic Tool Co.
Colgate Aircraft Corp.
Connecticut Precision Hardware Co.
Cunningham-Hall Aircraft Corp.
Ex-Cell-O Corp.
Farmingdale Aircraftsmen Manufacturing Corp.
Feick Mfg. Co., Div. of Detroit Aircraft Products
Floorola Products, Inc.
Gasket Manufacturing Co.
Heath Co.
International Aviation Corp.
Jessop Steel Co.
Kaiser Cargo, Inc., Fleetwings Div.
Kellett Aircraft Corp.
Koehler Aircraft Products Co.
Liberty Aircraft Products Corp.
Luscombe Airplane Corp.
Luscombe Engineering Co., Inc.
Machine Products Div., Armstrong Furnace Co.
Macwhyte Co.
Manufacturers Screw Product
Merz Engineering Co.
Meyers Aircraft Co.
National Radiator Co.
Pacific Aviation, Inc., Los Angeles Div.
Paulson Tools Inc.
Poulsen & Nardon, Inc.
Precision Products, Inc.
Republic Aircraft Products Div., The Aviation Corp.
Rohr Aircraft Corp.
Ryan Aeronautical Co.
Schweizer Aircraft Corp.
Solar Aircraft Co.
Spartan Aircraft Co.
Steel Improvement & Forge Co.
Steel Products Engineering Co.
Superior Tube Co.
Taylorcraft Aviation Div., Detroit Aircraft Products, Inc.
Teicher Manufacturing Corp.
Teleoptic Co.
Thompson Products, Inc.
United Aircraft Products, Inc.
Vimalert Co., Ltd.
Waco Aircraft Co.
Wells Aircraft Parts Co.
N. A. Woodworth Co.
Worcester Pressed Steel Co.
Wyman-Gordon Co.

### Synthetic

Acadia Synthetic Products Div. Western Felt Works
Adel Precision Products Corp., Huntington Precision Products Div.
Gasket Manufacturing Co.
Heath Co.
Resistoflex Corp.
United Aircraft Products, Inc.
United States Rubber Co.

### Wood

All American Aircraft Products, Inc.
Bellanca Aircraft Corp.
Hardman, Peck & Co.
Heath Co.
International Aviation Corp.
Jarvis Manufacturing Co.
Kellett Aircraft Corp.
Kilgen Aircraft Div. of Kilgen Organ Co.
Meyers Aircraft Co.
Schweizer Aircraft Corp.
Skydyne, Inc.
Spartan Aircraft Co.
Taylorcraft Aviation Div., Detroit Air-Craft Products, Inc.
Universal Moulded Products Corp.
Waco Aircraft Co.

## AIRPORT EQUIPMENT

### Designers & Builders

Airquipment Co.
Chas. W. Carll Sons
Independent Iron Works, Ltd.
International Aviation Corp.
Spencer & Morris

### Construction Equipment

Ariens Co.
Black & Decker Mfg. Co.
Caterpillar Tractor Co.
Cleveland Pneumatic Tool Co.
Clyde Iron Works, Inc.
P. & F. Corbin Div.
Independent Iron Works, Ltd.
Skilsaw, Inc.
Spencer & Morris
United States Plywood Corp.

### Maintenance Equipment

Air-Parts, Inc.
Aircraft-Marine Products Inc.
Airquipment Co.
Ariens Co.
D. L. Auld Co.
Aurora Equipment Co.
Balcrank Inc.
Black & Decker Mfg. Co.
Byrne Doors, Inc.
Caterpillar Tractor Co.
P. & F. Corbin Div.
Couse Manufacturing, Inc
Dockson Corp.
Economy Engineering Co.
Fischer & Porter Co.
Glenn-Roberts Co.
Goulds Pumps Inc.
W. F. Hebard & Co.
Independent Iron Works, Ltd.
International Derrick & Equipment Co.
Koehler Aircraft Products Co.
Menasco Manufacturing Co.
Shallcross Mfg. Co.
Skilsaw, Inc.
Spencer & Morris
United States Electrical Tool Co.
Washington Aircraft & Transport Corp.
Westinghouse Electric Corp.

### Operating Equipment

Airquipment Co.
All American Aircraft Products, Inc.
American Paulin System
American Airport Equipment Co.
Beryllium Corp.
Byrne Doors, Inc.
Caterpillar Tractor Co.
Collins Radio Co.
Fischer & Porter Co.
Goulds Pumps Inc.
Frederick Hart & Co., Inc.
W. F. Hebard & Co.
Intava Inc.
International Derrick & Equipment Co.
McColpin-Christie Corp., Ltd.
Pacific Scientific Co.
Scott Aviation Corp.
Smith Meter Co.
Spencer & Morris
Sperry Gyroscope Co., Inc.
M. C. Stewart
Towmotor Corp.
Trachte Bros. Co.
United Cinephone Corp.
Washington Aircraft & Transport Corp.
Westinghouse Electric Corp.

## AMMUNITION BOXES & COUNTERS

Buhl Manufacturing Co.
Chas. W. Carll Sons
Eclipse-Pioneer Div., Bendix Aviation Corp.

**(Ammunition Boxes and Counters)** *Continued*

Edo Aircraft Corp.
Kaiser Cargo, Inc., Fleetwings Div.
Kenyon Instrument Co., Inc.
United States Plywood Corp.

## AUXILIARY POWER PLANTS

Caterpillar Tractor Co.
Continental Electric Co. Inc.
Couse Manufacturing, Inc.
Eclipse-Pioneer Div., Bendix Aviation Corp.
Electric Specialty Co.
Hughes Aircraft Co.
Jack & Heintz
Jarvis Manufacturing Co.
St. Louis Tool & Mfg. Co.
Westinghouse Electric Corp.

## BASIC MATERIALS & FABRICATIONS

Aluminum Co. of America
Byrne Doors, Inc.
Chas. W. Carll Sons
Carnegie-Illinois Steel Corp.
Carpenter Steel Co.
Dow Chemical Co.
Duramold Div. of Fairchild Engine & Airplane Corp.
Newton-New Haven Co.
Reynolds Metals Co.
United States Plywood Corp.

## BATTERIES

Air-Parts, Inc.
Delco-Remy Div., General Motors Corp.
Ideal Commutator Dresser Co.
Kellogg Switchboard & Supply Co.
Reading Batteries, Inc.
Servair, Inc.
Standard Oil Co. of New Jersey

## BEARINGS

### Ball

Air-Parts, Inc.
Ex-Cell-O Corp.
Federal Bearings Co. Inc.
Jack & Heintz
Edward D. Maltby Co.
Norma Hoffmann Bearings Corp.
SKF Industries, Inc.
Thompson Industries, Inc.

### Roller

Air-Parts, Inc.
Heim Co.
Jack & Heintz
Edward D. Maltby Co.
Norma Hoffmann Bearings Corp.
SKF Industries, Inc.
Timken Roller Bearing Co.

### Sleeve

Air-Parts, Inc.
All American Aircraft Products, Inc.
Allison Div., General Motors Corp.
Bunting Brass & Bronze Co.
Cleveland Graphite Bronze Co.
Federal-Mogul Corp.
Heim Co.
Keystone Carbon Co.
P. R. Mallory & Co., Inc.
Pacific Aviation, Inc., Los Angeles Div.
Shenango-Penn Mold Co.

## BLIND LANDING SYSTEMS

Eclipse-Pioneer Div., Bendix Aviation Corp.
RCA-Victor Div., Radio Corp. of America
Sperry Gyroscope Co., Inc.
Westinghouse Electric Corp.

## BOMB RACKS

All American Aircraft Products, Inc.
Jarvis Manufacturing Co.
Kaiser Cargo, Inc., Fleetwings Div.
Kellett Aircraft Corp.
Liberty Aircraft Products Corp.
Pacific Aviation, Inc., Los Angeles Div.
Steel Products Engineering Co.
Westinghouse Electric Corp.

## BRAKES & PARTS

Air-Parts, Inc.
All American Aircraft Products, Inc.
Domestic Manufacturing Co.
General Tire & Rubber Co.
Pacific Div., Bendix Aviation Corp.
Scott Aviation Corp.

### BUSHINGS

Ace Manufacturing Corp.
Air-Parts, Inc.
All American Aircraft Products, Inc.
Allite Mfg. Co.
Atlantic India Rubber Works, Inc.
Beryllium Corp.
Bunting Brass & Bronze Co.
Cleveland Graphite Bronze Co.
Continental-Diamond Fibre Co.
Die Supply Co.
Downs Smith Brass & Copper Co., Inc.
Ex-Cell-O Corp.
Federal-Mogul Corp.
General Tire & Rubber Co.
Keystone Carbon Co.
Lord Manufacturing Co.
Machine Products Div., Armstrong Furnace Co.
Marquette Metal Products Co.
Pacific Aviation, Inc., Los Angeles Div.
Paulson Tools Inc.
Thompson Products, Inc.
Wells Aircraft Parts Co.

### CABIN HARDWARE & FURNISHINGS

All American Aircraft Products, Inc.
Chase Brass & Copper Co.
P. & F. Corbin Div.
Dunkirk Die & Machine Works
Hughes Aircraft Co.
Scott Aviation Corp.
Snapvent Co.
Soss Manufacturing Co.

### CAMERAS & SUPPLIES

Abrams Instrument Corp.
Chicago Aerial Survey Co.
Skyview Camera Co.
Specialties, Inc.

### CARBURETORS

Air-Parts, Inc.
Bendix Products Div., Bendix Aviation Corp.
Chandler-Evans Corp.
Standard Aircraft Equipment Co.
Zenith Carburetor Div., Bendix Aviation Corp.

### CARGO LOADING EQUIPMENT

G. B. Lewis Co.
Mechanical Handling Systems Inc.
Northrop Gaines, Inc.
Poulsen & Nardon, Inc.
Rapids-Standard Co., Inc.
Rocky Mountain Steel Products, Inc.
Spencer & Morris
Towmotor Corp.
Western Gear Works
E. W. Wiggins Airways, Inc.

### CASTINGS

Acme Aluminum Alloys Inc.
Advance Aluminum Castings Corp.
Airpath Instrument Co.
Aluminum Co. of America
Anderson Die Casting & Engineering Corp.
Beryllium Corp.
Buckeye Iron & Brass Works
Chase Brass & Copper Co.
Connecticut Precision Hardware Co.
Delloy Metal Corp.
Dow Chemical Co.
Eclipse-Pioneer Div., Bendix Aviation Corp.
Jessop Steel Co.
Newton-New Haven Co.
Parker Appliance Co.
Permold Co.
Scott Aviation Corp.
Shenango-Penn Mold Co.
Solar Aircraft Co.

### CHARGERS, BATTERY

General Electric Co.
General Scientific Equipment Co.
Hobart Brothers Co.
Ideal Commutator Dresser Co.
Kellogg Switchboard & Supply Co.
McColpin-Christie Corp., Ltd.
P. R. Mallory & Co., Inc.
Schauer Machine Co.
Western Mfg. Supply Co.
Westinghouse Electric Corp.

### CHEMICALS

American Chemical Paint Co.
American Oil & Supply Co.
Kelite Products, Inc.
Pittsburgh Plate Glass Co.

**(Chemicals)** *Continued*
Scott Aviation Corp.
Sundmark Supply Co.
Turco Products, Inc.
United States Rubber Co.

### CLAMPS

Adel Precision Products Corp., Huntington Precision Products Div.
Aero Supply Mfg. Co. Inc.
Aircraft Standard Parts Co., Inc.
All American Aircraft Products, Inc.
Cincinnati Tool Co.
Commercial Plastics Co.
Die Supply Co.
Kellogg Switchboard & Supply Co.
Molded Insulation Co.
United-Carr Fastener Corp.

### CLEANERS & CLEANING COMPOUNDS

AC Spark Plug Div., General Motors Corp.
American Chemical Paint Co.
American Oil & Supply Co.
American Plating Rack Co.
Circo Products Co.
Commercial Chemical Co. Inc.
Gaybex Corp.
Hanson-Van Winkle-Munning Co.
Intava Inc.
Kelite Products, Inc.
Magnaflux Corp.
Mercury Chemical Co. Inc.
Minnesota Mining & Manufacturing Co.
Phillips Manufacturing Co.
Pierce & Stevens, Inc.
Scott Aviation Corp.
Socony-Vacuum Oil Co., Inc.
Sundmark Supply Co.
Turco Products, Inc.
Wyandotte Chemicals Corp.

#### Buffing, Burring & Polishing

Adel Precision Products Corp., Huntington Precision Products Div.
American Plating Rack Co.
Black & Decker Mfg. Co.
Commercial Chemical Co. Inc.
Hanson-Van Winkle-Munning Co.
Minnesota Mining & Manufacturing Co.
Sundmark Supply Co.
Wayne Chemical Products Co.
Wyandotte Chemicals Corp.

### CLOSURES, DRUMS

American Flange & Manufacturing Co., Inc.

### CLUTCHES

Abrams Instrument Corp.
Carlyle Johnson Machine Co.
Eclipse-Pioneer Div., Bendix Aviation Corp.
Foote Bros. Gear & Machine Corp.
Hilliard Corp.
Lipe-Rollway Corp.
Rockford Clutch Div., Borg-Warner Corp.

### COLLECTOR RINGS

Air-Parts, Inc.
All American Aircraft Products, Inc.
American Tube Bending Co. Inc.
Buhl Manufacturing Co.
Guiberson Corp.
Kellett Aircraft Corp.
National Radiator Co.
Rohr Aircraft Corp.
Ryan Aeronautical Co.
Shenango-Penn Mold Co.
Solar Aircraft Co.
Thompson Products, Inc.
Vimalert Co., Ltd.

### COMMUNICATIONS SYSTEMS

Air Communications, Inc.
Air-Parts, Inc.
Airadio, Inc.
Aircraft Radio Corp.
Airplane & Marine Instruments, Inc.
Rex Bassett, Inc.
Collins Radio Co.
Communications Co., Inc.
Finch Telecommunications, Inc.
Harvey-Wells Electronics, Inc.
Heath Co.
Kellogg Switchboard & Supply Co.
Pacific Div., Bendix Aviation Corp.
RCA-Victor Div., Radio Corp. of America
Radio Frequency Laboratories, Inc.
Radio Receptor Co., Inc.

**(Communications Systems)** *Continued*

Servair, Inc.
Western Electric Co., Inc., Radio Div.

## CONTROLS

Foote Bros. Gear & Machine Corp.
General Controls Co.
Simmonds Aerocessories, Inc.

### Cables & Assemblies

AC Spark Plug Div., General Motors Corp.
Arens Controls, Inc.
Jacoel Cable Splicing Equipment Co.
Kenyon Instrument Co., Inc.
Liberty Aircraft Products Corp.
Macwhyte Co.
Pacific Aviation Corp.
Rochester Ropes, Inc.
John A. Roebling's Sons Co.
Schweizer Aircraft Corp.
Western Mfg. Supply Co.

### Chains, Sprockets & Assemblies

Western Mfg. Supply Co.

### Pulleys

Air-Parts, Inc.
Molded Insulation Co.
Precision Products, Inc.
Scott Aviation Corp.
Westinghouse Electric Corp.

### Sticks & Wheels

Schweizer Aircraft Corp.
Scott Aviation Corp.
United States Rubber Co.

## COOLING SYSTEMS

Clifford Manufacturing Co.
Taylorcraft Aviation Div., Detroit Air-Craft Products, Inc.
United Aircraft Products, Inc.
Winchester Repeating Arms Co., Div. of Ohio Industries, Inc.
Young Radiator Co.

## COVERS (ENGINE, COCKPIT, WINDSHIELD)

Adel Precision Products Corp., Huntington Precision Products Div.
Airquipment Co.
Schweizer Aircraft Corp.
Switlik Parachute Co.
Taylorcraft Aviation Div., Detroit Air-Craft Products, Inc.
United States Rubber Co.

## COWLINGS

All American Aircraft Products, Inc.
B. H. Aircraft Co., Inc.
Bellanca Aircraft Corp.
Buhl Manufacturing Co.
Guiberson Corp.
Kaiser Cargo, Inc., Fleetwings Div.
Kellett Aircraft Corp.
Rohr Aircraft Corp.
Ryan Aeronautical Co.
Solar Aircraft Corp.
Spartan Aircraft Co.
Taylorcraft Aviation Div., Detroit Air-Craft Products, Inc.

## CYLINDER DEFLECTORS, BAFFLES, BRACKETS

All American Aircraft Products, Inc.
B. H. Aircraft Co., Inc.
Buhl Manufacturing Co.
Guiberson Corp.
Spartan Aircraft Co.
Taylorcraft Aviation Div., Detroit Air-Craft Products, Inc.
Worcester Pressed Steel Co.

## DEHYDRATED PACKING

Chandler-Evans Corp.

## DE-ICING FLUIDS & EQUIPMENT

Adel Precision Products Corp.
Anemostat Corp. of America
Durkee-Atwood Co.
Eclipse-Pioneer Div., Bendix Aviation Corp.
Fischer & Porter Co.
Intava, Inc.
Liberty Aircraft Products Corp
Mercury Aircraft Inc.
Pacific Scientific Corp.
Weldon Tool Co.

# THE EYES

# AND EARS

## of modern aviation

In war, Western Electric was the nation's largest producer of aircraft communications and radar equipment. In peace, Western Electric will continue developments in radio—aircraft and ground station communications; and in radar—airborne equipment for navigation, anti-collision and terrain clearance, and ground station equipment for airport traffic control.

**Western Electric**

RADIO AND OTHER ELECTRONIC EQUIPMENT FOR A WORLD ON WINGS

## DESIGNERS & INDUSTRIAL ENGINEERS

Acme Aluminum Alloys, Inc.
Byrne Doors, Inc.
Chicago Aerial Survey Co.
Connecticut Precision Hardware Co.
Hughes Aircraft Co.
International Aviation Corp.
Kellett Aircraft Corp.
Kenyon Instrument Co., Inc.
Mechanical Handling Systems Inc.
Meriam Instrument Co.
Pioneer Engineering & Manufacturing Co.
Preco, Inc.
St. Louis Tool & Mfg. Co.
Specialties, Inc.
Western Gear Works

## DIES, PATTERNS, JIGS

Ace Manufacturing Corp.
Acme Aluminum Alloys, Inc.
Acromark Co.
Advance Pump Co.
Agerstrand Corp.
All American Aircraft Products, Inc.
Anderson Die Casting & Engineering Corp.
Connecticut Precision Hardware Co.
Cunningham-Hall Aircraft Corp.
Dunkirk Die & Machine Works
Floorola Products, Inc.
Hamilton Tool Co.
Hollywood Tool & Die Co.
International Aviation Corp.
Kellett Aircraft Corp.
Kenyon Instrument Co., Inc.
Langelier Mfg. Co.
Liberty Aircraft Products Corp.
Machine Products Div., Armstrong Furnace Co.
Merz Engineering Co.
Pacific Aviation, Inc., Los Angeles Div.
Pioneering Engineering & Manufacturing Co.
St. Louis Tool & Mfg. Co.
Spartan Aircraft Co.
Steel Products Engineering Co.
Vimalert Co., Ltd.
N. A. Woodworth Co.

## ELECTRICAL EQUIPMENT

Ace Manufacturing Corp.
Aeronautical Manufacturing Corp.
American Aircraft Manufacturing Co.
American Plating Rack Co.
Automatic Electrical Devices Co.
Benwood-Linze Co.
Beryllium Corp.
Commercial Plastics Co.
Delco-Remy Div., General Motors Corp.
Dunkirk Die & Machine Works
Eastern Air Devices
Eclipse Pioneer Div., Bendix Aviation Corp.
Grimes Mfg. Co.
Heinemann Circuit Breaker Co.
International Resistance Co.
Kellogg Switchboard & Supply Co.
Leece-Neville Co.
Mica Insulator Co.
Pacific Div., Bendix Aviation Corp.
Schauer Machine Co.
Shallcross Mfg. Co.
Sigma Instruments, Inc.
Solar Manufacturing Corp.
Specialties, Inc.
Teleoptic Co.
Westinghouse Electric Corp.

### Auxiliary Motors

American Aircraft Manufacturing Co.
Bodine Electric Co.
Continental Electric Co. Inc.
Diehl Mfg. Co.
Eastern Air Devices
Eclipse-Pioneer Div., Bendix Aviation Corp.
Eicor, Inc.
Electric Specialty Co.
General Electric Co.
Grimes Manufacturing Co.
Hughes Aircraft Co.
Jack & Heintz
Leece-Neville Co.
Leland Electric Co., Inc.
Ohio Electric Mfg. Co.
Pacific Div., Bendix Aviation Corp.
Quality Electric Co., Ltd.
L. N. Schwien Engineering Co.
Western Mfg. Supply Co.
Westinghouse Electric Corp.

### Disconnect Plugs

Aircraft-Marine Products Inc.
Beryllium Corp.
Breeze Corporations, Inc.
Cannon Electric Development Co.


Eclipse
SINCE AVIATION'S INFANCY THE LEADING PRODUCER OF DEPENDABLE AIRCRAFT AND ENGINE ACCESSORIES
Recognized headquarters for engineered Aviation accessories.
Precision aluminum and magnesium castings for all purposes produced by our own foundries.
Remember:—Eclipse* Service follows through from drawing board to sky.
Bendix
Eclipse AVIATION ACCESSORIES
Eclipse-Pioneer Division · Teterboro, N. J. · Los Angeles 36, Calif.
*REG. U.S. PAT. OFF.
Aviation Engine Starting Equipment
Aircraft Electric Power Supply Equipment
Aviation Engine Control Equipment
Hydraulic Equipment
Aircraft Suction and Air Pressure Equipment
Aircraft Mechanical Ice Elimination Equipment
Aircraft Supercharger Equipment
Aircraft Propeller Control Equipment
Aircraft Electric Motor Actuators

**(Disconnect Plugs)** *Continued*

Eclipse-Pioneer Div., Bendix Aviation Corp.
General Electric Co.
Howard B. Jones Co.
Molded Insulation Co.
Scintilla Magneto Div., Bendix Aviation Corp.

### Dynamotors

Beryllium Corp.
Continental Electric Co. Inc.
Eastern Air Devices
Eclipse Pioneer Div., Bendix Aviation Corp.
Eicor, Inc.
Electric Specialty Co.
General Electric Co.
Jack & Heintz
Ohio Electric Mfg. Co.
Pacific Div., Bendix Aviation Corp.
Pioneer Gen-E-Motor Corp.
Quality Electric Co., Ltd.
Westinghouse Electric Corp.
Wincharger Corp.

### Generators

Air-Parts, Inc.
American Aircraft Manufacturing Co.
Beryllium Corp.
Continental Electric Co. Inc.
Delco-Remy Div., General Motors Corp.
Eastern Air Devices
Eclipse-Pioneer Div., Bendix Aviation Corp.
Electric Specialty Co.
General Electric Co.
Jack & Heintz
Leece-Neville Co.
Leland Electric Co., Inc.
Pacific Div., Bendix Aviation Corp.
Pioneer Gen-E-Motor Corp.
Quality Electric Co., Ltd.
Servair, Inc.
Standard Aircraft Equipment Co.
Sundmark Supply Co.
Vimalert Co., Ltd.
Westinghouse Electric Corp.

### Ignition Assemblies, Radio Shielded

AC Spark Plug Div., General Motors Corp.
Air-Shields Inc.
All American Aircraft Products, Inc.
BG Corp.
Breeze Corporations, Inc.
Electric Auto-Lite Co., Wire & Cable Div.
General Electric Co.
Menaugh-Dutterer Co.
Packard Electric Div., General Motors Corp.
Scintilla Magneto Div., Bendix Aviation Corp.
Servair, Inc.
Washington Aircraft & Transport

### Magnetos

Air-Parts, Inc.
American Bosch Corp.
Beryllium Corp.
Edison-Splitdorf Corp.
Eisemann Corp.
General Electric Co.
Scintilla Magneto Div., Bendix Aviation Corp.
Standard Aircraft Equipment Co.
Washington Aircraft & Transport
Wico Electric Co.

### Relays

Abrams Instrument Corp.
Beryllium Corp.
C. P. Clare & Co.
R. W. Cramer Co., Inc.
Durakool, Inc.
Eclipse Pioneer Div., Bendix Aviation Corp.
Thomas A. Edison, Inc., Instrument Div.
General Electric Co.
Jack & Heintz
Kellogg Switchboard & Supply Co.
Leach Relay Co.
Leece-Neville Co.
Meletron Corp.
National Acme Co.
Pacific Div., Bendix Aviation Corp.
L. M. Persons Corp.
L. N. Schwien Engineering Co.
Scintilla Magneto Div., Bendix Aviation Corp.
Sigma Instruments, Inc.
Vapor Car Heating Co.
Westinghouse Electric Corp.

#### Rheostats

Beryllium Corp.
Daven Co.
Eclipse Pioneer Div., Bendix Aviation Corp.
General Electric Co.
International Resistance Co.
P. R. Mallory & Co., Inc.
Sundmark Supply Co.
Western Mfg. Supply Co.

#### Switches

Beryllium Corp.
C. P. Clare & Co.
Daven Co.
Delco-Remy Div., General Motors Corp.
Dunkirk Die & Machine Works
Eastern Air Devices
Eclipse Pioneer Div., Bendix Aviation Corp.
Thomas A. Edison, Inc., Instrument Div.
General Electric Co.
Robert Hetherington & Son, Inc.
Kellogg Switchboard & Supply Co.
Littelfuse Inc.
P. R. Mallory & Co., Inc.
Molded Insulation Co.
National Acme Co.
L. M. Persons Corp.
R-B-M Manufacturing Co., Div. of Essex Wire Corp.
Scintilla Magneto Div., Bendix Aviation Corp.
United-Carr Fastener Corp.
Westinghouse Electric Corp.

#### Terminals

Air-Shields Inc.
Aircraft-Marine Products Inc.
BG Corp.
Beryllium Corp.
Cannon Electric Development Co.
Dunkirk Die & Machine Works
Electric Auto-Lite Co., Wire & Cable Div.
Howard B. Jones Co.
Littelfuse Inc.
Menaugh-Dutterer Co.
United-Carr Fastener Corp
Western Mfg. Supply Co.

### ENGINE EQUIPMENT

Air-Parts, Inc.
B. H. Aircraft Co., Inc.
Caterpillar Tractor Co.
Eclipse Pioneer Div., Bendix Aviation Corp.
G & O Manufacturing Co.
Gladden Products Corp.
Lycoming Div., The Aviation Corp.
Menasco Manufacturing Co.
Sperry Gyroscope Co., Inc.
United Aircraft Products, Inc.
Washington Aircraft & Transport Corp.
Westinghouse Electric Corp.
Woodward Governor Co.

### ENGINE MOUNTS

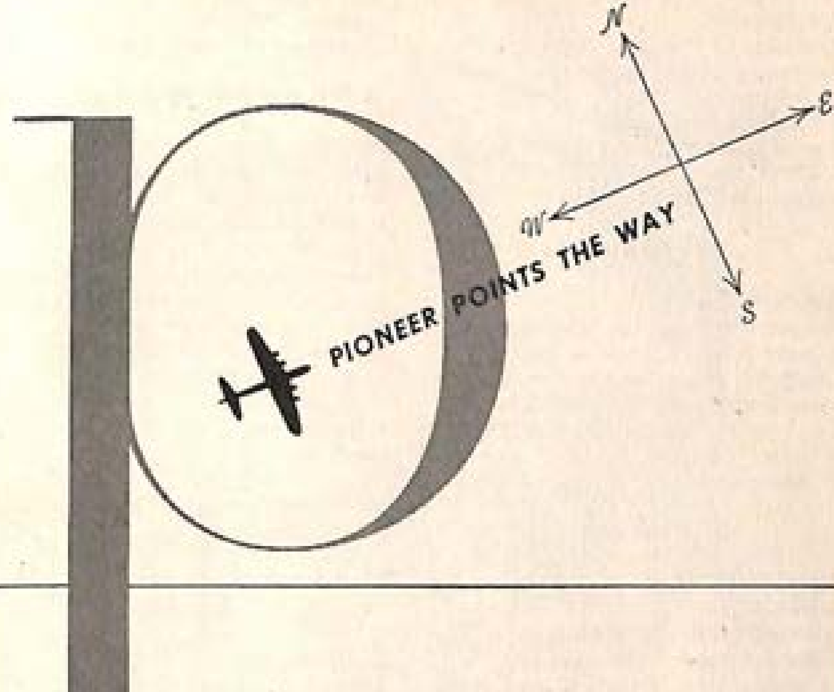
Agerstrand Corp.
Air-Parts, Inc.
All American Aircraft Products, Inc.
American Tube Bending Co. Inc.
B. H. Aircraft Co., Inc.
Bellanca Aircraft Corp.
Colgate Aircraft Co.
Connecticut Hard Rubber Co.
General Tire & Rubber Co.
Guiberson Corp.
Kellett Aircraft Corp.
Lord Manufacturing Co.
Rohr Aircraft Corp.
Ryan Aeronautical Corp.
Spartan Aircraft Co.
Taylorcraft Aviation Div., Detroit Air-Craft Products Corp.
United States Rubber Co.
Wells Aircraft Parts Co.

### ENGINE PARTS

Air-Parts, Inc.
Connecticut Hard Rubber Co.
Ex-Cell-O Corp.
Jacobs Aircraft Engine Co., Div. of Republic Industries, Inc.

#### Cams

Air-Parts, Inc.
Connecticut Precision Hardware Co.
Liberty Aircraft Products Corp.
Lycoming Div., The Aviation Corp.
Marquette Metal Products Co.
Saxl Instrument Co.
Thompson Products, Inc.
Wyman-Gordon Co.



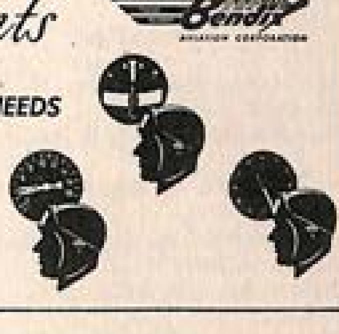

Foremost in the field of aircraft instrumentation since 1919. A complete line of flight, navigational and optical instruments for the modern airplane.

**ECLIPSE-PIONEER* DIVISION**
**TETERBORO, N. J.**

*Pioneer Instruments*

Bendix Aviation Corporation

**ANSWER THE INSTRUMENT NEEDS OF PILOT, NAVIGATOR AND FLIGHT ENGINEER**



*REG. U.S. PAT. OFF.

### Camshafts

Air-Parts, Inc.
Connecticut Precision Hardware Co.
Lycoming Div., The Aviation Corp.
Saxl Instrument Co.
Thompson Products, Inc.
Transue & Williams Steel Forging Corp.
Wyman-Gordon Co.

### Crankshafts

Air-Parts, Inc.
Connecticut Precision Hardware Co.
Liberty Aircraft Products Corp.
Lycoming Div., The Aviation Corp.
Merz Engineering Co.
Transue & Williams Steel Forging Corp.
Wyman-Gordon Co.

### Pistons

Agerstrand Corp.
Air-Parts, Inc.
Connecticut Precision Hardware Co.
Liberty Aircraft Products Corp.
Lycoming Div., The Aviation Corp.
Sealed Power Corp.
Thompson Products, Inc.
Wyman-Gordon Co.

### Rings

Air-Parts, Inc.
Connecticut Precision Hardware Co.
International Piston Ring Co.
Sealed Power Corp.
Simplex Products Corp.
Thompson Products, Inc.
Wells Aircraft Parts Co.

### Shims

Ace Manufacturing Corp.
Air-Parts, Inc.
Victor Manufacturing & Gasket Co.

### Valves & Valve Parts

Aeronautical Manufacturing Corp.
Air-Parts, Inc.
Eaton Manufacturing Co., Wilcox-Rich Div.
Koehler Aircraft Products Co.
Liberty Aircraft Products Corp.
Marquette Metal Products Co.
Saxl Instrument Co.
Superior Tube Co.
Thompson Products, Inc.

## EXHAUST MANIFOLDS

Air-Parts, Inc.
American Tube Bending Co. Inc.
B. H. Aircraft Co., Inc.
Buhl Manufacturing Co.
Chas. W. Carll Sons
Connecticut Precision Hardware Co.
Kaiser Cargo, Inc., Fleetwings Div.
Keeney Manufacturing Co.
Kellett Aircraft Corp.
Meyers Aircraft Co.
National Radiator Co.
Rohr Aircraft Corp.
Ryan Aeronautical Co.
Solar Aircraft Co.
Taylorcraft Aviation Div., Detroit Air-Craft Products, Inc.

## FABRICS, CLOTHS, TAPES

Air-Parts, Inc.
Aircraft Appliance Corp.
American Cord & Webbing Co., Inc.
Flightex Fabrics, Inc.
Irvington Varnish & Insulator Co.
Liberty Aircraft Products Corp.
Minnesota Mining & Manufacturing Co.
Servair, Inc.
W. Harris Thurston, Inc.
Uniform Hood Lace Co.
United States Rubber Co.
Zapon Div., Atlas Powder Co.

## FAIRINGS

Bellanca Aircraft Corp.
Edo Aircraft Corp.
Jarvis Manufacturing Co.
Kaiser Cargo, Inc., Fleetwings Div.
Kilgen Aircraft Div. of The Kilgen Organ Co.
Meyers Aircraft Co.
Schweizer Aircraft Corp.
Spartan Aircraft Co.
Taylorcraft Aviation Div., Detroit Air-Craft Products Corp.
Teicher Manufacturing Corp.
Universal Moulded Products Corp.
Westinghouse Electric Corp.

## FASTENERS, NUTS, BOLTS, SCREWS & WASHERS

Aero Supply Mfg. Co., Inc.
Air-Parts, Inc.
All American Aircraft Products, Inc.
American Screw Co.
Camloc Fastener Corp.
Chase Brass & Copper Co.
Cherry Rivet Co.
Connecticut Precision Hardware Co.
Continental Screw Co.
Die Supply Co.
Dzus Fastener Co., Inc.
Formica Insulation Co.
Gasket Manufacturing Co.
Manufacturers Screw Product
National Lock Co.
National Screw & Manufacturing Co.
New England Screw Co.
Palnut Co.
Pheoll Manufacturing Corp.
Precision Products, Inc.
Rockford Screw Products Co.
Shakeproof, Inc.
Simmonds Aerocessories, Inc.
Solar Aircraft Co.
United-Carr Fastener Corp.
United Screw & Bolt Corp.
Western Automatic Machine Screw Co.

## FENCES

All American Aircraft Products, Inc.
Aurora Equipment Co.

## FILTERS & STRAINERS

### Air

AC Spark Plug Div., General Motors Corp.
Air-Maze Corp.
All American Aircraft Products, Inc.
E. D. Bullard Co.
Cleveland Pneumatic Tool Co.
Cuno Engineering Corp.
Eclipse Pioneer Div., Bendix Aviation Corp.
Flotrol Systems, Inc.
Heath Co.
Skinner Purifiers, Inc.
Sperry Gyroscope Co., Inc.

### Oil

AC Spark Plug Div., General Motors Corp.
Adel Precision Products Corp.
Aero Supply Mfg. Co., Inc.
Air-Maze Corp.
All American Aircraft Products, Inc.
Cuno Engineering Corp.
Dunkirk Die & Machine Works
Eclipse Pioneer Div., Bendix Aviation Corp.
Flotrol Systems, Inc.
Hilliard Corp.
Koehler Aircraft Products Co.
Mercury Aircraft Inc.
Skinner Purifiers, Inc.
Sperry Gyroscope Co., Inc.
United Aircraft Products, Inc.

### Water

All American Aircraft Products, Inc.
Cuno Engineering Corp.
Flotrol Systems, Inc.
Skinner Purifiers, Inc.

## FINISHES, PAINTS, VARNISHES

American Chemical Paint Co.
American Oil & Supply Co.
Lowe Bros. Co.
Pierce & Stevens, Inc.
Pittsburgh Plate Glass Co., Industrial Paint Div.
Quigley Co., Inc.
Reynolds Metals Co.
Titanine, Inc.
United States Varnish Co.
Wilbur & Williams Co.
Zapon Div., Atlas Powder Co.

## FIRE FIGHTING EQUIPMENT

General Scientific Equipment Co.
Walter Kidde & Co., Inc.
M. L. Snyder & Son
Wil-X-Mfg. Corp.

## FIRST AID EQUIPMENT

Air-Parts, Inc.
E. D. Bullard Co.
Burroughs Wellcome & Co. Inc.
General Scientific Equipment Co.

# HILCO

## ENGINE LUBRICATING OIL PURIFICATION

● HILCO FLITE FILTERS are small, compact and light weight. They are direct-connected to engine lube oil system for continuous filtering to remove carbon, acids, leads, abrasives and tarry matter.

● Hilco Flite Filters are easily installed and serviced—Clean oil at all times means reduced wear and longer engine life.

## • HILCO PORTABLE LUBE OIL FILTER •

A SELF CONTAINED UNIT ALWAYS READY TO SERVICE INCOMING AIRCRAFT

For preventive maintenance making possible frequent and complete filtering of lube oils in aircraft power plants. A Hilco Portable will result in

## A COMPLETE OIL CHANGE IN 8 MINUTES

**WRITE TO-DAY!** for specifications and operating data on Hilco units for the aircraft Industry.

**THE HILLIARD CORPORATION**
85 W. FOURTH ST. ELMIRA, N. Y.

### FITTINGS

Aero Supply Mfg. Co. Inc.
All American Aircraft Products, Inc.
Balcrank Inc.
Breeze Corporations, Inc.
Chase Brass & Copper Co.
Colgate Aircraft Corp.
Connecticut Precision Hardware Co.
Downs Smith Brass & Copper Co., Inc.
Globe Steel Tubes Co.
International Aviation Corp.
Kellett Aircraft Corp.
Kohler Co.
Liberty Aircraft Products Corp.
Macwhyte Co.
Irvin W. Masters Inc.
Resistoflex Corp.
Saxl Instrument Co.
Schweizer Aircraft Corp.
Spartan Aircraft Co.
Wells Aircraft Parts, Inc.

### FLARES & SIGNALS

Aerial Products Inc.
Air-Parts, Inc.
Eclipse Pioneer Div., Bendix Aviation Corp.
Kilgore Manufacturing Co., International Flare Signal Div.

### FLOATS, SKIIS

Bellanca Aircraft Corp.
Colgate Aircraft Corp.
Edo Aircraft Corp.
Heath Co.
Kaiser Cargo, Inc., Fleetwings Div.
Kilgen Aircraft Div. of The Kilgen Organ Co.
Liberty Aircraft Products Corp.
Mercury Aircraft Inc.

### FORGINGS

Airchox Co., Div. of Joyce Aviation, Inc.
Aluminum Co. of America
Beryllium Corp.
Billings & Spencer Co.
Chase Brass & Copper Co.
Connecticut Precision Hardware Co.
Dow Chemical Co.
Endicott Forging & Mfg. Co. Inc.
Hinsdale Manufacturing Co.
Paulson Tools Inc.
Reynolds Metals Co.
Steel Improvement & Forge Co.
Timken Roller Bearing Co.
Transue & Williams Steel Forging Corp.
Universal Molded Products Corp.
Wyman-Gordon Co.

### FUEL PUMPS & SYSTEMS—AIRCRAFT

AC Spark Plug Div., General Motors Corp.
Adel Precision Products Corp., Huntington Precision Products Div.
Aero Supply Mfg. Co. Inc.
All American Aircraft Products, Inc.
American Bosch Corp.
Chandler-Evans Corp.
Eclipse Pioneer Div., Bendix Aviation Corp.
Ex-Cell-O Corp.
Parker Appliance Co.
Rohlm Manufacturing Co. Inc.
Thompson Products, Inc.
United Aircraft Products, Inc.
Weldon Tool Co.

### FUEL SYSTEMS—AIRPORT

Buckeye Iron & Brass Works
Flotrol Systems, Inc.
Intava Inc.
Koehler Aircraft Products Co.
Parker Appliance Co.
Skinner Purifiers, Inc.
Smith Meter Co.
Socony-Vacuum Oil Co., Inc.
Wells Aircraft Parts, Inc.

### FUELS

Gulf Oil Corp.
Intava, Inc.
Shell Oil Co., Inc.
Sinclair Refining Co.
Socony-Vacuum Oil Co., Inc.
Standard Oil Co. of California
Standard Oil Co. of New Jersey
Texas Co.

### GAS TURBINE EQUIPMENT

General Electric Co.
Thompson Products, Inc.

## GASKETS

Acadia Synthetic Products Div., Western Felt Works
American Flange & Manufacturing Co., Inc.
Atlantic India Rubber Works, Inc.
B. G. Corp.
Commercial Plastics Co.
Connecticut Hard Rubber Co.
Garlock Packing Co.
Gasket Manufacturing Co.
General Tire & Rubber Co.
Goodall Rubber Co.
Irvington Varnish & Insulator Co.
Miller Products Co., Inc.
Minnesota Mining & Manufacturing Co.
Radiator Specialty Co.
Resistoflex Corp.
United States Rubber Co.
Victor Manufacturing & Gasket Co.

## GAUGES
(*See also* Instruments)

AC Spark Plug Div., General Motors Corp.
Air-Parts, Inc.
Boston Auto Gage Co.
Eclipse Pioneer Div., Bendix Aviation Corp.
Federal Products Corp.
Kenyon Instrument Co., Inc.
Pioneer Engineering & Manufacturing Co.
Puritan Compressed Gas Corp.
Scott Aviation Corp.
Sigma Instruments, Inc.
Simmonds Aerocessories, Inc.
Stewart-Warner Corp.
P. A. Sturtevant Co.
N. A. Woodworth Co.

## GEARS

Airpath Instrument Co.
Allite Mfg. Co.
Connecticut Precision Hardware Co.
Cunningham-Hall Aircraft Corp.
De Laval Steam Turbine Co.
Foote Bros. Gear & Machine Corp.
Formica Insulation Co.
Hamilton Tool Co.
L. M. Gear Co.
Liberty Aircraft Products Corp.
Marquette Metal Products Co.
St. Louis Tool & Mfg. Co.
Steel Products Engineering Co.
Western Gear Works

## GLUES & ADHESIVES

Air-Parts, Inc.
Casein Co. of America, Div. of The Borden Co.
Delaney & Co., Inc.
Durez Plastics & Chemicals, Inc.
Irvington Varnish & Insulator Co.
I. F. Laucks, Inc.
Minnesota Mining & Manufacturing Co.
Sundmark Supply Co.
United States Rubber Co.
United States Plywood Corp.

## GRASS SEED

F. H. Woodruff & Sons, Inc.

## GROMMETS

Acadia Synthetic Products Div., Western Felt Works
Ace Manufacturing Corp.
Air-Parts, Inc.
Arens Controls, Inc.
Chase Brass & Copper Co.
Commercial Plastics Co.
General Tire & Rubber Co.
Miller Products Co., Inc.
United States Rubber Co.

## HARDWARE (MISCELLANEOUS)

Ace Manufacturing Corp.
Aeromark Co.
Aero Supply Mfg. Co. Inc.
Air-Parts, Inc.
Airchox Co., Div. of Joyce Aviation Inc.
All American Aircraft Products, Inc.
Chase Brass & Copper Co.
Connecticut Precision Hardware Co.
P. & F. Corbin Div.
Dunkirk Die & Machine Works
Macwhyte Co.
Paulson Tools Inc.
Precision Products, Inc.
Soss Manufacturing Co.
United-Carr Fastener Corp.

### HEATERS

Abrams Instrument Corp.
Eclipse Pioneer Div., Bendix Aviation Corp.
Electromode Corp. Div. of American Foundry Equipment Co.
General Electric Co.
C. M. Hall Lamp Co.
Liberty Aircraft Products Corp.
Ryan Aeronautical Co.
Surface Combustion Corp.
Thermador Electrical Mfg. Co.
Westinghouse Electric Corp.
Young Radiator Co.

### HOISTS, CRANES, LIFTS, ETC.

Byrne Doors, Inc.
Clyde Iron Works, Inc.
Conco Engineering Works
Couse Manufacturing, Inc.
Curtis Manufacturing Co.
Hughes-Keenan Co.
Independent Pneumatic Tool Co.
Preco Inc.
Rohr Aircraft Corp.
Shepard Niles Crane & Hoist Corp.
Spencer & Morris
Towmotor Corp.
West Bend Equipment Corp.
Western Gear Works

### HOSE-RUBBER & SYNTHETIC

Air-Parts, Inc.
Durkee-Atwood Co.
Goodall Rubber Co.
Irvington Varnish & Insulator Co.
Miller Products Co., Inc.
Puritan Compressed Gas Corp.
Resistoflex Corp.
M. L. Snyder & Son
United States Rubber Co.

### HOSE CLAMPS & HOSE FITTINGS

Aero Coupling Corp.
Aero Supply Mfg. Co. Inc.
Air-Parts, Inc.
Aircraft Standard Parts Co., Inc.
All American Aircraft Products, Inc.
Goodall Rubber Co.
Irvin W. Masters Inc.
Paasche Airbrush Co.
Parker Appliance Co.
Resistoflex Corp.
Wells Aircraft Parts, Inc.

### HYDRAULIC CONTROLS & ASSEMBLIES

Adel Precision Products Corp.
Aero Coupling Corp.
Aeronautical Manufacturing Corp.
All American Aircraft Products, Inc.
Cleveland Pneumatic Tool Co.
Domestic Manufacturing Co.
Eclipse-Pioneer Div., Bendix Aviation Corp.
Ex-Cell-O Corp.
Farmingdale Aircraftsmen Manufacturing Corp.
General Controls Co.
General Electric Co.
Gladden Products Corp.
Hollywood Tool & Die
Hoof Products Co.
Jack & Heintz, Inc.
Jacobs Aircraft Engine Co., Div. of Republic Industries, Inc.
Kaiser Cargo, Inc., Fleetwings Div.
Kenyon Instrument Co., Inc.
Kohler Co.
Liberty Aircraft Products Corp.
Oilgear Co.
Pacific Aviation, Inc., Los Angeles Div.
Pacific Div., Bendix Aviation Corp.
Parker Appliance Co.
Sciaky Bros.
Scott Aviation Corp.
Sperry Gyroscope Co., Inc.
Standard Oil Co. of California
United Aircraft Products, Inc.
Vickers, Inc.
Warner Aircraft Corp.
Wells Aircraft Parts Co.

### HYDRAULIC FLUIDS

Bell Co. Inc.
Intava, Inc.
Shell Oil Co., Inc.
Socony-Vacuum Oil Co., Inc.

### INSTRUMENTS

Boston Auto Gage Co.
Standard Aircraft Equipment Co.

# *Reliable Heating..*

## AT SEA LEVEL OR

## AT OVER 40,000 FEET

# *Janitrol*
## AIRCRAFT HEATERS

Proved in the rigors of wartime flying, Janitrol Combustion-type Aircraft Heaters have become virtually standard equipment on most of today's commercial planes. Lightweight and compact, yet readily accessible for inspection, these heaters are improving passenger comfort, holding heating maintenance and operating costs to a minimum. Standard models give capacities ranging from 15,000 to 300,000 Btu per hour output.

Equipped with special design high altitude spark or glow coil ignition systems, Janitrol heaters provide quick dependable heat at all practical flying altitudes. In flights, these heaters can be operated with recirculating fans, or on ram air. Fans are also used for pre-flight ground heating.

*The 100,000 Btu heater package including controls and blowers for installation in DC-3 class airplanes.*

Surface Combustion technicians, working with leading aircraft engineers, have developed complete heating systems for some of America's best known aircraft. You can probably benefit from this wide experience on the application and installation of various types of Janitrol equipment. Write, Surface Combustion Corporation, Aircraft Heater Division, Toledo 1, Ohio.

### Aircraft

AC Spark Plug Div., General Motors Corp.
Agawam Aircraft Products, Inc.
Air-Parts, Inc.
Aircraft Indicators Co.
American Paulin System
Beryllium Corp.
DeJur Amsco Corp.
Eclipse-Pioneer Div., Bendix Aviation Corp.
Thomas A. Edison, Inc., Instrument Div.
Edison-Splitdorf Corp.
Fenwal Inc.
General Aircraft Co.
Hickok Electrical Instrument Co.
Jarvis Manufacturing Co.
Kenyon Instrument Co., Inc.
Kollsman Instrument Div. of Square D Co.
Liquidometer Corp.
Pacific Scientific Co.
Saxl Instrument Co.
L. N. Schwien Engineering Co.
Servair, Inc.
Sperry Gyroscope Co., Inc.
Stewart-Warner Corp.
Westinghouse Electric Corp.

### Engine

AC Spark Plug Div., General Motors Corp.
Air-Parts, Inc.
Beryllium Corp.
Brown Instrument Co.
Cambridge Instrument Co., Inc.
DeJur Amsco Corp.
Eclipse-Pioneer Div., Bendix Aviation Corp.
Thomas A. Edison, Inc., Instrument Div.
Edison-Splitdorf Corp.
Fenwal Inc.
Fischer & Porter Co.
General Electric Co.
Jarvis Manufacturing Co.
Kenyon Instrument Co., Inc.
Kollsman Instrument Div. of Square D Co.
Liquidometer Corp.
Pacific Scientific Co.
Radio Frequency Laboratories, Inc.
Scott Aviation Corp.
Servair, Inc.
Sperry Gyroscope Co., Inc.
Stewart-Warner Corp.

### Flight

Aircraft Indicators Co.
Airpath Instrument Co.
Airplane & Marine Instruments, Inc.
Beryllium Corp.
Brown Instrument Co.
Diehl Mfg. Co.
Eclipse-Pioneer Div., Bendix Aviation Corp.
Fischer & Porter Co.
General Electric Co.
Jardur Aviation Co.
Kenyon Instrument Co., Inc.
Kollsman Instrument Div. of Square D Co.
Pacific Scientific Co.
Radio Frequency Laboratories, Inc.
Saxl Instrument Co.
L. N. Schwien Engineering Co.
Scott Aviation Corp.
Servair, Inc.
Specialties, Inc.
Sperry Gyroscope Co., Inc.
Weems System of Navigation

### Ground

American Paulin System
Brown Instrument Co.
Fischer & Porter Co.
Friez Instrument Div., Bendix Aviation Corp.
Kenyon Instrument Co., Inc.
Photoswitch Inc.
Saxl Instrument Co.
M. C. Stewart
United Cinephone Corp.

### Shop

Brown Instrument Co.
Cambridge Instrument Co., Inc.
Comtor Co.
Fischer & Porter Co.
General Electric Co.
Pacific Scientific Co.
Saxl Instrument Co.

### Testing & Measuring

Ace Manufacturing Corp.
Airplane & Marine Instruments, Inc.
All American Aircraft Products, Inc.

**(Testing & Measuring)** *Continued*
American Aircraft Manufacturing Co.
Brown Instrument Co.
Cambridge Instrument Co., Inc.
Comtor Co.
R. W. Cramer Co., Inc.
Charles Engelhard, Inc.
Fischer & Porter Co.
Friez Instrument Div., Bendix Aviation Corp.
Gaertner Scientific Corp.
General Electric Co.
Hickok Electrical Instrument Co.
Kollsman Instrument Div. of Square D Co.
Meriam Instrument Co.
Modern Optics, Inc.
Pacific Scientific Co.
Photoswitch Inc.
Reasor Manufacturing Co.
Saxl Instrument Co.
L. N. Schwien Engineering Co.
Scintilla Magneto Div., Bendix Aviation Corp.
Scott Aviation Corp.
Sperry Gyroscope Co., Inc.
P. A. Sturtevant Co.
Triplett Electrical Instrument Co.
Westinghouse Electric Corp.
N. A. Woodworth Co.

## INSULATING MATERIALS

Air-Parts, Inc.
All American Aircraft Products, Inc.
American Hair & Felt Co.
American Plating Rack Co.
Connecticut Hard Rubber Co.
Continental Diamond Fibre Co.
Durkee-Atwood Co.
Formica Insulation Co.
General Electric Co.
Irvington Varnish & Insulator Co.
Mica Insulator Co.
National Vulcanized Fibre Co.
Quigley Co., Inc.
Reynolds Metals Co.
Seaman Products, Div. of Seaman Paper Co.
United States Rubber Co.
Westinghouse Electric Corp.

## JET PROPULSION EQUIPMENT

(*See* Gas Turbine Equipment)

## JOINTS & COUPLINGS

Air-Parts, Inc.
Chase Brass & Copper Co.
Floorola Products, Inc.
Solar Aircraft Co.
Thompson Products, Inc.
Wells Aircraft Parts Co.

## LANDING GEAR

Bendix Products Div., Bendix Aviation Corp.
Menasco Manufacturing Co.

### Mechanism

Adel Precision Products Corp.
All American Products, Inc.
Cleveland Pneumatic Tool Co.
Eclipse-Pioneer Div., Bendix Aviation Corp.
Liberty Aircraft Products Corp.
Menasco Manufacturing Co.
Meyers Aircraft Co.
Wells Aircraft Parts Co.

### Nose Wheel Assemblies

Cleveland Pneumatic Tool Co.
Cunningham-Hall Aircraft Corp.
General Tire & Rubber Co.
Liberty Aircraft Products Corp.
Menasco Manufacturing Co.
Meyers Aircraft Co.
Pacific Div., Bendix Aviation Corp.
Scott Aviation Corp.
United Aircraft Products, Inc.
Wells Aircraft Parts Co.

### Shock Struts—Hydraulic

Adel Precision Products Corp.
Air-Parts, Inc.
Bendix Products Div., Bendix Aviation Corp.
Cleveland Pneumatic Tool Co.
Ex-Cell-O Corp.
Liberty Aircraft Products Corp.
Lipe-Rollway Corp.
Menasco Manufacturing Co.
Meyers Aircraft Co.
Pacific Div., Bendix Aviation Corp.
United Aircraft Products, Inc.
Wells Aircraft Parts Co.


# ONE BRAKE DESIGN

**Gives Maximum Braking Efficiency**

For a globe-circling airliner or a small private plane, the new Bendix* disc brake is completely adaptable.

Ranging in size from 5" to 31" diameter, the *same* principle of construction, the *same* compact, simple design give the *same* outstanding braking results regardless of the size or type of plane.

Especially important to plane manufacturers is that this design also permits considerable weight reduction in wheel and brake assembly, reducing operation costs and increasing efficiency.

*REG. U. S. PAT. OFF.

**DESIGN FEATURES**—Fixed discs are faced with friction lining; lining is segmented to scavenge lining dust and provide air circulation. Eliminates fading and gives greater braking force with less contact pressure. Rotating members, keyed to the wheels, provide large heat-absorbing capacity.

Rotors are made in segments instead of a continuous ring; this allows for heat expansion without warping or cracking.

PRODUCT OF Bendix AVIATION CORPORATION

## BENDIX PRODUCTS DIVISION

BENDIX AVIATION CORPORATION, SOUTH BEND 20, IND.

*Bendix* Landing Gear • Bendix Pneudraulic* Shock Struts • Bendix Airplane Wheels • Airplane Brakes • Hydraulic Master Cylinders and Power-Brake Valves make up the list of Bendix Landing Gear Equipment.*

### Tail Wheel Assemblies

Air-Parts, Inc.
Cleveland Pneumatic Tool Co.
Cunningham-Hall Aircraft Corp.
General Tire & Rubber Co.
Heath Co.
Liberty Aircraft Products Corp.
Meyers Aircraft Co.
Pacific Div., Bendix Aviation Corp.
Scott Aviation Corp.
Servair, Inc.
United Aircraft Products, Inc.
Washington Aircraft & Transport Corp.
Wells Aircraft Parts Co.

## LIFE SAVING EQUIPMENT

Aerial Products Inc.
Airchox Co., Div. of Joyce Aviation Inc.
Aircraft Appliance Corp.
American Cord & Webbing Co., Inc.
E. D. Bullard Co.
Durkee-Atwood Co.
Goodall Rubber Co.
Walter Kidde & Co., Inc.
Kidde Manufacturing Co., Inc.
Scott Aviation Corp.
Switlik Parachute Co.
United States Rubber Co.

## LIGHTING EQUIPMENT

Crouse Hinds Co.

### Aircraft

Air-Parts, Inc.
Eclipse-Pioneer Div., Bendix Aviation Corp.
General Electric Co.
Grimes Manufacturing Co.
C. M. Hall Lamp Co.
Kenyon Instrument Co., Inc.
S & M Lamp Co.
Servair, Inc.
Shallcross Mfg. Co.
Standard Aircraft Equipment Co.
Westinghouse Electric Corp.

### Airport

Crouse Hinds Co.
Grimes Manufacturing Co.
S & M Lamp Co.
United Cinephone Corp.
Westinghouse Electric Corp.

### Shop

Air-Parts, Inc.
Diehl Mfg Co.
S & M Lamp Co.
Western Mfg. Supply Co.
Westinghouse Electric Corp.

## LUBRICANTS

Air-Parts, Inc.
American Oil & Supply Co.
Gulf Oil Corp.
Intava, Inc.
Pacific Airmotive Corp., Manufacturing Div.
Parker Appliance Co.
Shell Oil Co., Inc.
Sinclair Refining Co.
Socony-Vacuum Oil Co., Inc.
Standard Oil Co. of California
Standard Oil Co. of New Jersey
Stewart-Warner Corp.
D. A. Stuart Oil Co.
Texas Co.
Wayne Chemical Products Co.

## MACHINE TOOLS

Ace Manufacturing Corp.
Acme Aluminum Alloys Inc.
Acromark Co.
Agerstrand Corp.
Atlas Press Co.
Boice-Crane Co.
Cincinnati Milling and Grinding Machines, Inc.
Cleveland Punch & Shear Works Co.
Connecticut Precision Hardware Co.
Couse Manufacturing, Inc.
Davis & Thompson Co.
Ex-Cell-O Corp.
Gammons-Hoaglund Co.
Geometric Tool Co.
George Gorton Machine Co.
Hamilton Tool Co.
Hole Engineering Service
Landis Machine Co.
Langelier Mfg. Co.
Lees-Bradner Co.
Lempco Products, Inc.
Lipe-Rollway Corp.
Lodge & Shipley Machine Tool Co.

**(Machine Tools)** *Continued*

Merz Engineering Co.
National Acme Co.
Oilgear Co.
Porter-Cable Machine Co.
Racine Tool & Machine Co.
Reasor Manufacturing Co.
St. Louis Tool & Mfg. Co.
Saxl Instrument Co.
Schauer Machine Co.
Schweizer Aircraft Corp.
Thompson Grinder Co.
Vimalert Co., Ltd.
Western Mfg. Supply Co.

## MACHINERY & MACHINE PARTS

Ace Manufacturing Corp.
Aeromark Co.
Aeronautical Manufacturing Corp.
Agastrand Corp.
All American Aircraft Products, Inc.
Boice-Crane Co.
Cedar Rapids Engineering Co.
Chicago Rivet & Machine Co.
Delloy Metal Corp.
Ex-Cell-O Corp.
Hamilton Tool Co.
Hole Engineering Service
Hollywood Tool & Die
Landis Machine Co.
Langelier Mfg. Co.
Lempco Products, Inc.
Liberty Aircraft Products Corp.
Merz Engineering Co.
Pioneer Engineering & Manufacturing Co.
Precision Products, Inc.
St. Louis Tool & Mfg. Co.
Saxl Instrument Co.
Steel Products Engineering Co.
Teleoptic Co.
Thompson Grinder Co.
Vimalert Co., Ltd.
N. A. Woodworth Co.

## MANIFOLDS

Air-Parts, Inc.
American Tube Bending Co., Inc.
B. H. Aircraft Co., Inc.
Buhl Manufacturing Co.
Keeney Manufacturing Co.
Rohr Aircraft Corp.
Ryan Aeronautical Co.
Sclar Aircraft Co.
Taylorcraft Aviation Div., Detroit Air-Craft Products, Inc.

## OIL SEALS

Adel Precision Products Corp., Huntington Precision Products Div.
Air-Parts, Inc.
Garlock Packing Co.
Gasket Manufacturing Co.
Edward D. Maltby Co.
Simplex Products Corp.
Victor Manufacturing & Gasket Co.

## OXYGEN EQUIPMENT, FLIGHT

Curtis Manufacturing Co.
Eclipse-Pioneer Div., Bendix Aviation Corp.
Gaertner Scientific Corp.
Walter Kidde & Co., Inc.
Pacific Scientific Co.
Parker Appliance Co.
Puritan Compressed Gas Corp.
Scott Aviation Corp.

## PANELS

AC Spark Plug Div., General Motors Corp.
Aeromark Co.
Air Communications, Inc.
Airplane & Marine Instruments, Inc.
D. L. Auld Co.
Eclipse-Pioneer Div., Bendix Aviation Corp.
Formica Insulation Co.
L. F. Grammes & Sons, Inc.
Kaiser Cargo, Inc., Fleetwings Div.
Parker Appliance Co.
Stewart-Warner Corp.
Universal Molded Products Corp.
United States Plywood Corp.

## PARACHUTE PARTS AND HARDWARE

Airchox Co., Div. of Joyce Aviation Inc.
American Cord & Webbing Co., Inc.
Beryllium Corp.
Eagle Parachute Corp.
Pioneer Parachute Co.
Reliance Manufacturing Co.
Switlik Parachute Co.
United-Carr Fastener Corp.

—LODWICK AIRPORT—LAKELAND, FLORIDA—

### PARACHUTES

Airchox Co., Div. of Joyce Aviation Inc.
Eagle Parachute Corp.
Pioneer Parachute Co.
Reliance Manufacturing Co.
Switlik Parachute Co.

### PLASTICS

Acadia Synthetic Products Div., Western Felt Works
Agerstrand Corp.
Air-Parts, Inc.
Commercial Plastics Co.
Connecticut Precision Hardware Co.
Continental-Diamond Fibre Co.
Cox and Stevens Aircraft Corp.
E. I. du Pont de Nemours & Co., Inc.
Durez Plastics & Chemicals, Inc.
Formica Insulation Co.
Irvington Varnish & Insulator Co.
Mica Insulator Co.
Molded Insulation Co.
National Vulcanized Fibre Co.
Pittsburgh Plate Glass Co.
Remler Co., Ltd.
Scott Aviation Corp.
United States Plywood Corp.
United States Rubber Co.
Universal Moulded Products Corp.
Westinghouse Electric Corp.

### PRIMERS (ENGINE)

Chandler-Evans Corp.
Parker Appliance Co.

### PROPELLER PARTS

Aero Supply Mfg. Co. Inc.
Aeroproducts Div., General Motors Corp.
B. H. Aircraft Co., Inc.
Bennett Propeller Co.
Connecticut Precision Hardware Co.
Curtiss-Wright Corp., Propeller Div.
Ex-Cell-O Corp.
McCauley Corp.
Marquette Metal Products Co.
Precision Products, Inc.
Republic Aircraft Products Div., The Aviation Corp.
Steel Products Engineering Co.
Thompson Products, Inc.
Wells Aircraft Parts Co.
Wyman-Gordon Co

### PROPELLERS

Aeroproducts Div., General Motors Corp.
Beech Aircraft Corp.
Curtiss-Wright Corp., Propeller Div.
Hamilton Standard Propellers, Div. of United Aircraft Corp.
Hardman Peck & Co.
Koppers Co.. Inc., Bartlett-Hayward Div.
G. B. Lewis Co.
Republic Aircraft Products Div., The Aviation Corp.
Stone Propeller Co.
Thompson Industries, Inc.
Washington Aircraft & Transport Corp.
Wyman-Gordon Co.

### PULLEYS AND FAIRLEADS

Adel Precision Products Corp, Huntington Precision Products Div.
Air-Parts, Inc.
All American Aircraft Products, Inc.
Allite Mfg. Co.
Formica Insulation Co.
Molded Insulation Co.
Precision Products, Inc.
Scott Aviation Corp.
Wells Aircraft Parts Co.
Western Mfg. Supply Co.
Westinghouse Electric Corp.

### PUMPS

Adel Precision Products Corp.
Advance Pump Co.
Aero Supply Mfg. Co. Inc.
Air-Parts, Inc.
Blackmer Pump Co.
Chandler-Evans Corp.
Cleveland Pneumatic Tool Co.
Cunningham-Hall Aircraft Corp.
De Laval Steam Turbine Co.
Eclipse-Pioneer Div., Bendix Aviation Corp.
Goulds Pumps Inc.
Independent Pneumatic Tool Co.
Jacobs Aircraft Engine Co., Div. of Republic Industries, Inc.
Liberty Aircraft Products Corp.
Pacific Aviation, Inc., Los Angeles Div.
Pacific Div., Bendix Aviation Corp.
Pacific Scientific Co.

**(Pumps)** *Continued*
Racine Tool & Machine Co.
Rohlm Manufacturing Co., Inc.
Scintilla Magneto Div., Bendix Aviation Corp.
Sperry Gyroscope Co., Inc.
United Aircraft Products, Inc.
Vickers Inc.
Weldon Tool Co.
Wells Aircraft Parts Co.

## RADIATORS

Clifford Manufacturing Co.
G & O Manufacturing Co.
United Aircraft Products, Inc.
Winchester Repeating Arms Co., Div. of Olin Industries Inc.

## RADIO ACCESSORIES & EQUIPMENT

Ace Manufacturing Corp.
Air Communications, Inc.
Airadio, Inc.
Aircraft Radio Corp.
Airplane & Marine Instruments, Inc.
Rex Bassett, Inc.
Bendix Radio Div., Bendix Aviation Corp.
Beryllium Corp.
Collins Radio Co.
Communications Co., Inc.
Daven Co.
Eastern Air Devices, Inc.
Eitel-McCullough, Inc.
Feick Mfg. Co. Div. of Detroit Aircraft Products
General Electric Co.
General Tire & Rubber Co.
Hallicrafters, Inc.
Harvey-Wells Electronics, Inc.
Heath Co.
Hickok Electrical Instrument Co.
Hollywood Tool & Die
Hughes Aircraft Co.
International Resistance Co.
P. R. Mallory & Co., Inc.
Molded Insulation Co.
National Co., Inc.
Pacific Div., Bendix Aviation Corp.
Permoflux Corp.
RCA-Victor Div., Radio Corp. of America
Radio Frequency Laboratories, Inc.
Servair, Inc.
Sigma Instruments, Inc.
Sperry Gyroscope Co., Inc.
Stoddard Aircraft Radio Co.
Superior Tube Co.
Thermador Electrical Mfg. Co.
United-Carr Fastener Co.
Washington Aircraft & Transport Corp.
Western Electric Co., Inc.
Western Mfg. Supply Co.
Westinghouse Electric Corp.

## RADIO COMPASSES

Air Communications, Inc.
Air-Parts, Inc.
Airplane & Marine Instruments, Inc.
Bendix Radio Div., Bendix Aviation Corp.
Hallicrafters, Inc.
Harvey-Wells Electronics, Inc.
RCA-Victor Div., Radio Corp. of America
Servair, Inc.
Sperry Gyroscope Co., Inc.

## RADIOS

Air Communications, Inc.
Air-Parts, Inc.
Airadio, Inc.
Aircraft Radio Corp.
Airplane & Marine Instruments, Inc.
Belmont Radio Corp.
Bendix Radio Div., Bendix Aviation Corp.
Collins Radio Co.
Communications Co., Inc.
General Electric Co.
Hallicrafters, Inc.
Harvey-Wells Electronics, Inc.
Heath Co.
Hughes Aircraft Co.
Molded Insulation Co.
National Co., Inc.
Pacific Div., Bendix Aviation Corp.
RCA-Victor Div., Radio Corp. of America
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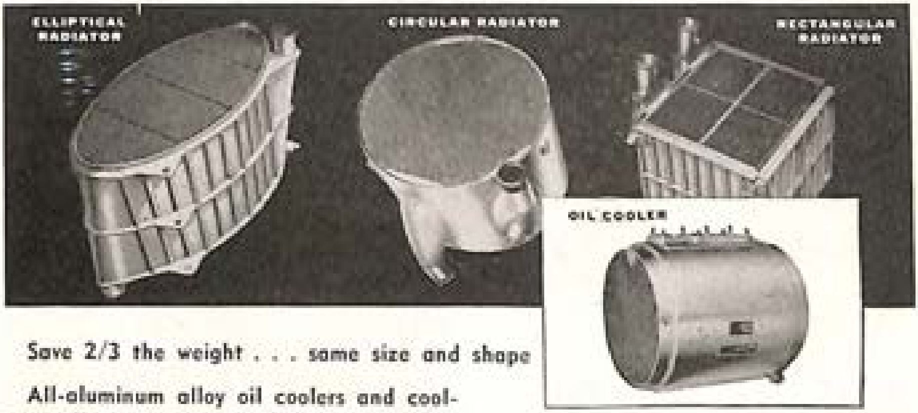
*Manufacturers of Hydron Metallic Bellows and Feather-Weight Oil Coolers and Coolant Radiators*

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All-aluminum alloy oil coolers and coolant radiators—products of Clifford's unique method of brazing aluminum in thin sections—are now offering to commercial aircraft the same weight-reducing, strength-increasing advantages enjoyed by fighting planes during the war.

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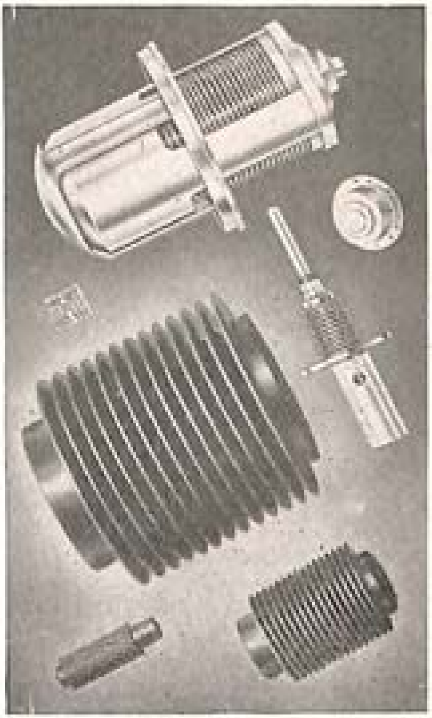

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Specializing in metallic bellows and bellows assemblies for remote and direct temperature control, for remote control of gasoline valves, for oxygen regulators, for oxygen flow indicators, for thermostatic units in liquid cooled aircraft engines, for refrigerator switches and controls, etc.—Clifford is *First with the Facts on Hydraulically-Formed Bellows.* For a sample of these facts, write to Clifford Manufacturing Co., 575 E. First Street, Boston 27, Mass.

### RIVETS

Air-Parts, Inc.
Aluminum Co. of America
Champion Rivet Co.
Chase Brass & Copper Co.
Cherry Rivet Co.
Chicago Rivet & Machine Co.
Downs Smith Brass & Copper Co., Inc.
Independent Pneumatic Tool Co.
Manufacturers Screw Product
Mid-State Manufacturing Co.
National Screw & Manufacturing Co.
New England Screw Co.
Reynolds Metals Co.

### SAFETY BELTS

Air-Parts, Inc.
Airchox Co., Div. of Joyce Aviation Inc.
Aircraft Appliance Corp.
E. D. Bullard Co.
General Scientific Equipment Co.
Switlik Parachute Co.

### SCALES

Acromark Co.
Cox and Stevens Aircraft Corp.

### SEATS

All American Aircraft Products, Inc.
Kellett Aircraft Corp.
Nukraft Manufacturing Co., Inc.
Taylorcraft Aviation Div., Detroit Air-Craft Products, Inc.
United States Plywood Corp.
United States Rubber Co.

### SHIELDING (RADIO & IGNITION)

Air-Shields Inc.
B. G. Corp.
Boston Insulated Wire & Cable Co.
Breeze Corporations, Inc.
Electric Auto-Lite Co., Wire & Cable Div.
General Electric Co.
Menaugh-Dutterer Co.
Packard Electric Div., General Motors Corp.
Rockbestos Products Corp.
Scintilla Magneto Div., Bendix Aviation Corp.
Standard Aircraft Equipment Co.

### SHOCK ABSORBERS

Adel Precision Products Corp.
Air-Parts, Inc.
Cleveland Pneumatic Tool Co.
Lipe-Rollway Corp.
Lord Manufacturing Co.
Pacific Aviation, Inc., Los Angeles Div.
Preco Inc.

### SHOP EQUIPMENT

Aurora Equipment Co.
Black & Decker Mfg. Co.
Boice-Crane Co.
Connecticut Precision Hardware Co.
Couse Manufacturing, Inc.
General Scientific Equipment Co.
Ideal Commutator Dresser Co.
Jacoel Cable Splicing Equipment Co.
Lempco Products, Inc.
Owatonna Tool Co.
Skilsaw, Inc.
Spencer & Morris
Turner Brass Works
United States Electrical Tool Co.

### SPARK PLUGS

AC Spark Plug Div., General Motors Corp.
Air-Shields Inc.
B. G. Corp.
Champion Spark Plug Co.
Edison-Splitdorf Corp.
Scintilla Magneto Div., Bendix Aviation Corp.
Simmonds Aerocessories, Inc.
Standard Oil Co. of New Jersey

### SPRINGS

Air-Parts, Inc.
Die Supply Co.
Downs Smith Brass & Copper Co., Inc.

### STAMPINGS

Ace Manufacturing Corp.
Acromark Co.
Adel Precision Products Corp., Huntington Precision Products Div.
Airchox Co., Div. of Joyce Aviation Inc.
All American Aircraft Products, Inc.

**(Stampings)** *Continued*

D. L. Auld Co.
B. H. Aircraft Co., Inc.
Buhl Manufacturing Co.
Chase Brass & Copper Co.
Colgate Aircraft Corp.
Conco Engineering Works
Connecticut Precision Hardware Co.
Dunkirk Die & Machine Works
Feick Mfg. Co., Div. of Detroit Aircraft Products
Gasket Manufacturing Co.
L. F. Grammes & Sons, Inc.
Guiberson Corp.
Hamilton Tool Co.
Hollywood Tool & Die
Jarvis Manufacturing Co.
Kaiser Cargo, Inc., Fleetwings Div.
Lempco Products, Inc.
Liberty Aircraft Products Corp.
Luscombe Airplane Corp.
Mercury Aircraft Inc.
National Radiator Co.
Poulsen & Nardon, Inc.
Precision Products, Inc.
Preco Inc.
Reynolds Metals Co.
Ryan Aeronautical Co.
Solar Aircraft Co.
Soss Manufacturing Co.
Spartan Aircraft Co.
Taylorcraft Aviation Div., Detroit Air-Craft Products, Inc.
Teicher Manufacturing Corp.
Teleoptic Co.
Transue & Williams Steel Forging Corp.
United-Carr Fastener Corp.
United Screw & Bolt Corp.
Worcester Pressed Steel Co.

## STANDS (ENGINE, PROPELLER, SERVICING)

Air-Parts, Inc.
Airquipment Co.
Connecticut Precision Hardware Co.
International Derrick & Equipment Co.
Liberty Aircraft Products Corp.

## STARTERS

Air-Parts, Inc.
Breeze Corporations, Inc.
Eclipse-Pioneer Div., Bendix Aviation Corp.
Jack & Heintz, Inc.
Servair, Inc.
Standard Aircraft Equipment Co.
Westinghouse Electric Corp.

## SUBASSEMBLIES

Ace Manufacturing Corp.
All American Aircraft Products, Inc.
B. H. Aircraft Co., Inc.
B-W Superchargers, Inc.
Buhl Manufacturing Co.
Colgate Aircraft Corp.
Edo Aircraft Corp.
Farmingdale Aircraftsmen Manufacturing Corp.
Feick Mfg. Co., Div. of Detroit Aircraft Products
Hardman Peck & Co.
Kaiser Cargo, Inc., Fleetwings Div.
Kellett Aircraft Corp.
Kilgen Aircraft Div. of The Kilgen Organ Co.
Liberty Aircraft Products Corp.
Machine Products Div., Armstrong Furnace Co.
Mercury Aircraft Inc.
National Radiator Co.
Ryan Aeronautical Co.
Skydyne, Inc.
Taylorcraft Aviation Div., Detroit Air-Craft Products, Inc.

## SUPERCHARGERS

Benwood-Linze Co.

### Cabin

B-W Superchargers, Inc.
Eclipse-Pioneer Div., Bendix Aviation Corp.
General Electric Co.

### Engine

B-W Superchargers, Inc.
Eclipse Pioneer Div., Bendix Aviation Corp.
General Electric Co.
Thompson Products, Inc.

## TANKS

American Plating Rack Co.
B. H. Aircraft Co., Inc.

**(Tanks)** *Continued*

Bellanca Aircraft Corp.
Chas. W. Carll Sons
Colgate Aircraft Corp.
Jarvis Manufacturing Co.
Kaiser Cargo, Inc., Fleetwings Div.
Mercury Aircraft Inc.
National Radiator Co.
Poulsen & Nardon, Inc.
Preco Inc.
Sundmark Supply Co.
Taylorcraft Aviation Div., Detroit Air-Craft Products, Inc.
United States Rubber Co.

## TESTING & INSPECTION EQUIPMENT

Airplane & Marine Instruments, Inc.
American Aircraft Manufacturing Co
American Machine and Metals, Inc
B. G. Corp.
Cambridge Instrument Co., Inc
Fischer & Porter Co.
Gaertner Scientific Corp.
Hickok Electrical Instrument Co.
Industrial Sound Control
Jack & Heintz, Inc.
Jacoel Cable Splicing Equipment Co.
Kellogg Switchboard & Supply Co.
McColpin-Christie Corp., Ltd.
Magnaflux Corp.
Meriam Instrument Co.
Preco Inc.
Rocky Mountain Steel Products, Inc.
Scintilla Magneto Div., Bendix Aviation Corp.
Shallcross Mfg. Co.
Sperry Gyroscope Co., Inc.
Takk Corp.
Western Gear Works

## TIRES & TUBES

Air-Parts, Inc.
General Tire & Rubber Co.
Scott Aviation Corp.
Servair, Inc.
Standard Oil Co. of New Jersey
United States Rubber Co.

## TOOLS

Ace Manufacturing Corp.
Acme Aluminum Alloys Inc.
Agerstrand Corp.
Airquipment Co.
All American Aircraft Products, Inc.
American Plating Rack Co.
Armstrong Mfg. Co.
E. C. Atkins and Co.
Billings & Spencer Co.
Black & Decker Co.
Bridgeport Hardware Mfg. Corp.
Chase Brass & Copper Co.
Cleveland Pneumatic Tool Co.
Connecticut Precision Hardware Co.
Cowles Tool Co.
Davis & Thompson Co.
Delloy Metal Corp.
Ex-Cell-O Corp.
Floorola Products, Inc.
Gabb Manufacturing Co.
Gammons-Hoaglund Co.
Genesee Tool Co.
Geometric Tool Co.
Greenfield Tap & Die Corp.
Hinsdale Manufacturing Co.
Hollywood Tool & Die
Ideal Commutator Dresser Co.
Independent Pneumatic Tool Co.
Jacoel Cable Splicing Equipment Co.
Kennametal Inc.
Merz Engineering Co.
Metal & Tool Reconditioning Service
National Acme Co.
Nedco Co.
Owatonna Tool Co.
Paulson Tools Inc.
Pioneer Engineering & Manufacturing Co.
Reasor Manufacturing Co.
Saxl Instrument Co.
Skilsaw, Inc.
Stevens Walden, Inc.
Universal Moulded Products Corp.
Utica Drop Forge & Tool Corp.
Weldon Tool Co.

## TRACTORS

Caterpillar Tractor Co.
W. F. Hebard & Co.
Towmotor Corp.

## TRAINING DEVICES

Abrams Instrument Corp.
Airplane & Marine Instruments, Inc.
Byrne Doors, Inc.
Cox and Stevens Aircraft Corp.
Link Aviation Devices, Inc.
Specialties, Inc.

### TUBE BENDING

Air-Parts, Inc.
All American Aircraft Products, Inc.
American Tube Bending Co., Inc.
Aurora Equipment Co.
Colgate Aircraft Corp.
Connecticut Precision Hardware Co.
Farmingdale Aircraftsmen Manufacturing Corp.
Kaiser Cargo, Inc., Fleetwings Div.
Keeney Manufacturing Co.
Meyers Aircraft Co.
National Radiator Co.
Parker Appliance Co.
Taylorcraft Aviation Div., Detroit Air-Craft Products, Inc.

### TUBING

Acadia Synthetic Products Div., Western Felt Works
Aluminum Co. of America
Atlantic India Rubber Works, Inc.
Breeze Corporations, Inc.
Chase Brass & Copper Co.
Commercial Plastics Co.
Downs Smith Brass & Copper Co., Inc.
Eclipse-Pioneer Div., Bendix Aviation Corp.
Globe Steel Tubes Co.
Irvington Varnish & Insulator Co.
Miller Products Co., Inc.
Resistoflex Corp.
Reynolds Metals Co.
Shenango-Penn Mold Co.
Superior Tube Co.
Timken Roller Bearing Co.
United States Rubber Co.
Winchester Repeating Arms Co., Div. Olin Industries Inc.

### TURRETS & PARTS

Bellanca Aircraft Corp.
General Electric Co.
Kilgen Aircraft Div. of The Kilgen Organ Co.
Liberty Aircraft Products Corp.
Pittsburgh Plate Glass Co.
Sperry Gyroscope Co., Inc.
Steel Products Engineering Co.

### UNIFORMS

S. Appel & Co., Inc.
Switlik Parachute Co.

### VALVES (CONTROL)

Adel Precision Products Corp.
Aero Supply Mfg. Co. Inc.
Aeronautical Manufacturing Corp.
Air-Parts, Inc.
Buckeye Iron & Brass Works
Domestic Manufacturing Co.
Eclipse-Pioneer Div., Bendix Aviation Corp.
Kaiser Cargo, Inc., Fleetwings Div.
Kenyon Instrument Co., Inc.
Kohler Co.
Liberty Aircraft Products Corp.
Pacific Aviation, Inc., Los Angeles Div.
Pacific Div., Bendix Aviation Corp.
Parker Appliance Co.
Puritan Compressed Gas Corp.
Rohlm Manufacturing Co., Inc.
Saxl Instrument Co.
Sciaky Bros.
Scott Aviation Corp.
United Aircraft Products, Inc.
Vickers Inc.
Wm. R. Whittaker, Ltd.
Young Radiator Co.

### VENEERS

D. L. Auld Co.
United States Plywood Corp.
Universal Moulded Products Corp.

### VENTILATING & AIR CONDITIONING EQUIPMENT

American Machine and Metals, Inc.
Anemostat Corp. of America
Automatic Electrical Devices Co.
Curtis Manufacturing Co.
Diehl Mfg. Co.
General Electric Co.
Pacific Scientific Co.
Snapvent Co.
United States Rubber Co.
Vapor Car Heating Co.
Westinghouse Electric Corp.
Young Radiator Co.

### VIBRATION DAMPERS

Connecticut Hard Rubber Co., Inc.
General Tire & Rubber Co.
Lord Manufacturing Co.
United States Rubber Co.

### WELDING EQUIPMENT

Chas. W. Carll Sons
Champion Rivet Co.
Couse Manufacturing, Inc.
Delloy Metal Corp.
General Electric Co.
General Scientific Equipment Co.
Glenn-Roberts Co.
Hobart Brothers Co.
Krembs & Co.
P. R. Mallory & Co., Inc.
Sciaky Bros.
Solar Aircraft Co.
Taylor-Winfield Corp.
Western Mfg. Supply Co.
Westinghouse Electric Corp.

### WHEELS

Air-Parts, Inc.
Bendix Products Div., Bendix Aviation Corp.
General Tire & Rubber Co.
Northrop Gaines, Inc.
Rapids-Standard Co., Inc.
Scott Aviation Corp.

### WINDSHIELD WIPERS

Marquette Metal Products Co.
Pacific Scientific Co.

### WIRE & CABLE—ELECTRICAL

Air-Parts, Inc.
All American Aircraft Products, Inc.
Boston Insulated Wire & Cable Co.
Champion Rivet Co.
Chase Brass & Copper Co.
Crescent Insulated Wire & Cable Co.
Electric Auto-Lite Co., Wire & Cable Div.
General Electric Co.
Kellogg Switchboard & Supply Co.
Okonite Co.
Packard Electric Div., General Motors Corp.
Rockbestos Products Corp.
John A. Roebling's Sons Co.
Standard Aircraft Equipment Co.
United States Rubber Co.

### WIRE & CABLE—MECHANICAL & FLEXIBLE SHAFTS

Air-Parts, Inc.
All American Aircraft Products, Inc.
Breeze Corporations, Inc.
Kenyon Instrument Co., Inc.
Macwhyte Co.
Rochester Ropes Inc.
John A. Roebling's Sons Co.
Western Mfg. Supply Co.

# CRESCENT

***Insulated***

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SYNTHOL Instrument and Control Wire

IMPERIAL Portable Cords and Cables

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## CRESCENT WIRE AND CABLE

NEMA

**CRESCENT INSULATED WIRE & CABLE CO.**

TRENTON, N. J.

# ALPHABETICAL DIRECTORY OF EQUIPMENT MANUFACTURERS AND SUPPLIERS OF BASIC MATERIALS AND FABRICATIONS

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**ADEL PRECISION PRODUCTS CORP., 10777 Van Owen St., Burbank, Calif.**
PERSONNEL: W. A. DeRidder, Pres.; R. D. Cavanaugh, V. Pres. & Treas.; G. S. Gillespie, Secy. & Compt.; D. A. Schlosser, Prod. Mgr.; J. S. Garraway, Sales Mgr.; S. Presho, Pur. Dir.; K. Gleed, Pers. Dir.; C. W. Pohlmann, Adv. Mgr.; J. W. Kelly, Chief Engr.

**ADEL PRECISION PRODUCTS CORP., HUNTINGTON PRECISION PRODUCTS DIV., 1444 Washington Ave., Huntington, W. Va.**
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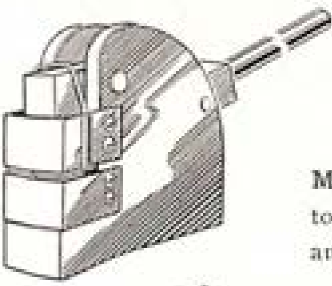

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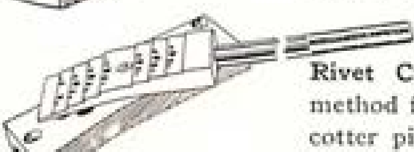

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PERSONNEL: H. Hertz, Pres.; W. O. Langille, V. Pres.; T. W. Paterson, Supt.; W. J. Jockers, Sales Mgr.; H. A. Conrad, Pur. Dir.; H. W. Kloth, Adv. Mgr.; P. H. Trickey, Chief Engr.

**THE DOALL CO.,**
**1301 S. Washington Ave., Minneapolis, Minn.**
PERSONNEL: R. J. Wilkie, Pres.; J. W. Wilkie, V. Pres.; L. R. Rothenberger, Sales Mgr.; W. Hamlett, Pur. Dir.; C. H. Rosene, Pub. Dir. & Adv. Mgr.; R. Crane, Chief Engr.

**DOCKSON CORP.,**
**3839 Wabash Ave., Detroit 8, Mich.**
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**DOMESTIC MANUFACTURING CO.,**
**87745 Mettler St., Los Angeles 3, Calif.**
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**THE DOW CHEMICAL CO.,**
**Midland, Mich.**

**DOWNS SMITH BRASS & COPPER CO., INC.,**
**304 E. 45th St., New York 17, N. Y.**
PERSONNEL: H. L. Downs, Pres.; B. H. McDevitt, V. Pres.; W. C. Kohl, Secy.; P. J. Fiumara, Treas.

**DUNKIRK DIE & MACHINE WORKS,**
**212-214 Lake Shore Dr. W., Dunkirk, N. Y.**
PERSONNEL: J. V. Serio, Pres.; A. W. Serio, Gen. Mgr.

**E. I. DUPONT de NEMOURS & CO., INC.,**
**626 Schuyler Ave., Arlington, N. J.**
PERSONNEL: A. E. Pitcher, Pres.; A. Armquist, V. Pres.; B. Garland, Secy. & Treas.; R. R. Johnston, Gen. Mgr.; W. D. Diver, Prod. Mgr.; W. A. Joslyn, Sales Mgr.; B. Van Voorhis, Pur. Dir.; W. Baine, Pers. Dir.; R. Bailey, Pub. Dir.; R. J. Pechin, Adv. Mgr.; H. Hayden, Chief Engr.

**DURAKOOL, INC.,**
**1010 N. Main St., Elkhart, Ind.**
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**DURAMOLD DIV. OF FAIRCHILD ENGINE & AIRPLANE CORP.,**
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PERSONNEL: T. K. Pierce, Gen. Mgr.; C. Coughlin, Asst. Gen. Mgr.; A. W. Loerke, Chief Engr.; D. Depew, Gen. Factory Supt.; E. W. Farrell, Compt.; W. T. C. Smith, Sales Mgr.; E. L. Butler, Pers. Mgr.; W. Lawrence, Pur. Mgr.; D. A. MacKenzie, Planning Mgr.

**DUREZ PLASTICS & CHEMICALS, INC.,**
**Walck Rd., North Tonawanda, N. Y.**
PERSONNEL: H. M. Dent, Pres. & Gen. Mgr.; J. F. Snyder, V. Pres., Secy. & Treas.; R. E. Dodd, A. W. Hanmer, Jr., C. T. O'Connor, Sales Mgrs.; C. M. Bell, Pur. Dir.; C. B. Crane, Pers. Dir.; H. S. Spencer, Pub. Dir. & Adv. Mgr.; G. M. Loomis, Chief Engr.

**DURKEE-ATWOOD CO.,**
**Minneapolis 13, Minn.**
PERSONNEL: H. C. Atwood, Pres., Treas. & Gen. Mgr.; E. P. Atwood, V. Pres.; L. Cromer, Secy.; J. Smith, Prod. Mgr.; A. J. Traun, Sales Mgr.; L. Murray, Pur. Dir.; W. McGrath, Pers. Dir. & Pub. Dir.; W. E. Anderson, Adv. Mgr.; C. Walz, Chief Engr.

**DZUS FASTENER CO., INC.,**
**Babylon, N. Y.**
PERSONNEL: W. Dzus, Pres., Gen. Mgr. & Prod. Mgr.; D. H. Kane, V. Pres.; T. Dzus, Secy.; F. X. Clarke, Treas.; L. F. Acker, Sales Mgr. & Adv. Mgr.; G. H. Arnold, Pur. Dir.; J. Gunther, Chief Engr.

## E

**EAGLE PARACHUTE CORP.,**
**424 N. Queen St., Lancaster, Pa.**
PERSONNEL: C. J. Follmer, Pres.; R. E. Knoll, Secy.; J. W. Van Buskirk, Prod. Mgr.

**EASTERN AIR DEVICES, INC.,**
**130 Flatbush Ave., Brooklyn, N. Y.**
PERSONNEL: H. G. Hamilton, Pres. & Gen. Mgr.; H. R. Menefee, V. Pres.-Sales; W. Goat, Secy.; G. K. Young, Prod. Mgr.; A. Hansee, Pur. Dir.; R. Tierney, Pers. Dir.; L. C. Pratt, Chief Engr.

**EATON MANUFACTURING CO., WILCOX-RICH DIV.,**
**9771 French Rd., Detroit 13, Mich.**
PERSONNEL: R. H. Daisley, Gen. Mgr.; H. Dyer, Mgr., Battle Creek Plant; H. Russell, Mgr., Saginaw Plant; A. Alexander, Mgr., Marshall Plant; M. D. Archangeli, Sales Mgr.; S. H. Morgan, Pers. Dir.; W. L. Adams, Adv. Mgr.; V. C. Young, Chief Engr.

**ECLIPSE-PIONEER DIV., BENDIX AVIATION CORP., Teterboro, N. J.**
PERSONNEL: E. R. Breech, Pres.; R. P. Lansing, V. Pres. & Gen. Mgr.; C. J. Brennan, Mfg. Dir.; R. H. Isaacs, Dir. of Sales & Services; R. H. Anderson, Pur. Agt.; W. Tracy, Ind. Rel. Dir.; F. G. Muller, Pub. Rel. Dir. & Adv. Mgr.; R. C. Sylvander, Engrg. Dir.

**ECONOMY ENGINEERING CO., 2653 W. Van Buren St., Chicago, Ill.**
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**THOMAS A. EDISON, INC., INSTRUMENT DIV., Lakeside Ave., W. Orange, N. J.**
PERSONNEL: C. D. Geer, V. Pres. & Gen. Mgr.; C. H. Odell, Asst. Mgr.; W. T. Gray, Prod. Mgr.; H. S. Jones, Chief Engr.

**EDISON-SPLITDORF CORP., West Orange, N. J.**
PERSONNEL: A. Walsh, Pres.; A. J. Clark, V. Pres. & Gen. Mgr.; F. C. Erwin, Secy.; H. H. Eckert, Treas.; C. A. Ericksen, Prod. Mgr.; F. W. Watson, Sales Mgr.; R. B. Lockhart, Pur. Dir.; S. F. Larchar, Pers. Dir.; J. F. Coakley, Pub. Dir.; S. Schaeffer, Adv. Mgr.; G. D. Cerf, Chief Engr.

**EDO AIRCRAFT CORP., 13-10 - 111th St., College Point, N. Y.**
PERSONNEL: E. D. Osborn, Pres.; G. B. Post, V. Pres.-Sales; K. D. Vosler, V. Pres.-Prod.; B. V. Korvin-Kroukovsky, V. Pres.-Engrg.; S. E. Bostwick, Secy. & Treas.; P. E. Battilana, Sales Mgr.; W. F. Konrad, Pur. Dir.; J. H. Burkett, Pers. Dir.; F. Sunderland, Pub. Dir. & Adv. Mgr.

**EICOR, INC., 1501 W. Congress St., Chicago 7, Ill.**
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**EISEMANN CORP., 32-33rd St., Brooklyn, N. Y.**
PERSONNEL: B. C. Milner, Jr., Pres.; E. R. Legg, V. Pres. & Gen. Mgr.; H. J. McAfee, Secy.; J. Chrysler, Treas.; E. E. Bradway, Prod. Mgr.; E. J. Goggins, Sales Mgr.; M. W. Perrine, Pur. Dir.; S. R. Leavitt, Pers. Dir.; L. Scott, Chief Engr.

**EITEL-McCULLOUGH, INC., San Bruno, Calif.**
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**ELECTRIC AUTO-LITE CO., WIRE & CABLE DIV., 3529-24th St., Port Huron, Mich.**
PERSONNEL: R. G. Martin, Pres.; D. H. Kelly, Exec. V. Pres.; F. H. Landwehr, Secy.; J. B. Fenner, Treas.; J. A. Minch, Gen. Mgr.; W. W. Kesteloot, Prod. Mgr.; V. F. Dobbins, Sales Mgr.; G. L. Blessing, Pur. Dir.; T. Jones, Pers. Dir.; F. Thomas, Pub. Dir.; R. Kilgore, Adv. Mgr.; P. H. Wetzel, Chief Engr.

**ELECTRIC SPECIALTY CO., 211 South St., Stamford, Conn.**
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**ELECTROMODE CORP., DIV. OF AMERICAN FOUNDRY EQUIPMENT CO., 500 S. Byrkit St., Mishawaka, Ind.**
PERSONNEL: R. E. Peugignot, Gen. Mgr.; L. R. Mast, Prod. Mgr.; T. B. Owen, Sales Mgr.

**ENDICOTT FORGING & MFG. CO. INC., 1961 North St., Endicott, N. Y.**
PERSONNEL: A. W. Schaefer, Secy. & Sales Mgr.

**CHARLES ENGELHARD, INC., 233 N. J. R. R. Ave., Newark 5, N. J.**
PERSONNEL: C. Engelhard, Pres. & Treas.; C. B. Mitchell, V. Pres.; J. H. Laub, Secy.; A. W. Taber, Gen. Mgr.; O. Kunze, Pur. Dir.; J. Kromer, Chief Engr.

**ESSO AVIATION PRODUCTS**
(See Standard Oil Co. of New Jersey)

**EX-CELL-O CORP., 1200 Oakman Blvd., Detroit 6, Mich.**
PERSONNEL: P. Huber, Pres.; T. Olson, V. Pres.-Sales; J. K. Fulks, V. Pres.-Mfg.; H. G. Bixby, Secy. & Treas.; D. H. McIver, Asst. Sales Mgr.; F. Sicklesteel, Pur. Dir.; J. F. Miller, Machine Tools Mgr.; M. B. Montgomery, Factory Mgr.; H. L. J. Humphry, Adv. Mgr.

**EXPERIMENTAL ENGINEERING DIV., BENDIX AVIATION CORP., Detroit 7, Mich.**
PERSONNEL: W. A. Mara, Gen. Mgr.; A. P. Fontaine, Engrg. Dir.

## F

**FARMINGDALE AIRCRAFTSMEN MANUFACTURING CORP., Massapequa Rd., Farmingdale, N. Y.**
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**THE FEDERAL BEARINGS CO., INC., Poughkeepsie, N. Y.**
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**FEDERAL-MOGUL CORP., 11031 Shoemaker Ave., Detroit 13, Mich.**
PERSONNEL: H. G. Muzzy, Pres.; G. S. Peppiatt, V. Pres.; E. O. Jones, V. Pres., Secy. & Sales Mgr.; S. C. Reynolds, V. Pres. & Treas.; E. F. Bauman, Pur. Dir.; R. I. Marquis, Pers. Dir.; T. J. Marshall, Adv. Mgr.; H. F. Dixon, Chief Engr.

**FEDERAL PRODUCTS CORP., Eddy St., Providence, R. I.**

**FEICK MFG. CO., DIV. OF DETROIT AIRCRAFT PRODUCTS,**
**10525 Meech Ave., Cleveland, O.**
PERSONNEL: R. Nash, Pres.; J. Rodd, V. Pres.; H. G. Telford, Gen. Mgr.; C. G. Koch, Pur. Dir.; W. McAdam, Adv. Mgr.

**FENWAL INC.,**
**75 Pleasant St., Ashland, Mass.**

**FINCH TELECOMMUNICATIONS, INC.,**
**Fourth & Virginia Sts., Passaic, N. J.**
PERSONNEL: W. G. H. Finch, Pres.; P. R. Brick, Secy.; H. J. Frees, Treas.; R. E. Mathes, Gen. Mgr.; H. H. Rathkamp, Sales Mgr.

**FIRESTONE AIRCRAFT CO.,**
**1200 Firestone Parkway, Akron, O.**

**FISCHER & PORTER CO.,**
**P. O. Box 127, Hatboro, Pa.**
PERSONNEL: K. Fischer, Pres. & Gen. Mgr.; W. A. Diament, V. Pres., Sales Mgr., Pub. Dir. & Adv. Mgr.; N. Brewer, Secy. & Chief Engr.; A. P. Hulme, Treas. & Pers. Dir.; L. S. Subber, Prod. Mgr.

**FLIGHTEX FABRICS INC.,**
**93 Worth St., New York 13, N. Y.**
PERSONNEL: V. Dietz, Jr., Pres., Gen. Mgr. & Sales Mgr.; L. Green, Secy.; D. Langdon, Treas.; G. P. Young, Prod. Mgr.; D. A. Simmons, Chief Engr.

**FLOOROLA PRODUCTS, INC.,**
**560 Maryland Ave., York, Pa.**
PERSONNEL: E. J. Newcomer, Pres. & Gen. Mgr.; K. Busser, Secy., Treas., Pers. Dir. & Adv. Mgr.; H. S. Butler, Prod. Mgr. & Pur. Dir.; W. L. Y. Davis, Sales Mgr.; P. S. Atkins, Jr., Chief Engr.

**FLOTROL SYSTEMS, INC.,**
**385 Gerard Ave., New York 51, N. Y.**
PERSONNEL: A. C. Kaestner, Pres. & Treas.; W. Lewis, V. Pres. & Sales Mgr.; G. A. Burns, V. Pres.; W. Erny, Secy.; W. A. Gresh, Chief Engr.

**FOOTE BROS. GEAR & MACHINE CORP.,**
**5225 S. Western Blvd., Chicago, Ill.**
PERSONNEL: W. A. Barr, Pres., Gen. Mgr. & Dir.; J. R. Fagan, Secy., Treas. & Dir.; E. A. Johnson, V. Pres., Manufacturing Precision Gear Div.; R. G. Davis, V. Pres. & Gen. Mgr., Industrial Gear Div.

**THE FORMICA INSULATION CO.,**
**4614 Spring Grove Ave., Cincinnati 32, O.**
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**FRIEZ INSTRUMENT DIV., BENDIX AVIATION CORP.,**
**Towson, Baltimore 4, Md.**
PERSONNEL: L. D. Kiley, Gen. Mgr.; R. B. Stevenson, Sales Mgr.; V. D. Hauck, Chief Engr.

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**THE G & O MANUFACTURING CO.,**
**138 Winchester Ave., New Haven 8, Conn.**
PERSONNEL: A. J. Verdi, Pres.; V. Carangelo, V. Pres.; F. I. Newton, Secy. & Prod. Mgr.; C. Oppe, Treas. & Gen. Mgr.; H. E. Benevento, Pur. Dir.

**GABB MANUFACTURING CO.,**
**16 Orchard St., East Hartford, Conn.**
PERSONNEL: W. J. Gabb, R. S. Cooper, Partners.

**THE GAERTNER SCIENTIFIC CORP.,**
**1201 Wrightwood Ave., Chicago 14, Ill.**
PERSONNEL: W. Gaertner, Pres., Treas. & Gen. Mgr.; S. Jacobsohn, V. Pres.; J. Mandel, Secy.; K. Krebs, Prod. Mgr.; L. W. Higgins, Sales Mgr. & Adv. Mgr.; P. F. Meyn, Chief Engr.

**THE GAMMONS-HOAGLUND CO.,**
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**THE GARLOCK PACKING CO.,**
**402 E. Main St., Palmyra, N. Y.**
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**THE GASKET MANUFACTURING CO.,**
**324 Venice Blvd., Los Angeles 15, Calif.**
PERSONNEL: L. B. Van De Car, Gen. Mgr. & Pur. Dir.; R. Sater, Prod. Mgr.; E. A. Kellenberger, Sales Mgr. & Adv. Mgr.; R. Crest, Chief Engr.

**GAYBEX CORP.,**
**510 Franklin Ave., Nutley 10, N. J.**
PERSONNEL: J. B. Moore, Pres. & Gen. Mgr.; H. W. Stoddard, V. Pres.; W. J. Camarata, Secy. & Treas.; R. C. Blodgett, Prod. Mgr.; W. A. Hancock, Sales Mgr.

**GENERAL CONTROLS,**
**801 Allen Ave., Glendale 1, Calif.**

**GENERAL ELECTRIC CO.,**
**1 River Rd., Schenectady 5, N. Y.**
PERSONNEL: C. E. Wilson, Pres.; J. C. Miller, Mgr., Aviation Div.; W. V. Merrihue, Adv. Mgr., Apparatus Dept.

**GENERAL SCIENTIFIC EQUIPMENT CO.,**
**1346-48 W. Somerset St., Philadelphia 32, Pa.**
PERSONNEL: M. Kline, Gen. Mgr.

**THE GENERAL TIRE & RUBBER CO.,**
**Akron, O.**
PERSONNEL: W. O'Neil, Pres.; L. A. McQueen, V. Pres.-Sales; H. R. Jenkins, Secy.; T. S. Clark, Treas.; P. E. Shobert, Aviation Product Sales Mgr.; R. Graham, Pur. Dir.; W. Mason, Pub. Dir.; R. Harrington, Adv. Mgr.; R. Iredell, Chief Engr.

**GENESEE TOOL CO., Fenton, Mich.**
PERSONNEL: E. Sjogren, Gen. Mgr. & Sales Mgr.; A. F. Denham, Adv. Mgr.

**THE GEOMETRIC TOOL CO.,**
**Blake & Valley Sts., New Haven 15 Conn.**
PERSONNEL: H. L. Bill, Pres.; A. S. Redway, V. Pres. & Gen. Mgr.; G. A. Denison, Sales Mgr.; D. P. Robinson, Pur. Agt.; A. F. Breitenstein, Chief Engr.

**GLADDEN PRODUCTS CORP.,**
**635 W. Colorado Blvd., Glendale 4, Calif.**
PERSONNEL: J. N. Gladden, Pres.; G. Brashears, V. Pres.; J. M. Wilson, Secy. & Treas.; G. Burland, Prod. Mgr.; W. P. Stratton, Jr., Sales Mgr.; P. A. Coleson, Pur. Dir.; J. G. Kuhn, Chief Engr.

**GLENN-ROBERTS CO.,**
**3100 E. 10th St., Oakland 1, Calif.**
PERSONNEL: G. G. Glenn, Pres.; S. S. Byers, Sales Mgr.; P. A. Carrothers, Pur. Dir. & Pers. Dir.; H. W. Smith, Chief Engr.

**GLOBE STEEL TUBES CO.,**
**3839 W. Burnhan St., Milwaukee 4, Wisc.**
PERSONNEL: W. C. Buchanan, Pres.; F. J. O'Brien, V. Pres. & Sales Mgr.; G. O. Ross, Secy. & Treas.; G. W. Walzer, Prod. Mgr.; A. Korsan, Pur. Dir.; A. Friss, Pers. Dir.; F. K. Krell, Pub. Dir. & Adv. Mgr.; E. Wrage, Chief Engr.

**GOODALL RUBBER CO.,**
**5 S. 36th St., Philadelphia 4, Pa.**
PERSONNEL: J. W. Eagleson, Sales Mgr.; E. B. Allen, Adv. Mgr.

**GEORGE GORTON MACHINE CO.,**
**Racine, Wisc.**
PERSONNEL: G. Gorton, Sr., Pres.; W. B. Tomlinson, Secy. & Treas.; G. Gorton, III, Gen. Mgr. & Sales Mgr.; S. Larsen, Prod. Mgr.; E. Reitzel, Pur. Dir.; A. F. Olson, Pers. Dir.; I. R. Ogilvie, Pub. Dir. & Adv. Mgr.; T. Eserkaln, Chief Engr.

**GOULDS PUMPS INC.,**
**Seneca Falls, N. Y.**
PERSONNEL: N. J. Gould, Pres.; H. Garmsey, Jr., V. Pres.; G. W. Medden, Treas.; E. E. Backlund, Sales Mgr.; C. H. Kissel, Pur. Dir.; G. W. Cramer, Adv. Mgr.; J. Mann, Chief Engr.

**L. F. GRAMMES & SONS, INC.,**
**391 Union St., Allentown, Pa.**
PERSONNEL: F. Weindel, Jr., Pres., Treas. & Sales Mgr.; R. Lamont, V. Pres., Gen. Mgr. & Prod. Mgr.; W. G. J. Baur, Secy.; J. Schaefer, Pur. Dir.; J. Schroeder, Pers. Dir.; M. Seibert, Pub. Dir. & Adv. Mgr.; J. Folwell, Chief Engr.

**GREENFIELD TAP & DIE CORP.,**
**Greenfield, Mass.**
PERSONNEL: D. G. Millar, Pres.; H. L. Bill, V. Pres. & Gen. Mgr.; J. B. Roys, Secy.; F. A. Yeaw, Treas.; E. A. Enderle, Prod. Mgr.; W. J. Eberlein, Sales Mgr.; J. W. Harrington, Pur. Dir.; G. H. Burrer, Pers. Dir.; R. C. Helbig, Pub. Dir. & Adv. Mgr.; O. E. Koehler, Chief Engr.

**GRIMES MANUFACTURING CO.,**
**Urbana, O.**
PERSONNEL: W. G. Grimes, Pres.; N. Black, Secy.; C. Grimes, Treas.; L. B. Moore, Gen. Mgr. & Sales Mgr.; D. O. Printz, Prod. Mgr.; J. C. Davis, Pur. Dir.; M. Wyant, Pers. Dir.

**THE GUIBERSON CORP.,**
**1000 Forest Ave., Dallas, Tex.**
PERSONNEL: A. Guiberson, Pres.; W. W. Finlay, V. Pres. & Gen. Mgr.; H. S. Zane, Jr., Secy. & Pur. Dir.; A. P. Smith, Treas.; C. E. Adams, Prod. Mgr.; A. Pranger, Sales Mgr. & Adv. Mgr.; M. B. Bogarte, Pers. Dir.; W. E. Lind, Chief Engr.

**GULF OIL CORP.,**
**Gulf Bldg., Pittsburgh, Pa.**
PERSONNEL: A. J. Williams, Mgr., Aviation Dept.; W. B. Lenkard, Asst. Mgr., Aviation Dept.

## H

**C. M. HALL LAMP CO.,**
**1035 E. Hancock, Detroit 7, Mich.**
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**THE HALLICRAFTERS CO.,**
**2611 S. Indiana Ave., Chicago, Ill.**
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**HAMILTON STANDARD PROPELLERS, DIV. OF UNITED AIRCRAFT CORP.,**
**East Hartford 8, Conn.**
PERSONNEL: S. A. Stewart, Gen. Mgr.; J. H. Cooper, Admin. Asst.; R. W. Russell, Asst. to Gen. Mgr.; E. Martin, Engrg. Mgr.; C. F. Baker, Chief Engr.; A. Nelson, Factory Mgr.; S. P. Crago, Materials Mgr.; A. C. Wolz, Pur. Agt.; H. M. Ellis, Sales Mgr.; B. W. Whitten, Div. Accountant; H. W. Beh, Asst. Treas.; C. P. Schory, Service Mgr.; W. T. Beebe, Pers. Mgr.; E. R. Trotman, Pub. Rep.

**THE HAMILTON TOOL CO.,**
**Hamilton, O.**
PERSONNEL: F. W. Schlichter, Pres.; C. W. Jung, W. H. Franzmann, V. Pres.; J. E. Grove, Secy., Sales Mgr. & Adv. Mgr.; O. Schlichter, Treas. & Gen. Mgr.; K. B. Huey, Pur. Dir.; R. E. Kelly, Pers. Dir.; R. Zihlman, Chief Engr.

**HANSON-VAN WINKLE-MUNNING CO.,**
**Church St., Matawan, N. J.**
PERSONNEL: V. W. Todd, Pres.; L. M. Hague, V. Pres.-Sales; N. A. Munning, Secy.; W. H. Slavin, Asst. Treas.; J. A. Bauer, Sales Mgr.; G. Todd, Chief Engr.

**HARDMAN, PECK & CO.,**
**542 W. 52nd St., New York 19, N. Y.**
PERSONNEL: E. A. Schmitt, Pres. & Gen. Mgr.; M. B. Colwin, V. Pres. & Prod. Mgr.; H. F. Hagemeyer, Secy. & Sales Mgr.; M. Barile, Treas.; J. Sauerland, Chief Engr.

**FREDERICK HART & CO., INC.,**
**837 Main St., Poughkeepsie, N. Y.**
PERSONNEL: C. R. D'Olive, Pres.; C. P. Galloway, V. Pres., Gen. Mgr. & Prod. Mgr.; J. A. Coleman, Secy.; W. S. Marder, Treas.; A. Stern, Sales Mgr.; B. O'Connell, Pur. Dir.; P. Peters, Pers. Dir.; T. Smith, Chief Engr.

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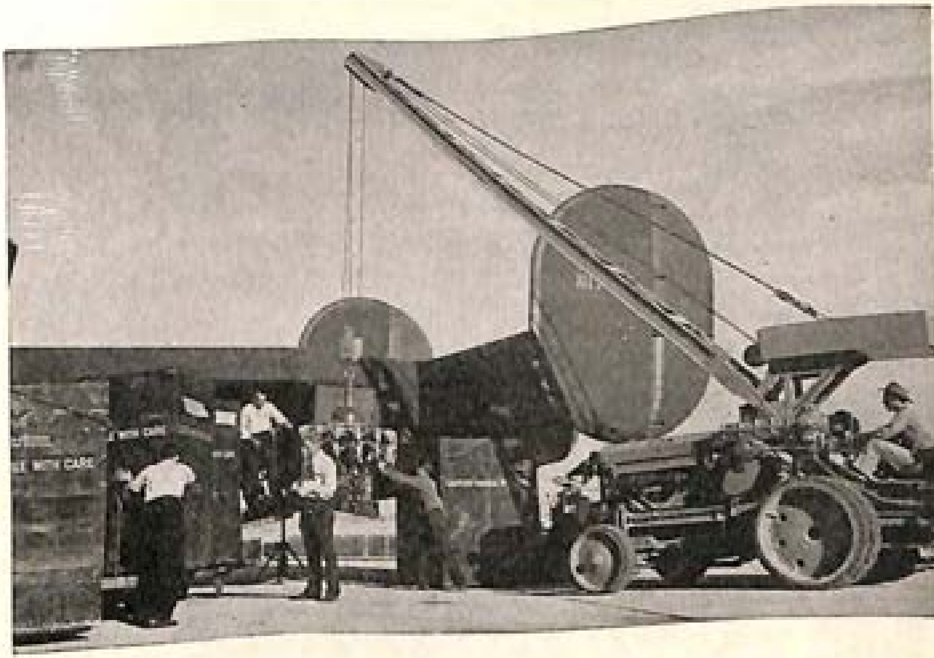

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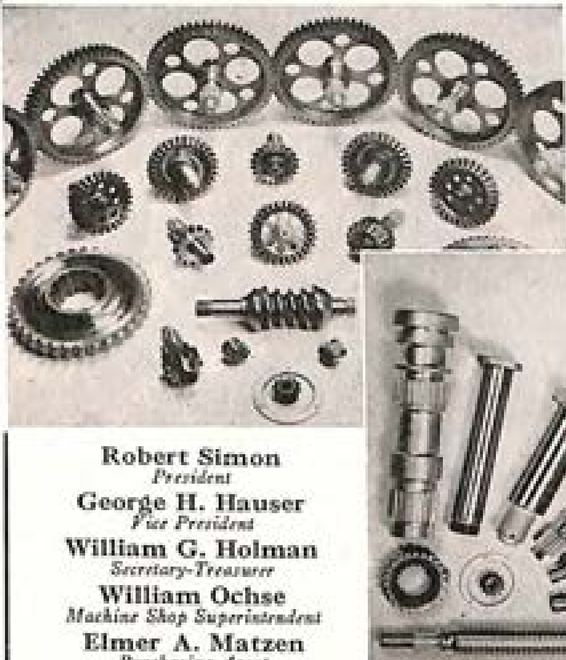

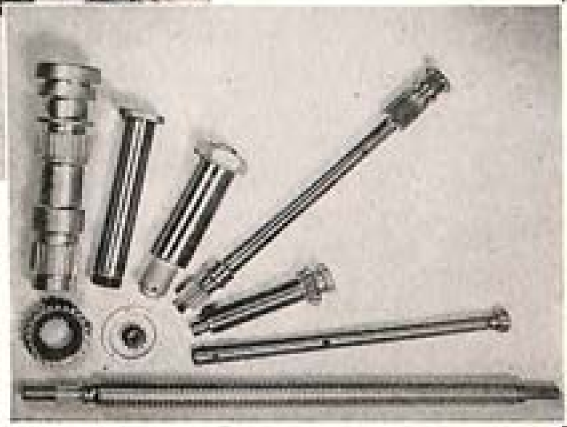

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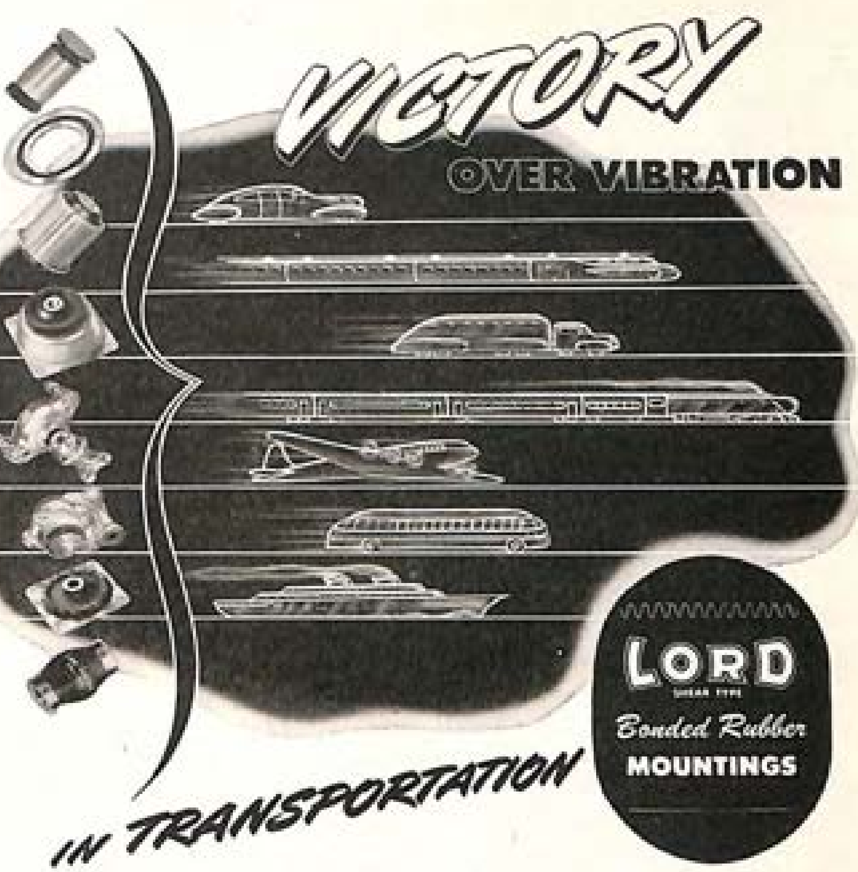
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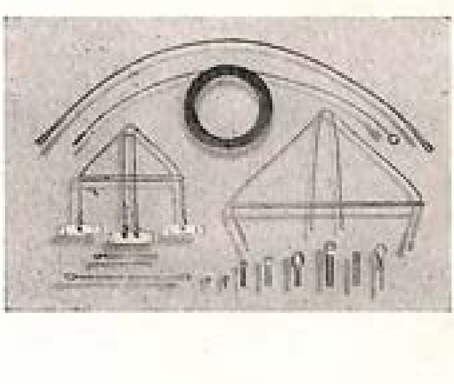

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