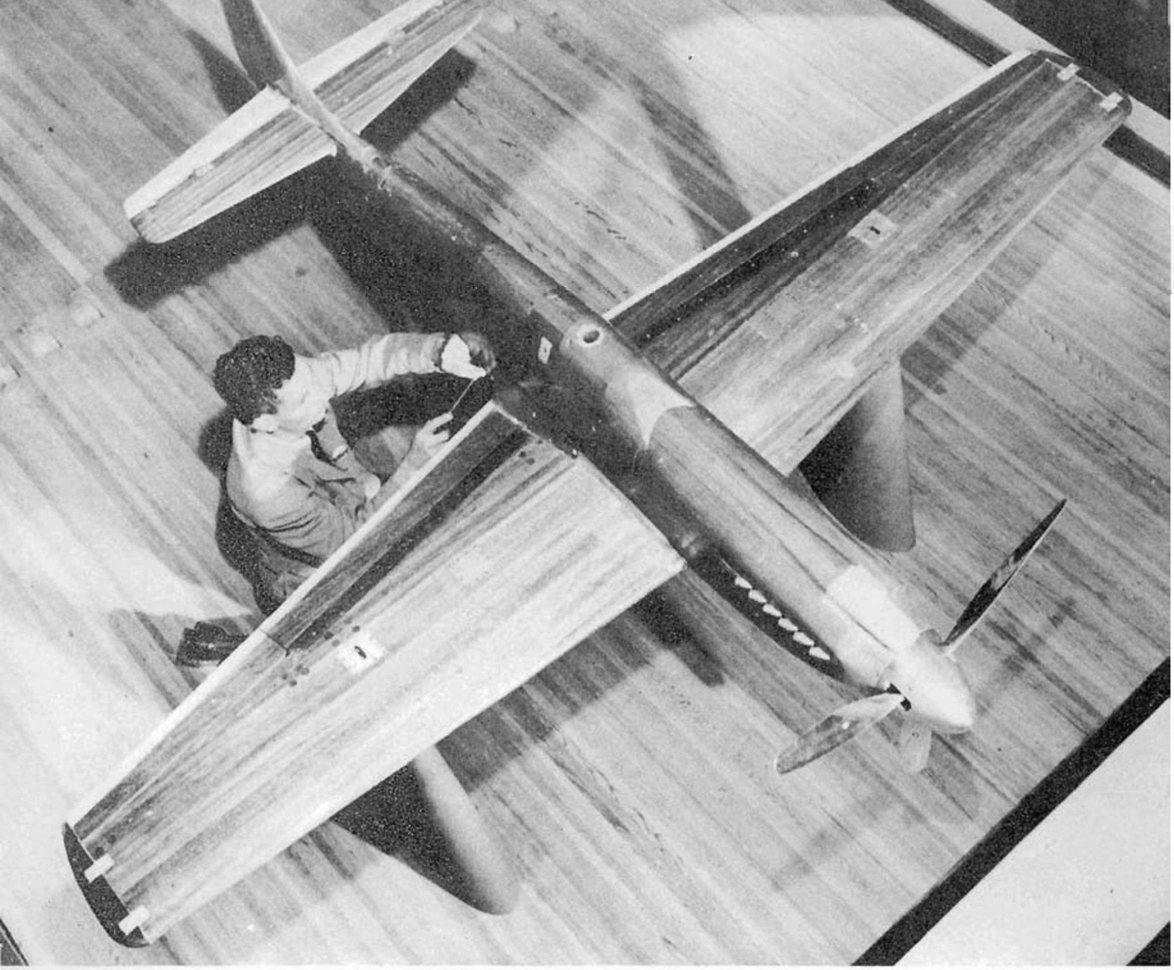
THE MODEL PLANE ANNUAL 1944



This graphic photograph shows how models are set up in wind tunnels for airflow tests. Such wind-tunnel models, like this P-51 Mustang, are built with the greatest care and to the closest tolerances. In some cases, through the use of exact replicas, engineers have been able to estimate a warplane's performance within 4 per cent.
(*North American Aviation photo*)

THE MODEL PLANE ANNUAL

1944

By

DAVID C. COOKE

Third Annual Edition

ROBERT M. McBRIDE & COMPANY
New York

DEDICATION

For their sincere interest and friendship,

this book is dedicated to

T. L. Wood and R. E. McDonald

ACKNOWLEDGMENT

FOR THEIR KIND assistance in preparing or supplying various data appearing in this book, the author wishes to express his appreciation to the General Motors Corp. and *GM Folks*; Benjamin Weinstein, of G.H.Q. Motors, Inc.; L. Horace Silberkleit, editor of *Aircraft Age*; Alfred Cleave; Paul Plecan; Edward Dakin and Consolidated Vultee Aircraft Co.; N. E. Walker, of the American Junior Aircraft Co.; R. W. Mair and James R. Wyse, of Maircraft: Famous Planes in Miniature; John T. Franklin, of Modern Hobbycraft Products; and the Academy of Model Aeronautics. Special thanks are also due Irwin and Nathan Polk for their suggestions and Harold W. Kulick and Eugene W. Kettering for the use of their excellent model photographs.

INTRODUCTION

WITH THE NATIONALS, Tri-State, and many other important model meets canceled for the duration, one might have the impression that aircraft modeling is on the downgrade and that interest in this hobby is waning. Such, however, is definitely not the case, and, like other peacetime pursuits and commodities, the model plane has gone to war.

The wartime use of model aircraft was first displayed by the Army-Navy program for building scale models to be used in identification classes. And the results of those classes are being shown every day in our war communiqués. While previously virtually anything and everything on wings was a target, and often it was discovered too late that the machines were friendly, both air and ground crews are now able to spot makes and nationalities in a split second. This prevents surprise attacks by the enemy and does much to bolster the morale of our fighting men to an even higher peak.

While the modeler in the schoolroom can only hope that his handiwork is being used to a good advantage by the armed forces, those men firing the guns know without a shadow of doubt that their efficiency has been improved many times through their thorough indoctrination courses in aircraft recognition—courses which would be much less efficient without the use of accurate scale models.

In other fields of model aviation, too, progress is continually being made. In the years immediately before the present war there was a great change in the model designing trend, making not only for more efficient and stronger models but also for better flight times and control. And in this time of war our model engineers have worked out still other design principles for the postwar modeler, which are already showing on some model planes.

The Nationals, Wakefield, Moffett, and other huge contests are no longer being held, as we have said. But after the peace has been signed they will be back again—and we have been promised by those who should know that where there were previously hundreds of contestants there will be thousands, and where there were thousands of fans there will be millions.

Balsa wood and rubber are almost impossible to obtain, and you are more than fortunate if you can find an engine. The modeler is going through a difficult period in trying to keep his hobby intact, and more power to him—to all of you—for these efforts.

CONTENTS

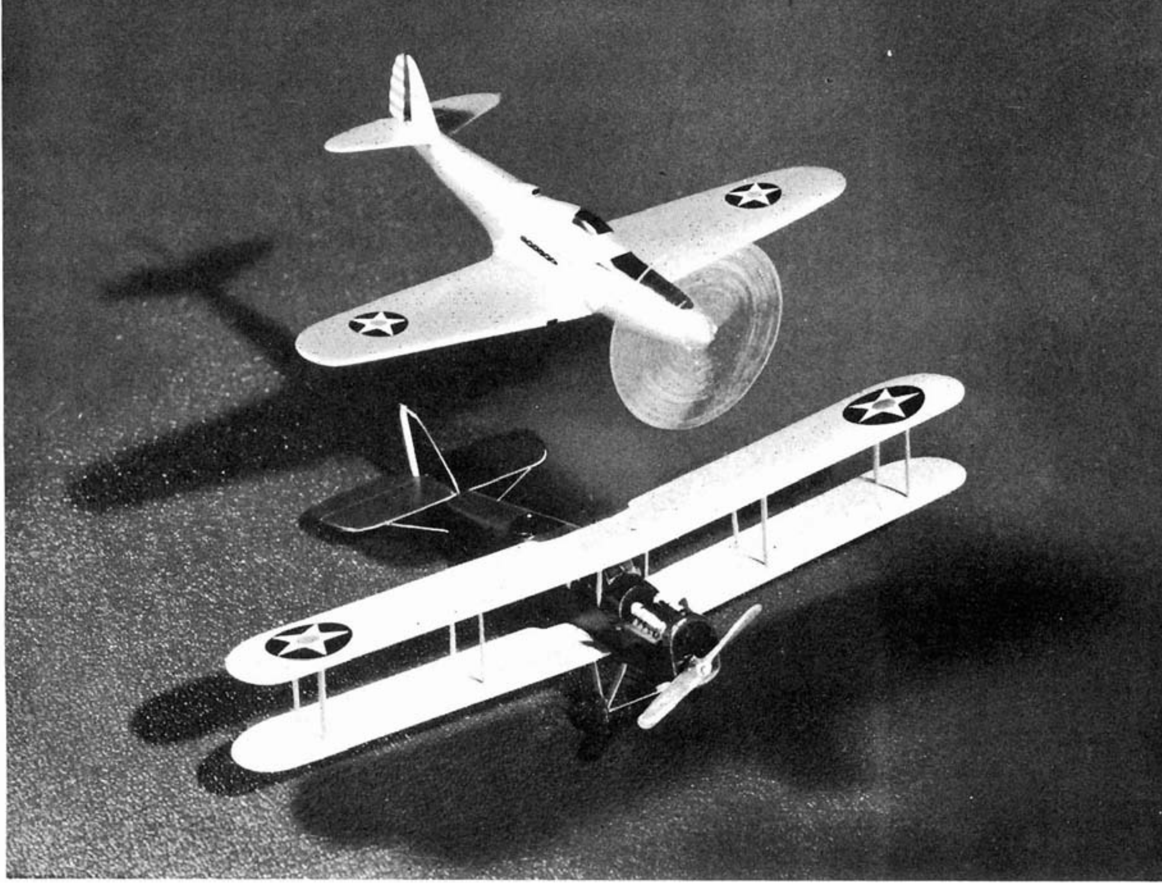
CHAPTER I

CONQUEST OF THE AIR

IN THE LAST ISSUE of *The Model Plane Annual* the history of model aeronautics was discussed in considerable detail, ending with the flights of the Wright brothers and formation of the New York Model Airplane Club. And because of the interest expressed in the data contained in that chapter, it has been decided to carry on with the early history, presenting material concerning man's actual conquest of the air.

Although this is not fundamentally model material, the photographs presented are of models from the nationally known collection of Eugene W. Kettering, who is now an employee of the General Motors Electro-Motive Division in LaGrange, Illinois. The models are all built to the same scale of four millimeters (about 5/32″) to the foot.

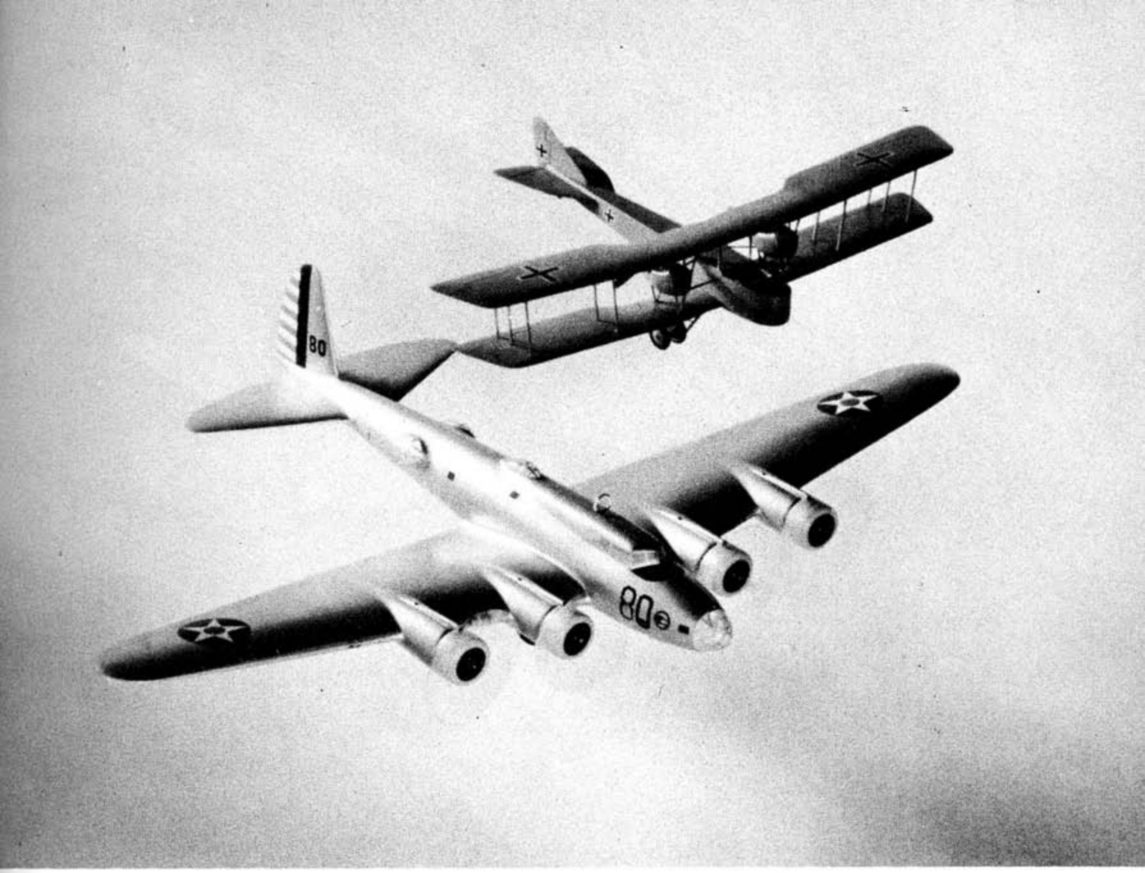
Toward the end of 1908 the value of the airplane as a weapon became obvious. How valuable, it was left for the first World War to show. Little was known of the forces affecting aircraft in motion, the laws regulating flow of air in their vicinity, the conditions required for balance and safety, the relation between the form and dimensions



In 1917 the DeHavilland DH-4, which had a top speed of only 126 m.p.h., was one of the most powerful warplanes turned out by American aircraft factories. Now it's Bell P-39 Airacobra instead, and improved versions of the latter are said to do much better than 400 m.p.h. at best operating altitude.

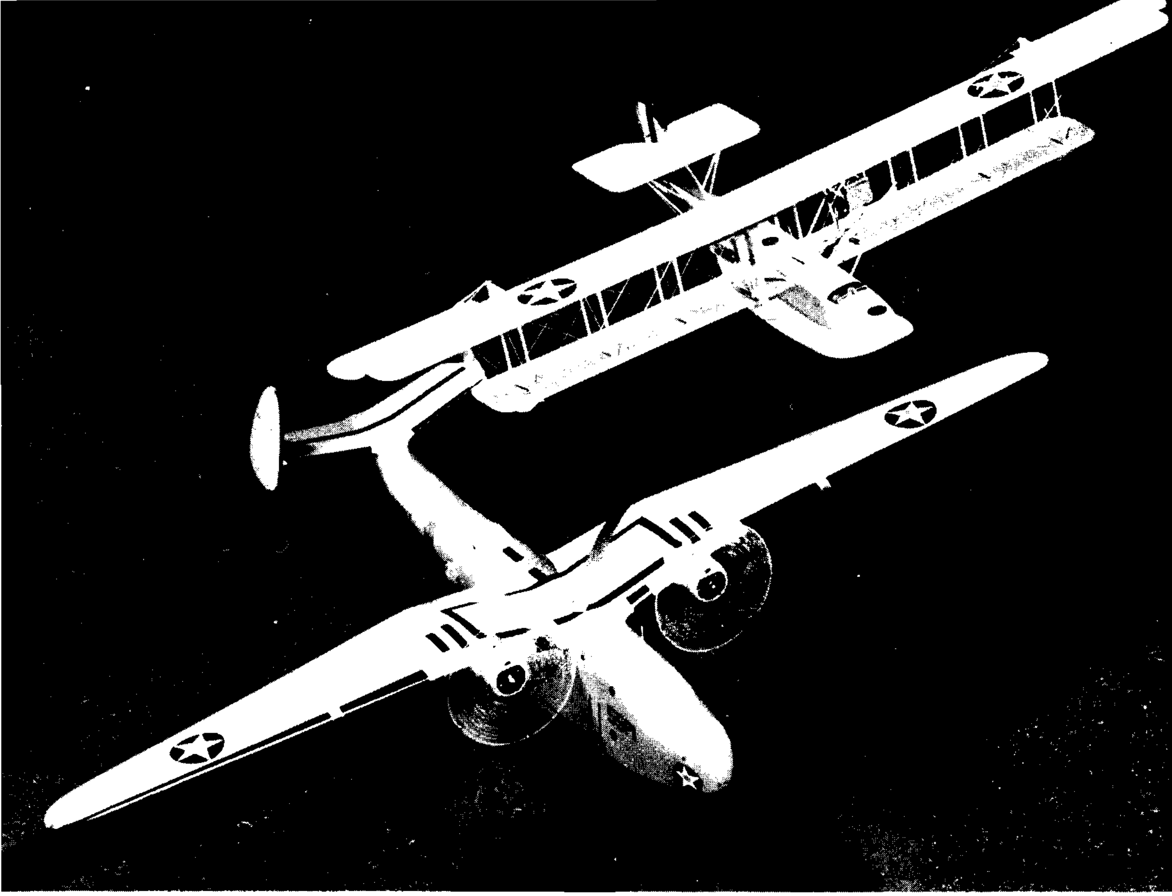
of the supporting planes and weight carried, or the mechanism necessary for the control of the machine in flight.

The internal combustion engine had made flight possible, but the way to combine efficiency and lightness was not clearly understood. The propeller brought problems of its own. Naval architects had made a study of the action of the screw in a ship, but it was not understood whether the same conditions and laws applied to aircraft.



The German Friedrickshafen bomber of 1916 weighed 6,960 pounds fully loaded and had a top speed of 75 m.p.h. Its current counterpart is the Boeing B-17 Flying Fortress, which has a loaded weight of about 60,000 pounds and a maximum speed of more than 300 m.p.h. The Fortress shown is the early B model.

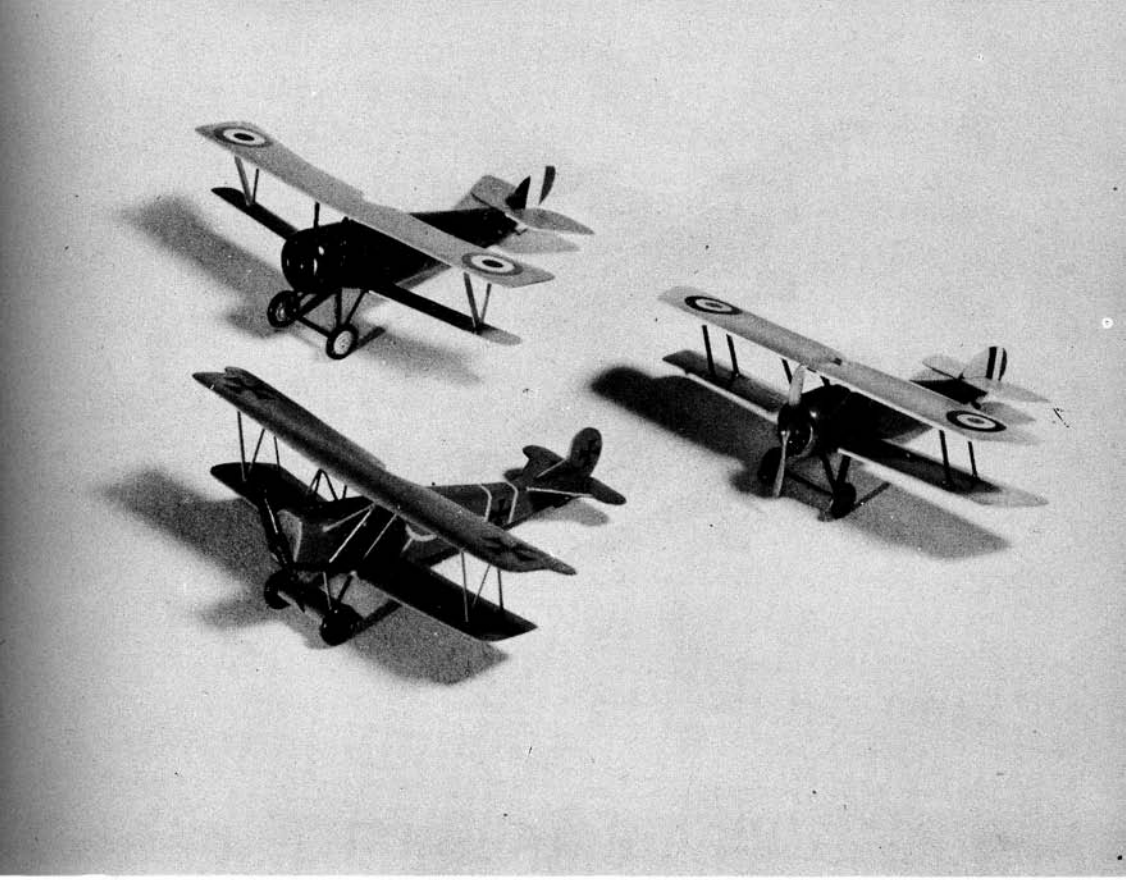
An aeronautical division was estaplished in the Office of the Chief Signal Officer of the Army on July 1, 1907, and in December of that year the War Department advertised for bids for construction of an airplane. The Wright brothers' machine was delivered at Fort Myer, Virginia, on August 28, 1908. It was a biplane with a wing span of about 40 feet and a wing area of some 500 square feet; the weight of the plane was about 800 pounds. The lateral control was effected by



The Curtiss Navy F-5-L flying boat of 1918 had two 330-h.p. engines and was able to cruise only comparatively short distances. The modern Martin PBM Mariner is far removed from that class, with two 2,000-h.p. engines and a cruising range of 3,200 miles at 10,000 feet with a 20-ton load.

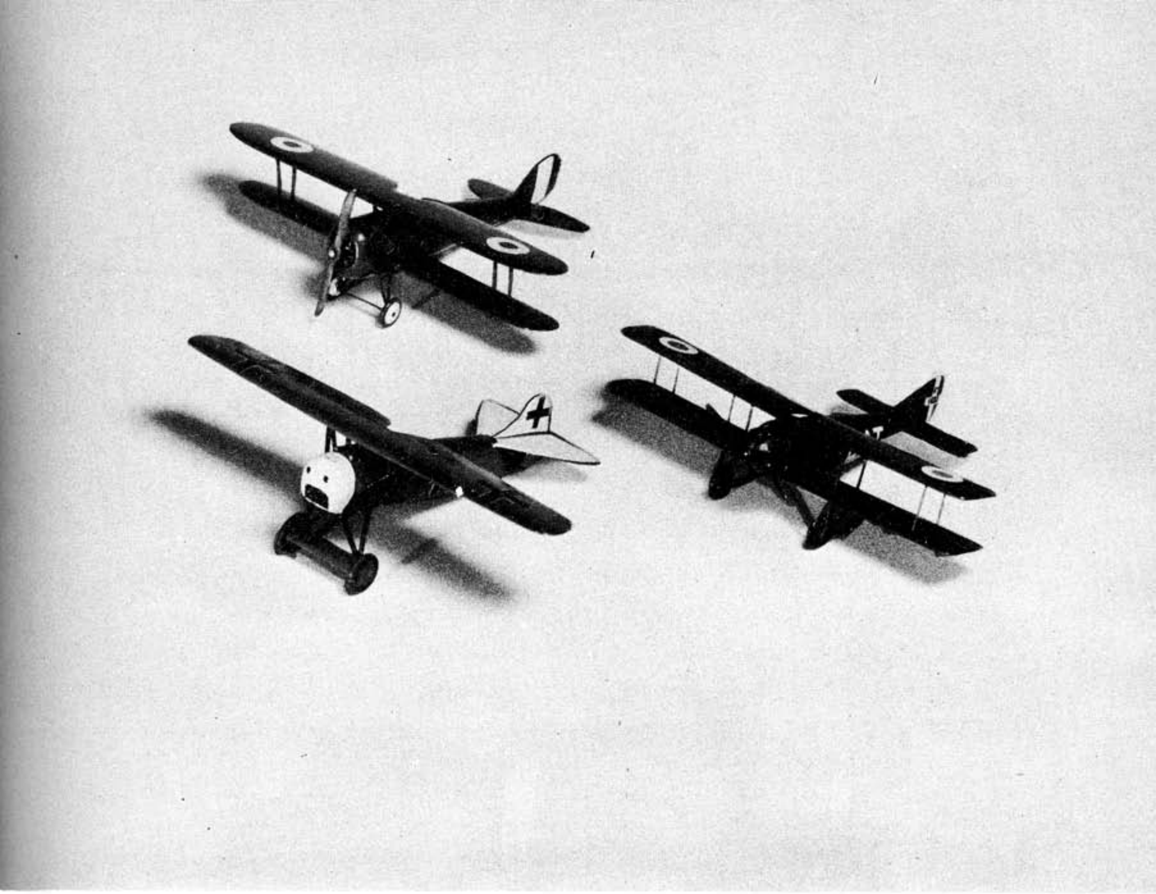
warping the wings, and the double elevators and rudders were supported in front of the wings by an outrigger. The undercarriage consisted of two runners, or skids, and the plane was launched from a monorail.

The requirement that the aircraft attain a speed of 36 miles per hour was exceeded by about five miles per hour. Other specifications,



Three first World War models from the famous Kettering collection. The ships are the Nieuport 27, Sopwith Camel, and Fokker D-7. Of the three, the D-7 was the fastest and generally most dangerous. When the war ended the Germans had just completed preliminary work on a new fighter which was more powerful and faster than anything seen up to that time.

namely, that it should be able to remain in the air for an hour with two occupants and that it should have a range of more than 125 miles, were also satisfied. Another requirement, specifying that the plane should lend itself to transportation in an Army wagon, was fulfilled as well. The Wrights received $25,000 for their airplane, plus a bonus of $5,000 for its having exceeded the required performance.

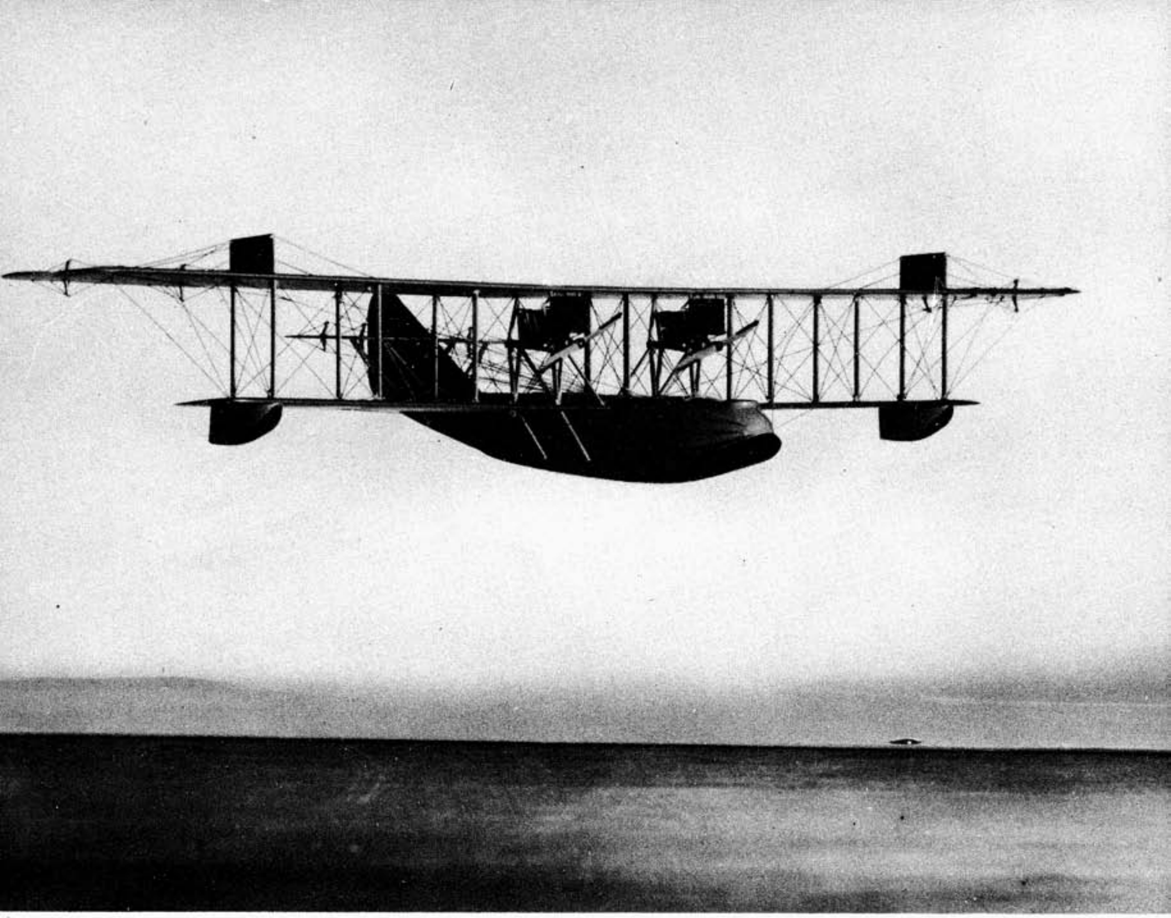


Two of these three ships are really prizes for Kettering, and many modelers would probably go to great lengths to obtain accurate three-view drawings of the Nieuport 28 (upper left) and British Bat Bantam (upper left). The lead ship, of course, is the Fokker D-8, which was good, though unpopular with German flyers because of its wing bracing.

favorable recommendation on August 2, 1909, and the Chief Signal Officer of the Army approved this recommendation on the same date.

On March 3, 1911, Congress for the first time specifically appropriated money for aviation—$125,000. By September 30, 1913, Army aviation had grown to 17 airplanes, with a personnel of 23 officers and 91 enlisted men.

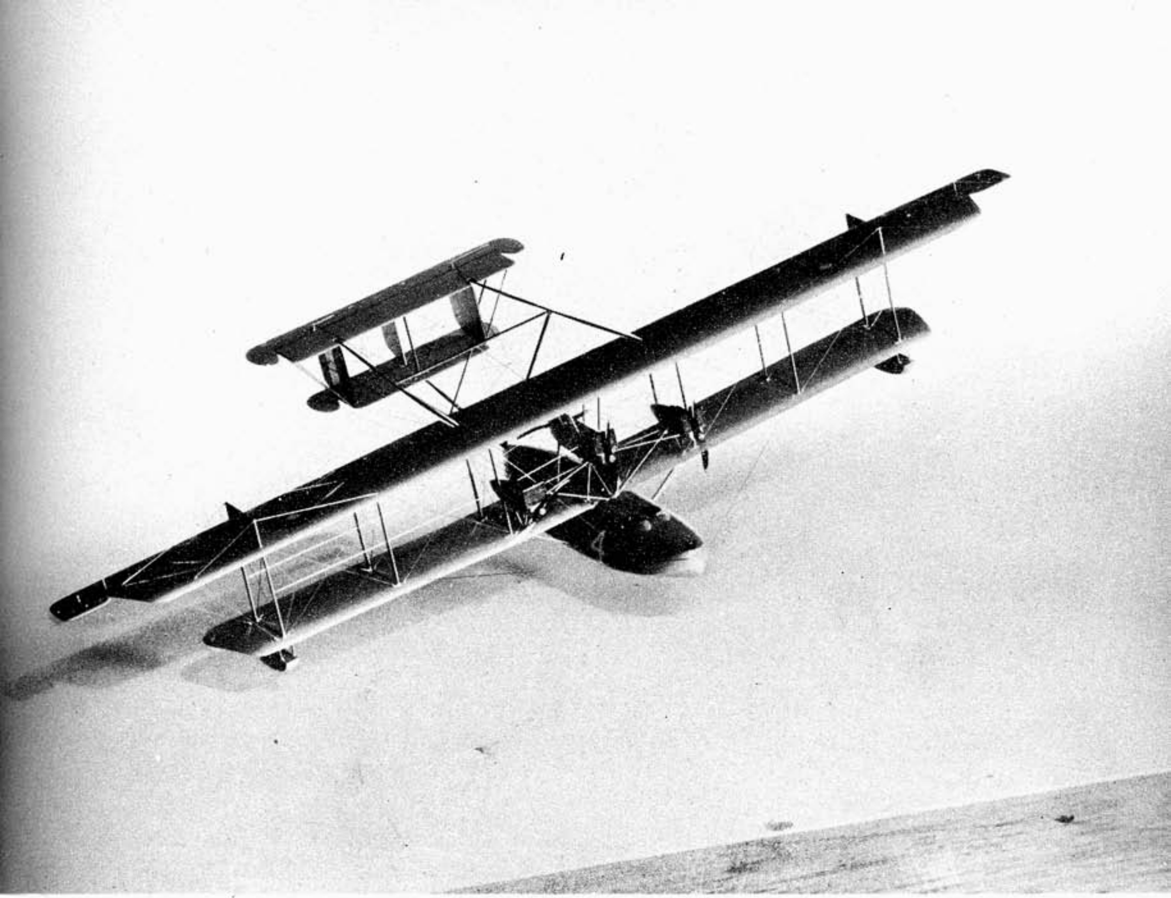
The Aviation Section, Signal Corps, of the Army was created on



Here is scale modeling at its best. This Curtiss F-5-L model is so detailed and realistic that it actually appears to be the real thing, preparing to land on a smooth stretch of water. Note the intricate interplane bracing. Even the radiators are grilled, and the leading edges of the propeller blades are painted in the accepted fashion.

July 18, 1914, with 60 officers and 260 enlisted men authorized, and on September 1 of that year the First Aero Squadron, comprising 16 officers, 77 enlisted men, and 8 airplanes, was organized at San Diego, California. This squadron, on March 15, 1916, began operations with the Punitive Expedition in Mexico.

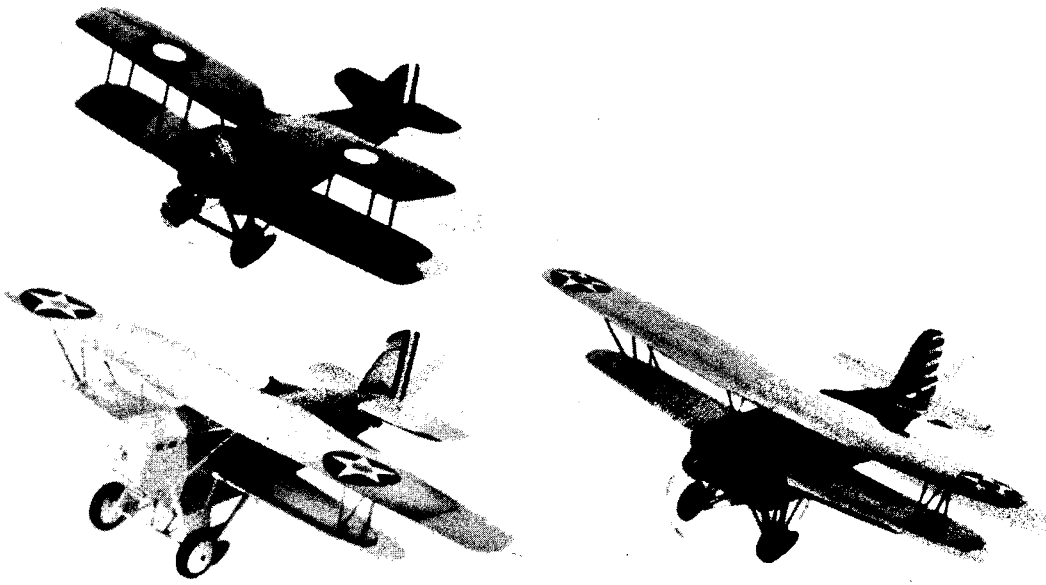
Due to the influence of the first World War, Congress passed the National Defense Act on June 3, 1916, which authorized for the



One of the most famous of them all, the Curtiss NC-4 of 1919 was the first airplane to fly the Atlantic from west to east. Powered with four liquid-cooled Liberty engines, it had a cruising speed of only 90 m.p.h.

Aviation Section, Signal Corps, a personnel strength of 148 officers and 4,000 enlisted men, and provided for an Officers' and Enlisted Reserve Corps. Upon the U. S. declaration of war with Germany, on April 6, 1917, Army aviation consisted of 65 officers (35 of whom were flyers), 1,087 enlisted men, and 55 airplanes, none of which aircraft mounted guns.

During the first eight years of its existence, 1909 to 1916, a total



Three more grand old ships. Of the companies represented by these early fighting planes, only Thomas-Morse is now out of business. The Thomas-Morse MB-3, which was tricky but liked by Army flyers, is at the upper left. Curtiss' P-1, of 1923, was the first of the famous Hawk series, which is still going strong. The plane at the apex is the Boeing FB-5, of 1926, which was the forerunner of the later P-12E and F4B-4.

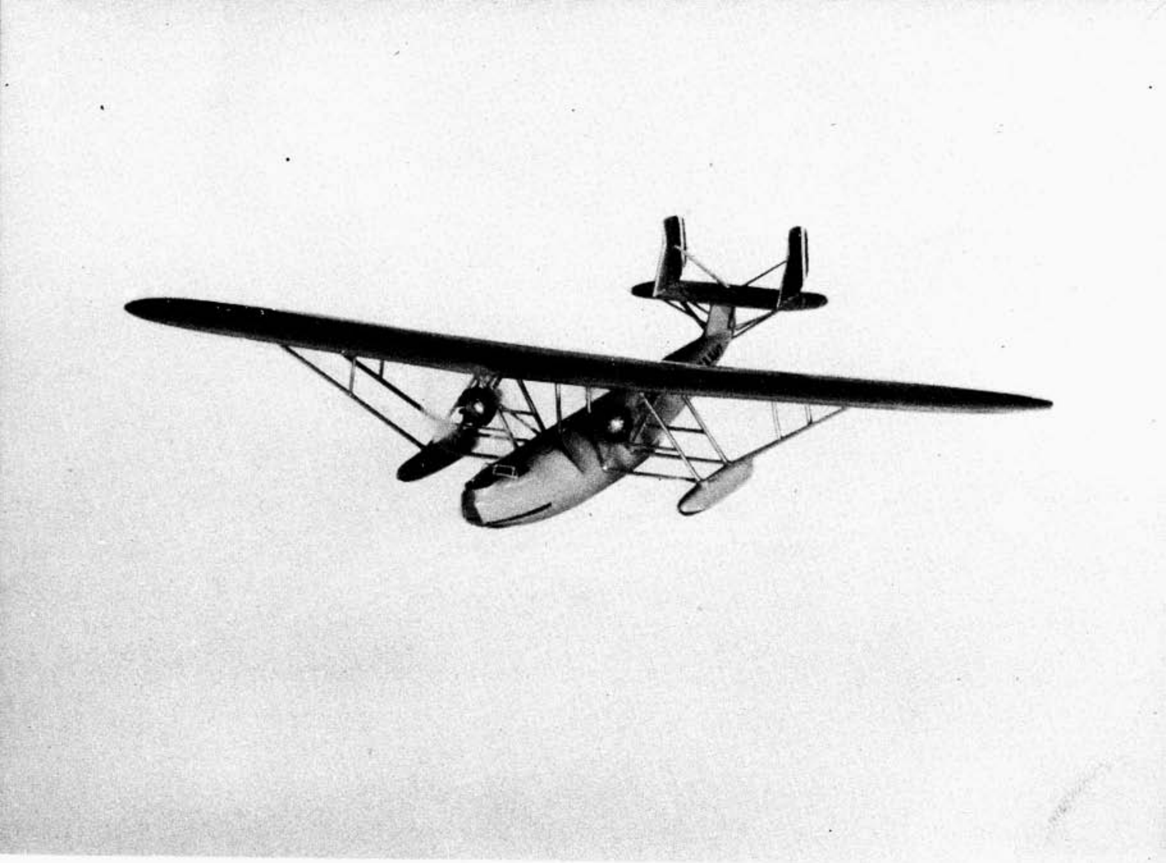
of only 142 airplanes had been delivered to the Army. As soon as we entered the war, the French presented us with a production program which was their idea of aviation quantity—16,500 modern airplanes to be delivered during the first half of 1918.

On July 24, 1917, Congress appropriated $640,000,000—the largest sum Congress had ever appropriated for a single purpose up to that time—to build up as large an air force as we could possibly get. In a

Another American plane which blazed history was the PM-9. It attempted the first U. S.-to-Honolulu flight. Forced down en route, the plane sailed the rest of the way on the surface, arriving safely at its destination. The PM-9 was powered by two liquid-cooled engines and had a top speed of 128 m.p.h.

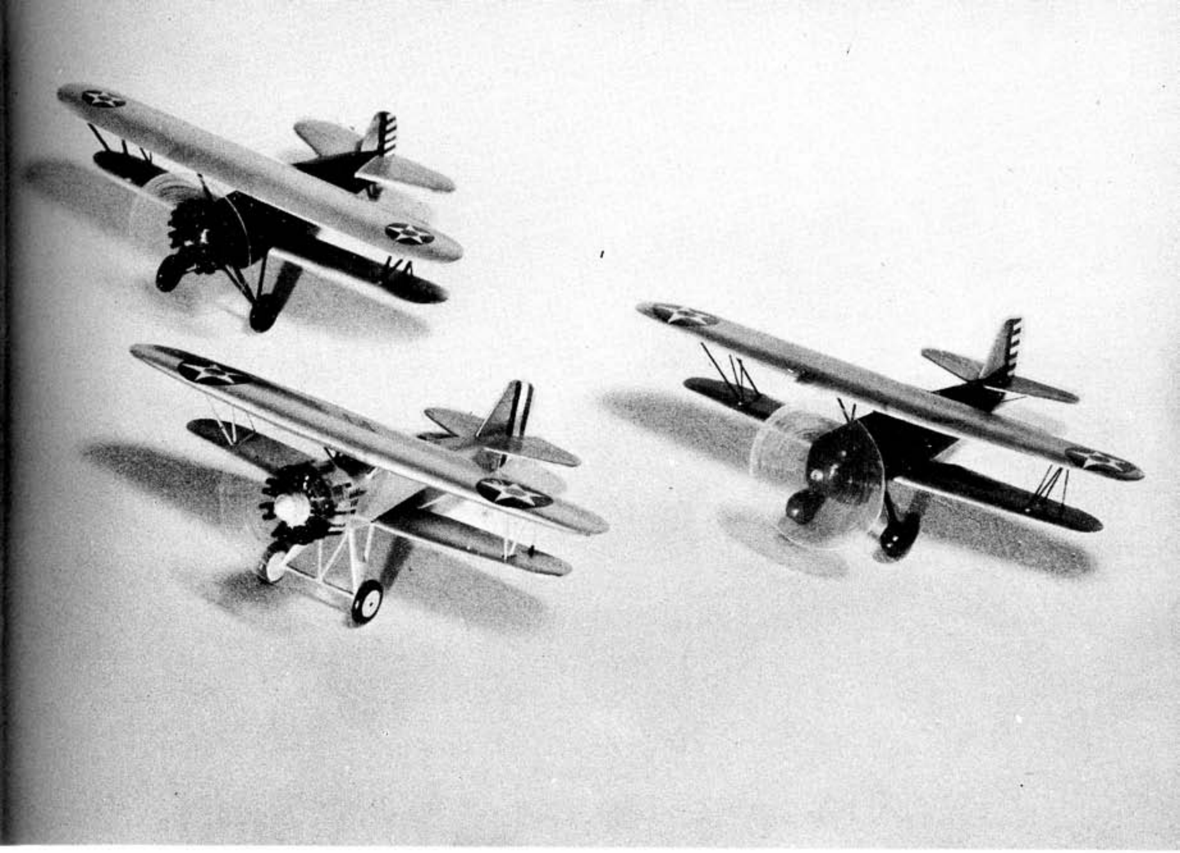
matter of weeks we established flying schools in various parts of the country, mostly in the South and West. Colleges and schools also pitched in and helped with this program. Almost 15,000 flying cadets received training in this country, and about 1,800 in Europe. By March, 1918, the Army aviation strength was 11,000 officers and 120,000 enlisted men.

For production as a day fighter and bomber, the United States



Consolidated's 1928 PY-1 was the first of the present type of Navy patrol-bombers. Fitted with two Pratt & Whitney Wasp engines of 425 h.p. each, the ship had a top speed of 118 m.p.h. Planes of similar type are still being used by the Navy for training purposes.

adopted the British-designed DeHavilland 4, and the American 450-horse power Liberty engine, our outstanding contribution, was installed. Contracts for 5,000 DeHavillands were let in September, 1917, and by the following May 155 of them had been delivered and 49 had been shipped overseas. At the signing of the Armistice, sufficient parts for 70 Handley-Page bombers had been made in this country and shipped to England; in addition, the United States was

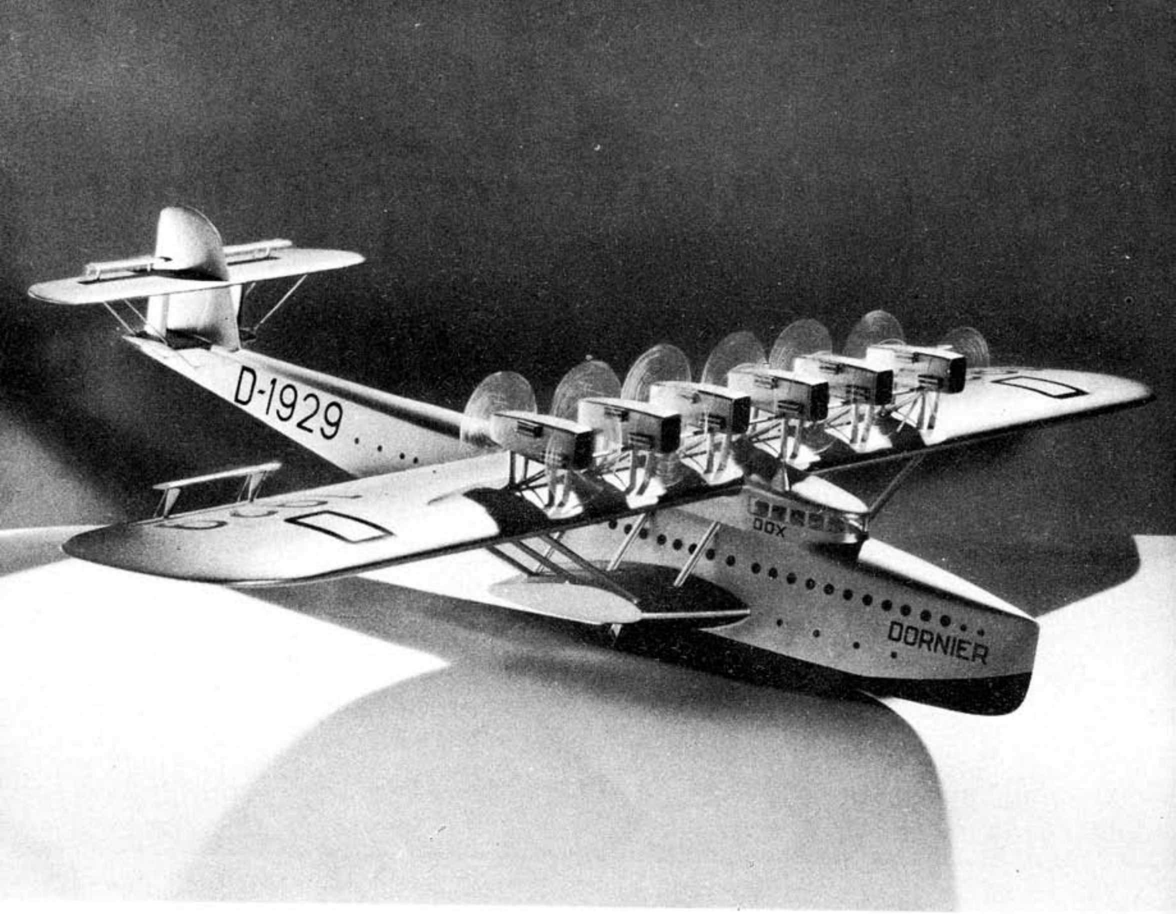


First World War design trends continued in vogue until many years after that war, and the only real change in military aircraft was that they were stronger, faster, and more powerful. Between 1926 and about 1937 our Army and Navy used planes of this type as fighters. From top to bottom, the ships are: Boeing P-12B, Curtiss F6C-4, and Curtiss P-6E. The P-6E was the most powerful of the three, with a 675-h.p. Curtiss Conqueror engine.

arranging with the Italian government for manufacture of Caproni bombers.

At the time of the Armistice, the U. S. had 757 pilots and 481 observers, with 740 planes and 77 balloons at the front; and 1,402 pilots, 769 airplanes, and 252 balloon observers had entered the zone of advance.

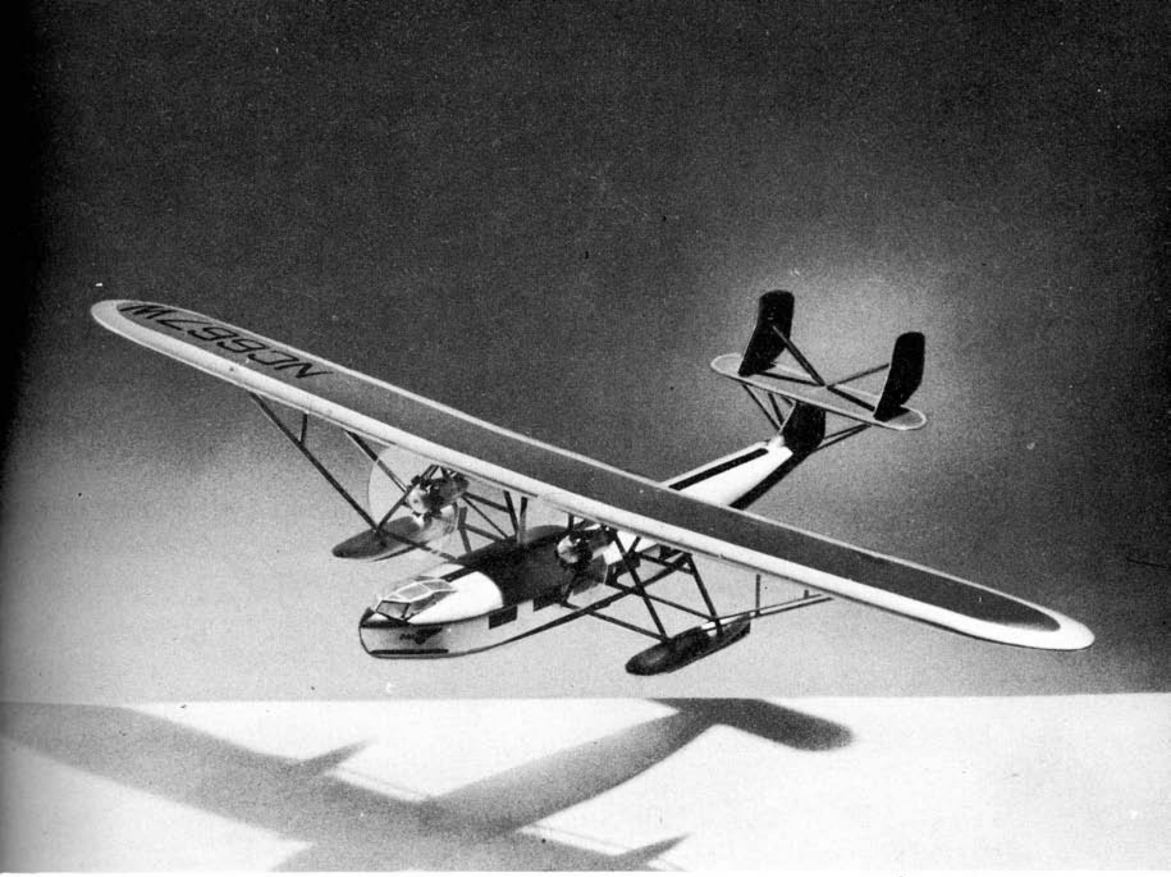
American aviators were credited with the destruction of 491 enemy



The German Dornier Do. X was an interesting experiment in large flying boats, but it proved unsuccessful because at that time there had been no powerful aircraft engines evolved. Consequently, twelve engines were fitted on the top of its massive wing—and still there was not enough power to make the plane fly as it should.

airplanes, of which 462 were accounted for by 63 aviators. The Army had 43 squadrons at the front at the Armistice, and of these less than 25 per cent were equipped with American-built aircraft.

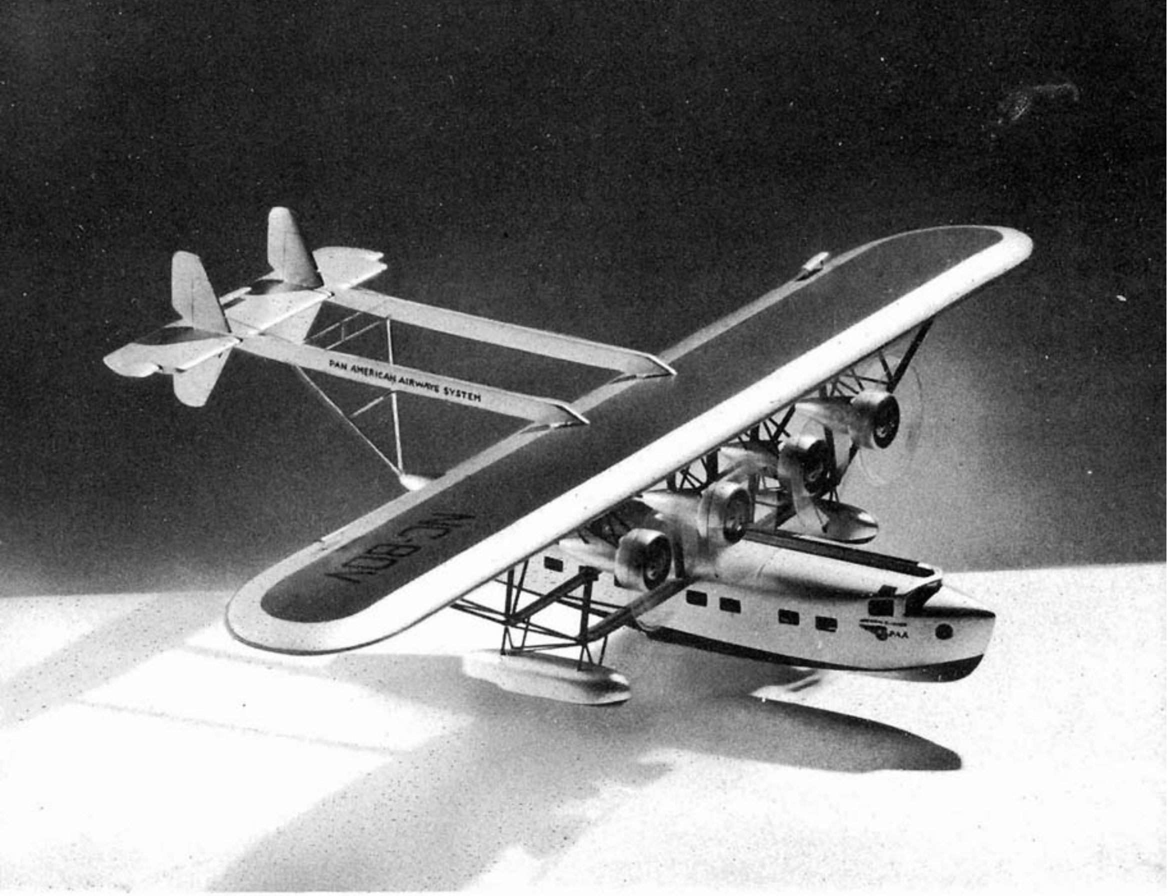
Aviation activities were divorced from the Signal Corps in May, 1918, and expanded into two new departments—the Bureau of Military Aeronautics and the Bureau of Aircraft Production. Upon the



While the Consolidated Commodore of 1929 proved more successful than the Dornier Do. X, it was comparatively slow; mounting two Pratt & Whitney Wasp engines of 575 h.p., it had a top speed of 128 m.p.h. Twenty passengers were accommodated.

termination of the war, these two departments were consolidated into the Air Service.

The end of the war found aviation manufacturers in the United States proceeding at full speed. Airplane contracts were terminated as rapidly as possible, but for several years it was necessary to utilize reconditioned wartime airplanes and engines. At this time, the person-



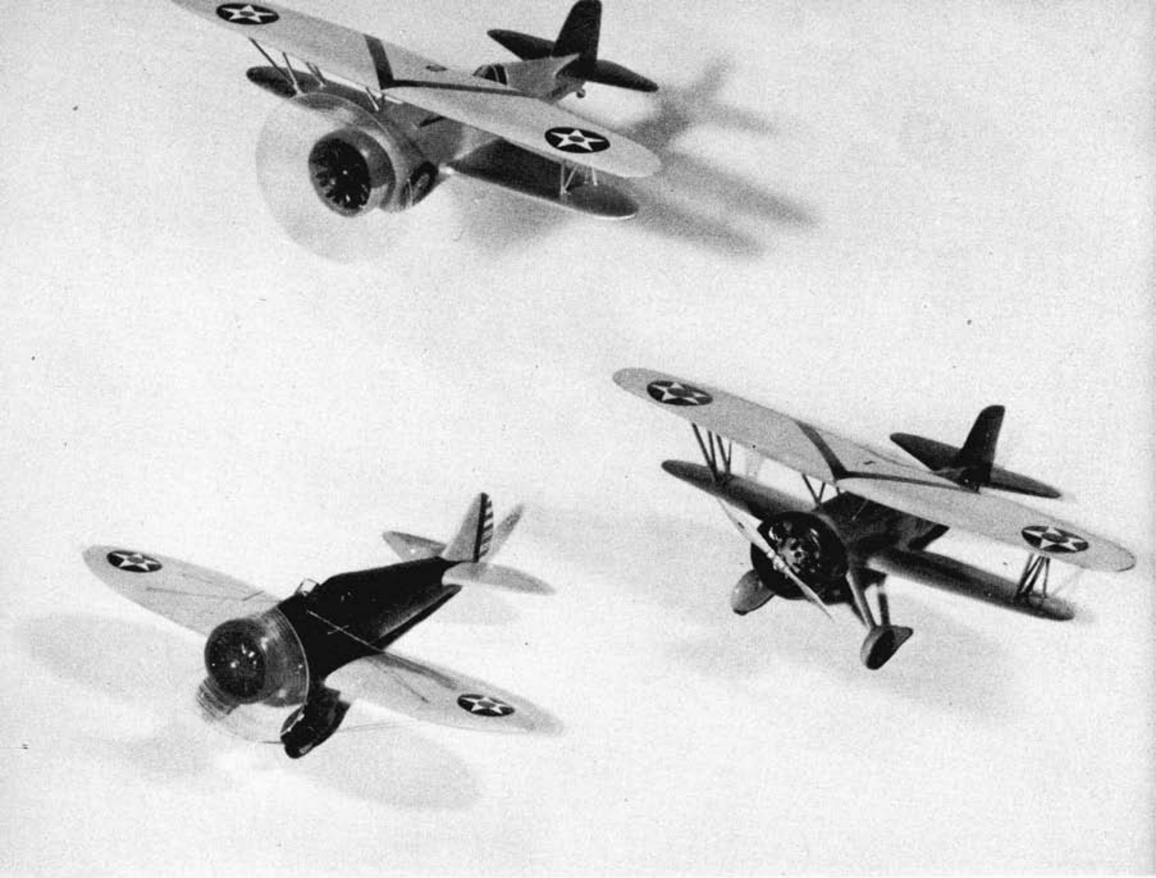
Sikorsky's 17-ton S-40 Clipper was used by Pan American Airways, and had a top speed of 130 m.p.h. and a cruising range of 935 miles. Built in 1931, the S-40 was many years ahead of its time. It was christened in Washington, D. C., by the wife of the President of the United States, Mrs. Herbert Hoover.

nel strength of the Air Service was 18,000 officers and 135,000 men. This strength shortly dwindled to 1,000 officers and 10,000 men.

In September, 1908, the U. S. Navy first took official cognizance of aviation during a demonstration by Orville Wright and his plane at Fort Myer, Virginia. It was on this occasion that Mr. Wright established a world's record for duration—remaining in the air one

The 1933 Sikorsky S-42 Clipper weighed 42,000 pounds loaded and carried 37 passengers 1,200 miles at 157 m.p.h. In its day the ship was a world-beater, and interior accommodations were more luxurious than anything that had been seen up to that time. Power was supplied by four air-cooled radial Pratt & Whitney engines of 750 h.p. each.

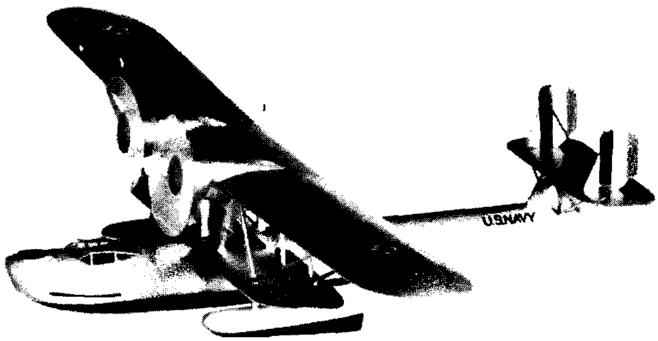
hour, two minutes, and fifteen seconds. The Navy observers, enthusiastic over this performance, immediately suggested that an airplane be equipped with pontoons to enable the craft's adaptability for naval use. This recommendation was not carried out for several years, however, and then not by the Wright brothers, who had declined to make an attempt in flying from the deck of a battleship.



In the 1930's American military fighters became still stronger and faster. The Boeing P-26A was the Army's first single-seat fighter monoplane, and the Curtiss BF2C-1 was the Navy's first plane with a retractable landing gear. The ship at the lower right, the Curtiss F11C-2 Goshawk, was one of the Navy's most popular planes. It had a top speed of 193 m.p.h.

This flight was accomplished in 1910 from a platform constructed on the bow of the U.S.S. *Birmingham* at Hampton Roads, Virginia, and in the presence of Army, Navy, and other government officials.

The potent value of aviation to the Navy was brought out more forcibly a month later when a test pilot landed on a platform built on the stern of the U.S.S. *Pennsylvania*, anchored in San Francisco



Consolidated developed its patrol planes still further in the P2Y-3 of 1934. It was similar to the PY-1 in general layout, and power was supplied by two 700-h.p. Wright Cyclone engines set in wing nacelles. This airplane had a range of 2,650 miles.

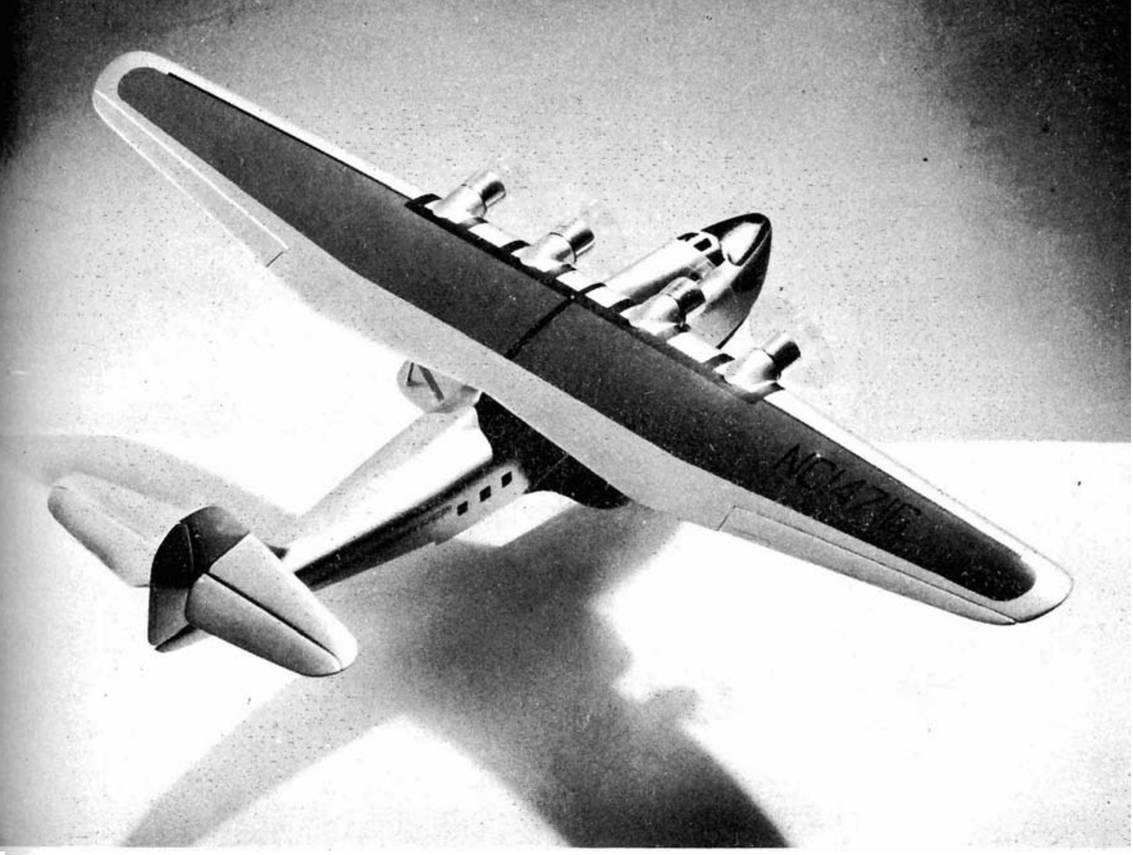
harbor, and a few minutes later took off from the platform and returned to his base.

Experiments on a hydroplane attachment, which had been going on for some time, were successfully demonstrated when Glenn Curtiss made a landing in the water alongside the U.S.S. *Pennsylvania* on February 17, 1911. The plane was hoisted aboard, then back into the

In 1935 Consolidated brought out its first flying boat with a patrol-bomber designation, the PBY-1. This plane had a range of 4,000 miles and a top speed of 206 m.p.h. at 10,400 feet. In this model there were no fixed wing floats; instead, they retracted in flight to form the tips of the wing.

water again; the take-off was made from the water and the plane was flown back to its base.

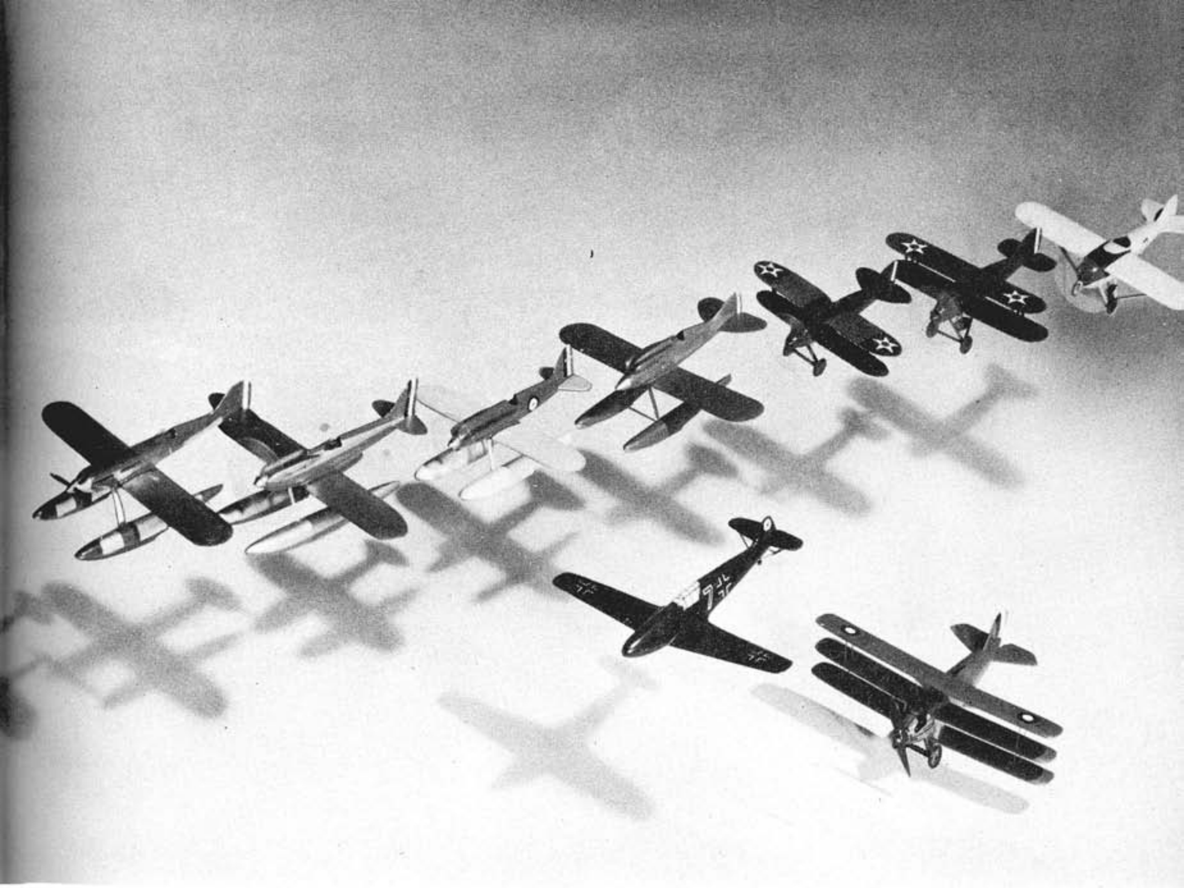
It is a matter of record that this flight, in addition to the convincing demonstrations made previously, greatly stimulated interest in naval aviation, both in this country and abroad, and, actually, our active participation in naval aviation may be said to date from this time.



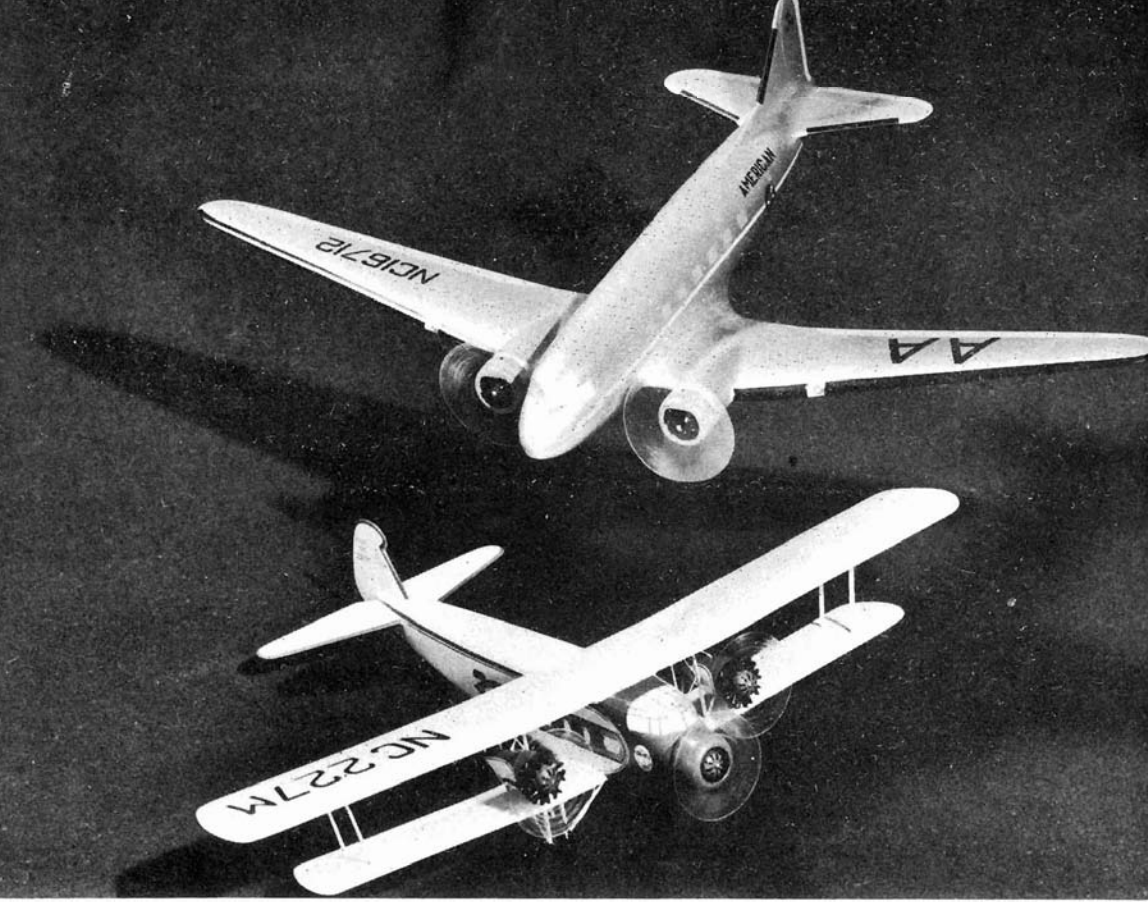
The first airliner to fly commercially from America to the Orient was the Martin China Clipper. Powered by four Pratt & Whitney Wasp engines of 800 h.p. each, the ship has a cruising range of 3,200 miles at 180 m.p.h. and can carry up to 52 passengers. Note the beautiful finish on this model.

As a result of the Navy's investigation into aviation, recommendations were made to Congress and an appropriation of $25,000 was included in the 1911-1912 Naval Appropriations Act.

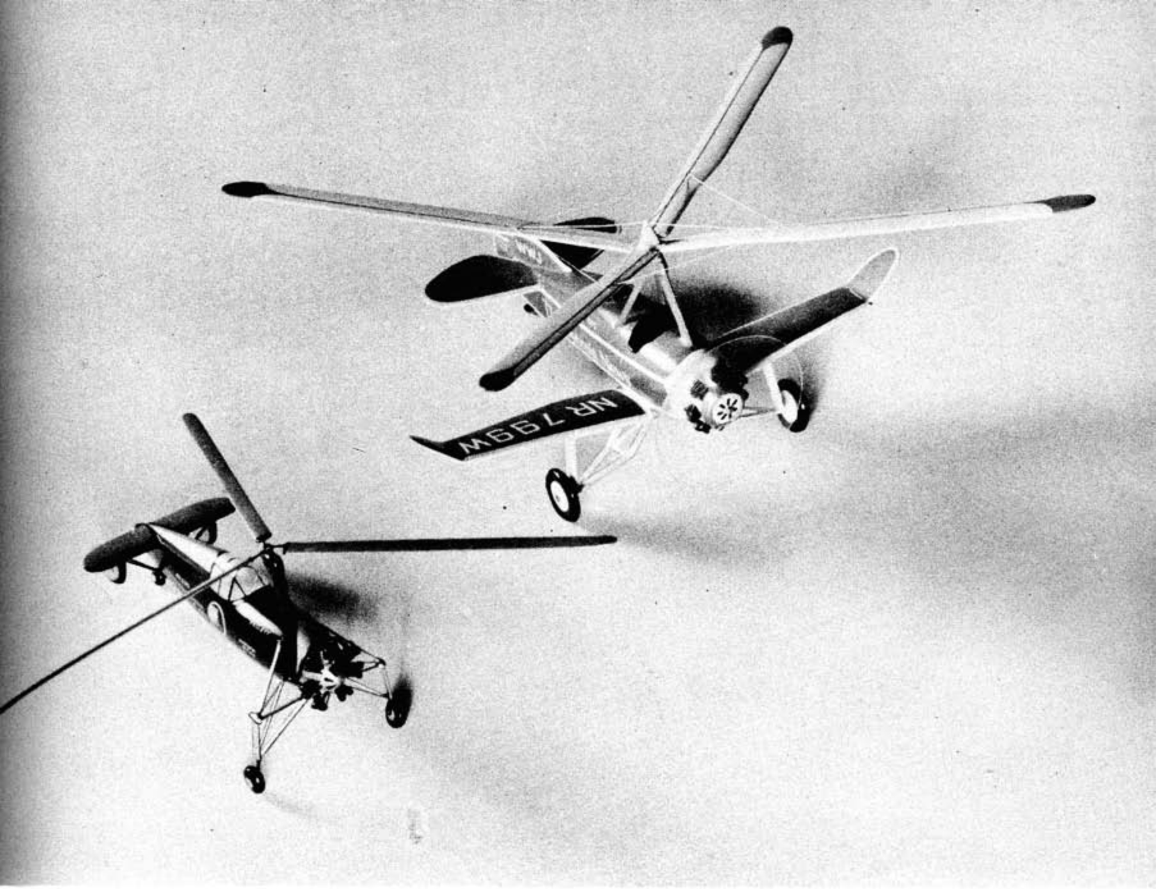
In the spring of 1911, Lieutenants John Rodgers and John H. Towers and Ensign V. D. Herbster were detailed to aviation duty and sent to the Curtiss and Wright camps for instruction.



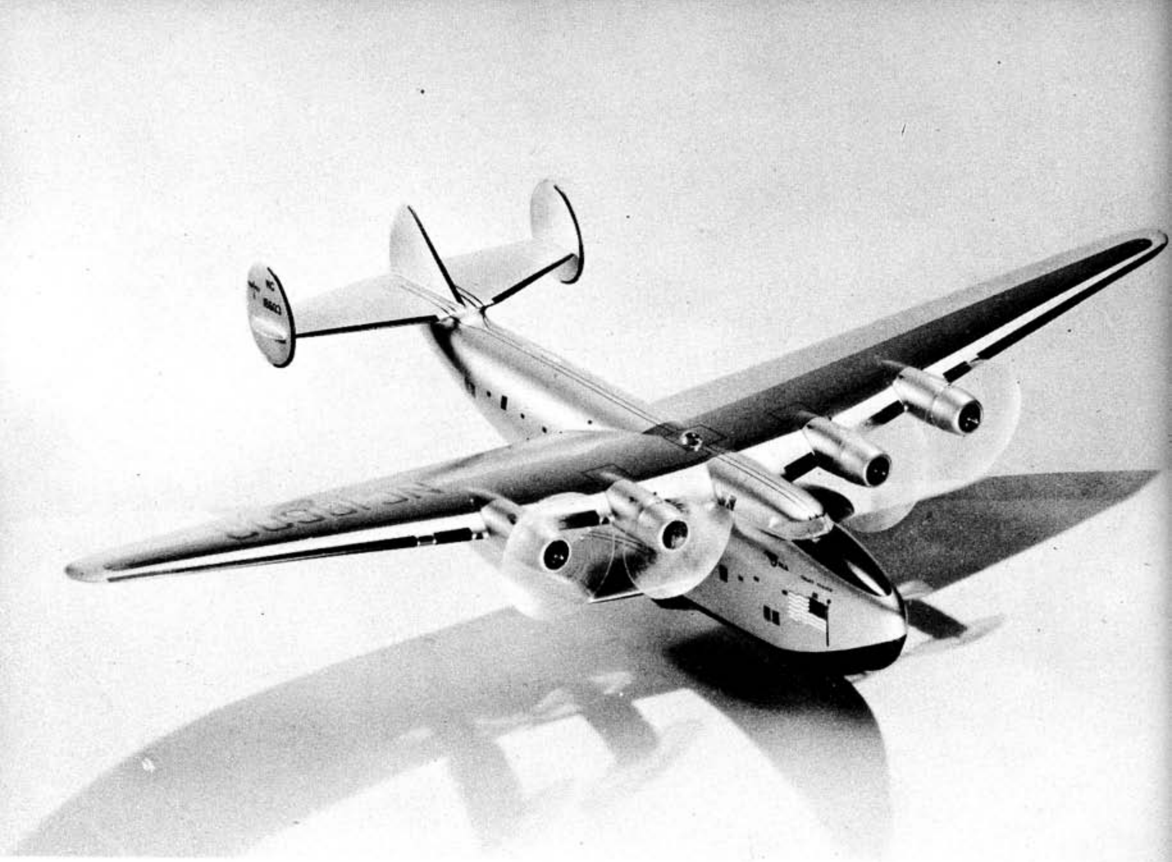
These nine models are of planes which held world speed records up to 1939. They are, from left to right: 1934 Italian Macchi, which did 440 m.p.h.; 1931 Vickers-Supermarine S-6B, 407 m.p.h.; 1928 Vickers-Supermarine, 319 m.p.h.; 1927 Italian Macchi, 318 m.p.h.; 1923 Curtiss R3C-1, 266 m.p.h.; 1922 Curtiss Racer, 228 m.p.h.; and the 1921 Nieuport Delage, 211 m.p.h. In the foreground are the 1939 German Messerschmitt Me. 109, 481 m.p.h., and the 1919 Curtiss Triplane, 165 m.p.h.



Passenger plane development is graphically portrayed by these two models. The tri-motored Boeing 80 biplane of 1929 was the last word in its day, but it is far eclipsed by the modern, speedy Douglas DC-3. The growth of commercial airlines has done more to advance aviation than is generally realized.



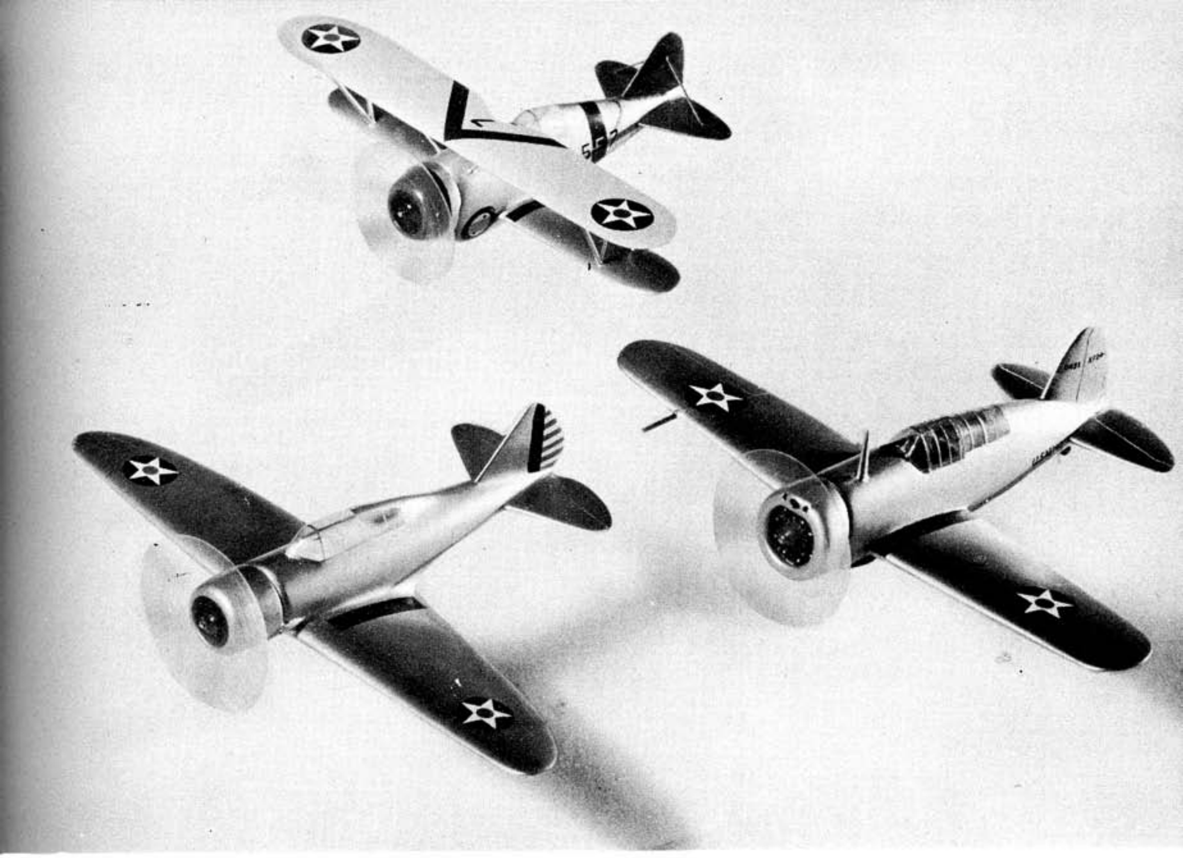
Because of the detail work required in the blades, autogiros are usually quite difficult to build accurately. Kettering, however, made these Kellett KD-1 and Pitcairn PCA-2 models so perfect that they appear almost capable of flying. Note landing gear detail and built-up engines.



One of the most modern flying boats is the Boeing Yankee Clipper, which regularly flies across the Atlantic. It carries 40 passengers and weighs 82,500 pounds fully loaded. The ship has a cruising range of 3,100 miles at 190 m.p.h.

One Wright and two Curtiss planes were purchased, a camp was set up at Greenbury Point at Annapolis, and the first naval aviation organization began operations.

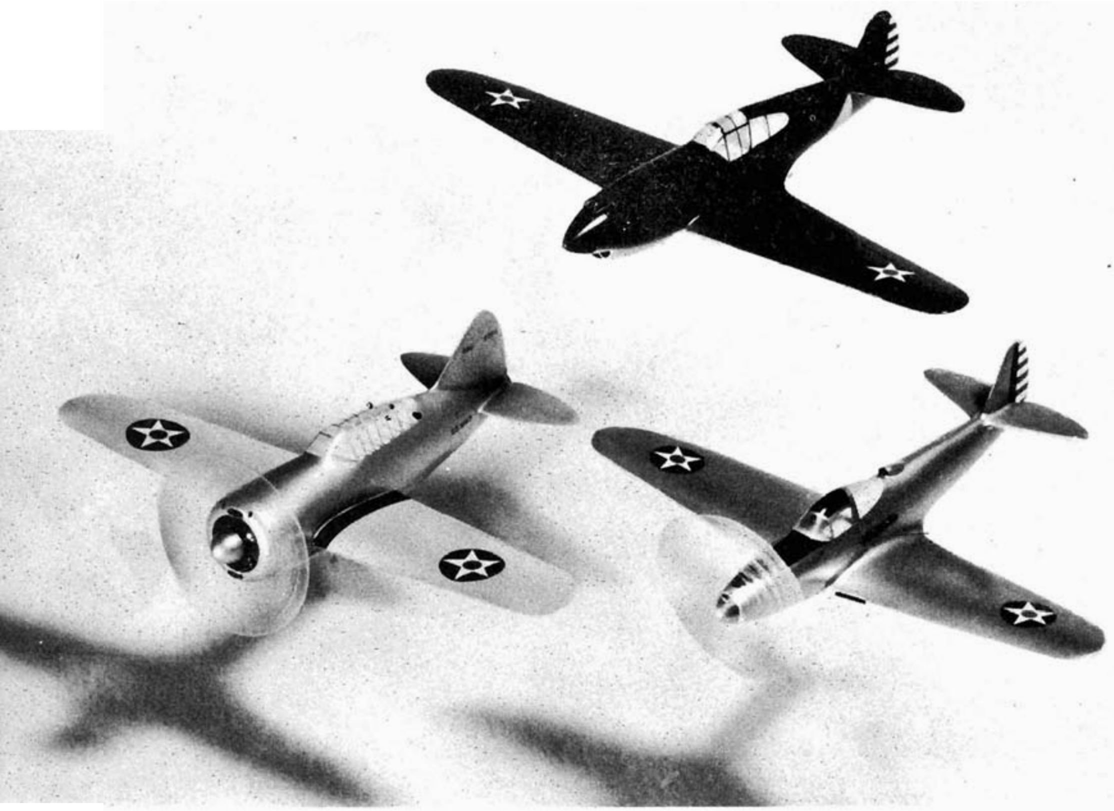
From 1911 on, naval aviation contributed much to the world history of aviation. Progress was rapid and many notable flights were made, one of which was a world's endurance record for seaplanes



In 1937 American fighting machines at last began to change drastically from former models. The Seversky P-35 (apex) was our first fighter incorporating both a cantilever wing and a retractable landing gear, and the Brewster F2A-1 (lower right) was the first low-wing monoplane fighter ordered for carrier duty with the Navy. The Grumman F2F-1 followed the biplane principle, but it had a top speed of more than 230 m.p.h. Grumman biplane fighters continued to be popular until about 1939.

established by Lieutenant Towers when he remained in the air for six hours and ten minutes.

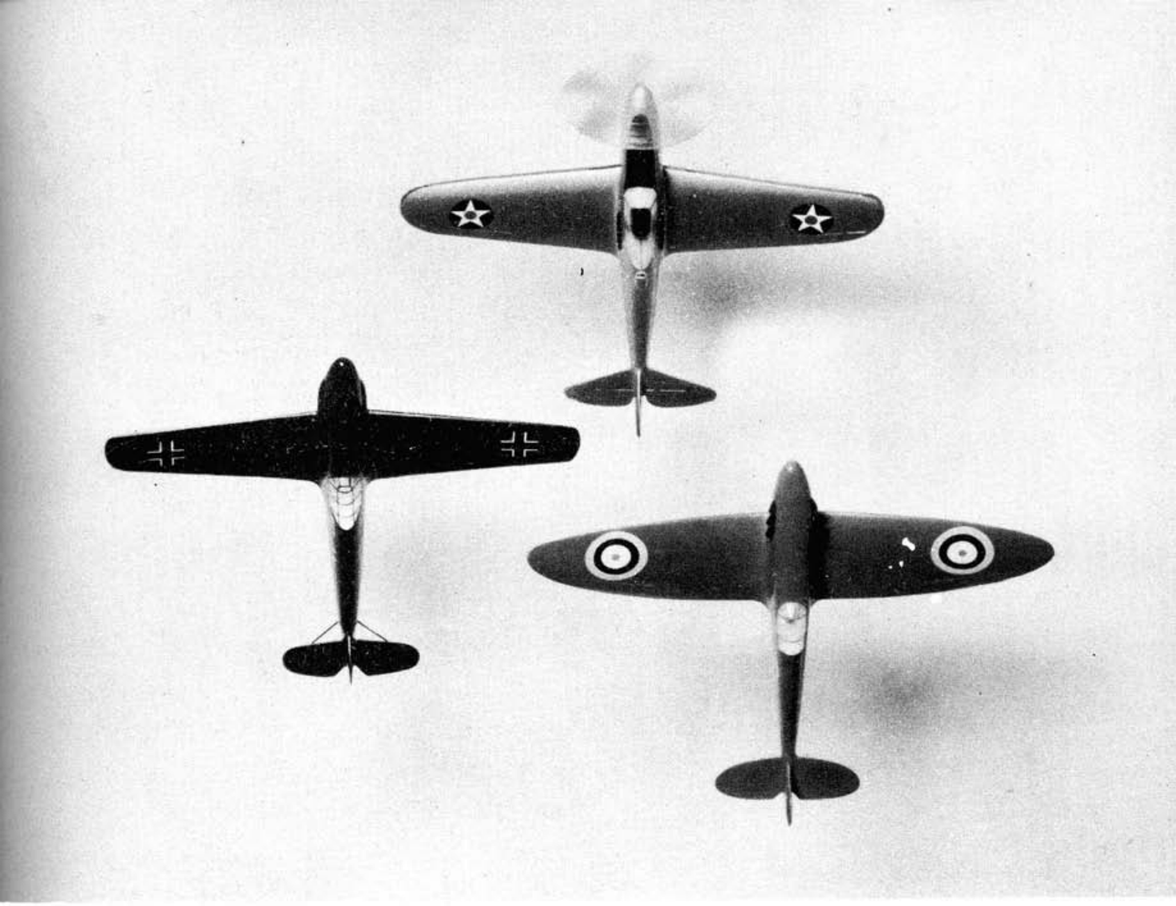
In 1915, the aviation detachment operated as a unit of the Fleet. Two planes with complete equipment were sent aboard the U.S.S. *Mississippi*, which was ordered to Vera Cruz, and another attached to the U.S.S. *Birmingham*, which was sent to Tampico, all three



After 1937 the biplane was all but dead as a military fighter. In quick succession the Curtiss P-40 (upper right), Bell P-39 (lower right), and Brewster F2A-2 were developed. Speeds, too, jumped from less than 300 m.p.h. to much in excess of that figure. Moreover, every plane had a cantilever wing and retractable landing gear.

planes being used in connection with the occupation of Vera Cruz. The scouting flight over the trenches in and around the city of Vera Cruz marked the first instance of a military plane of the United States being operated in the face of, and actually struck by, hostile fire.

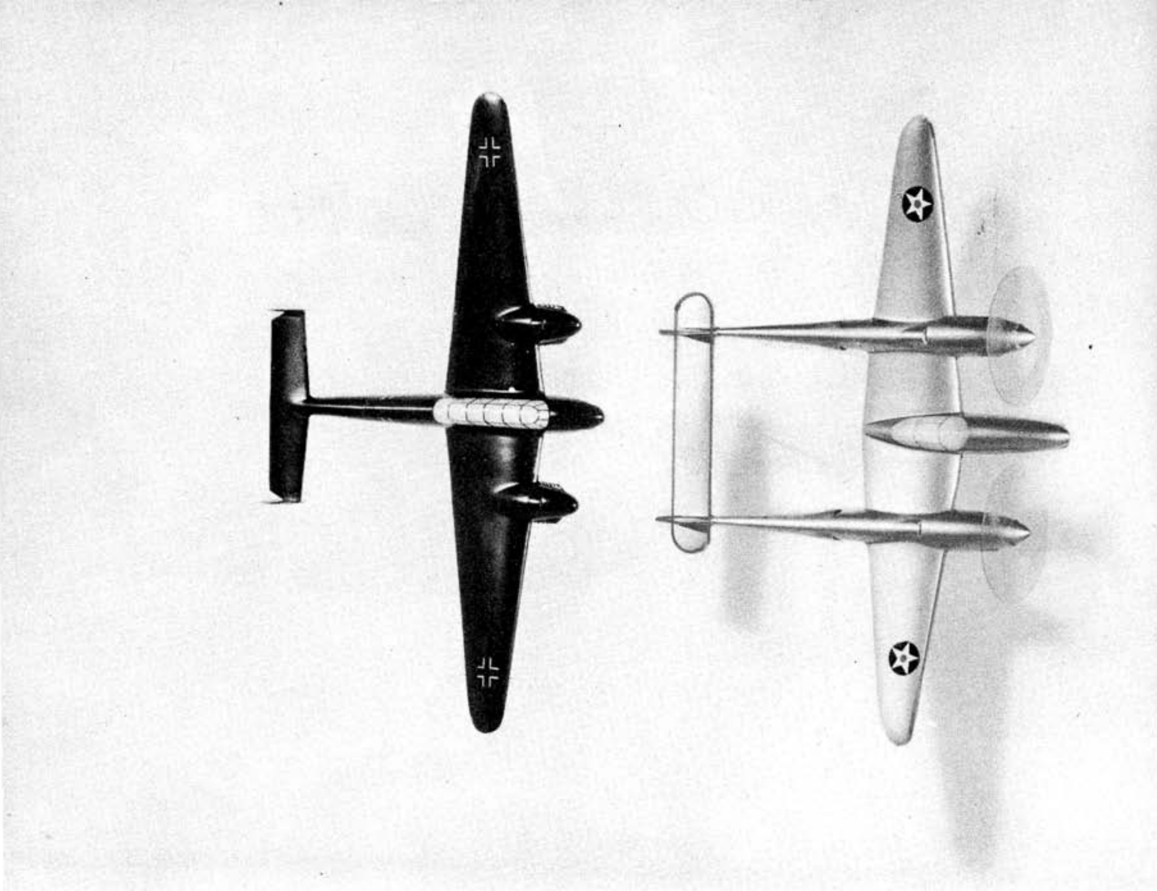
Through these years, the aeronautical engineering department set up by the Navy had been conducting experiments on types of floats



Single-engine fighters of three countries for comparison. Upper left is the Supermarine Spitfire I, which mounts eight machine guns; upper right is the Messerschmitt Me. 109E, which has two machine guns and two cannon; and at point is the Bell P-39 Airacobra, which mounts six machine guns and one cannon.

and pontoons, wing types, and dual control, having in view the possibility of building a plane capable of making a trans-Atlantic flight. Such a plane was designed and actual construction started on a twin-engine flying boat, the "America." The outbreak of the first World War put an end to the project.

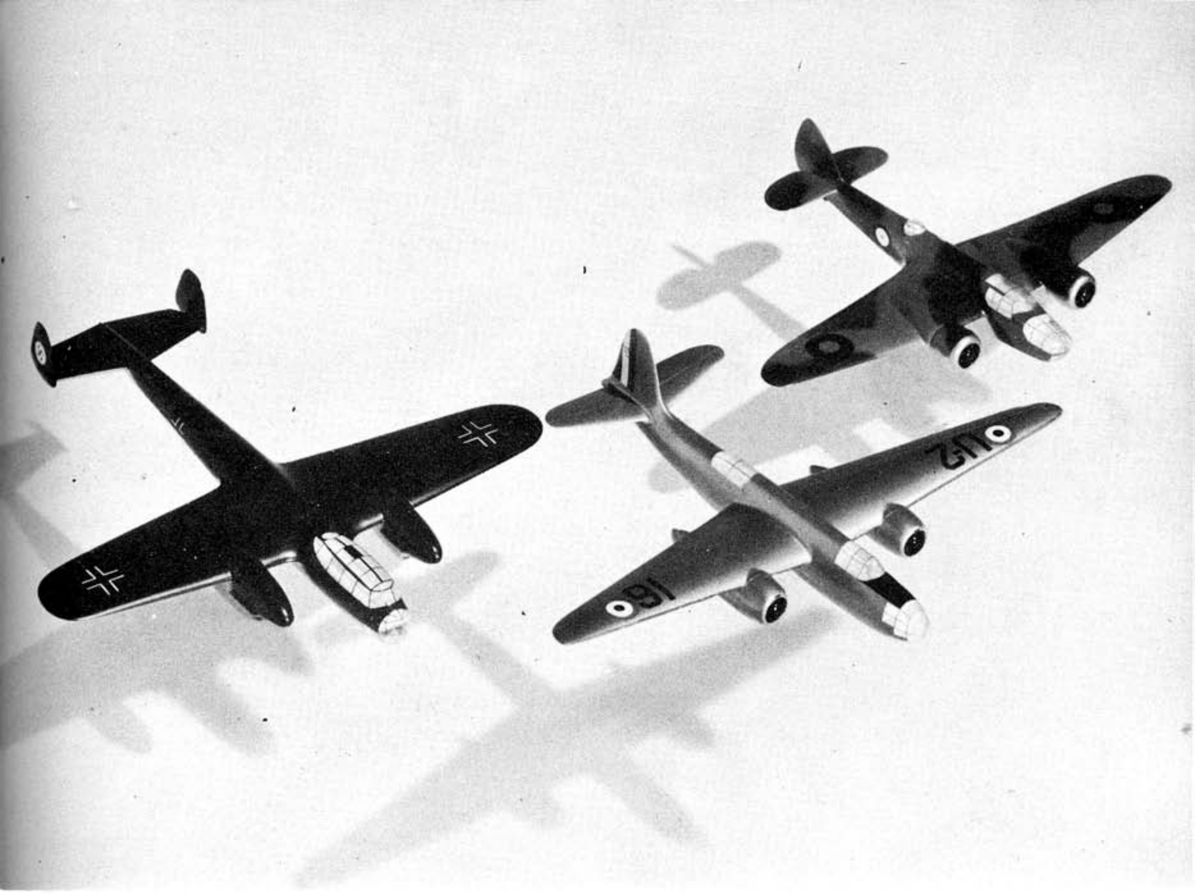
While the entire Navy was faced with the problem of expansion



Top views of the Lockheed P-38 Lightning and Messerschmitt Me. 110. Somewhat similar in size and weight, the P-38 is a single-seater and the Me. 110 has accommodations for a crew of two. Although the Lightning has continued its career with only minor changes, alterations in the Messerschmitt have been drastic, later models having little similarity to the original.

in 1917 at the declaration of war, the flying branch was comparatively new and quantity production of airplanes was practically unknown.

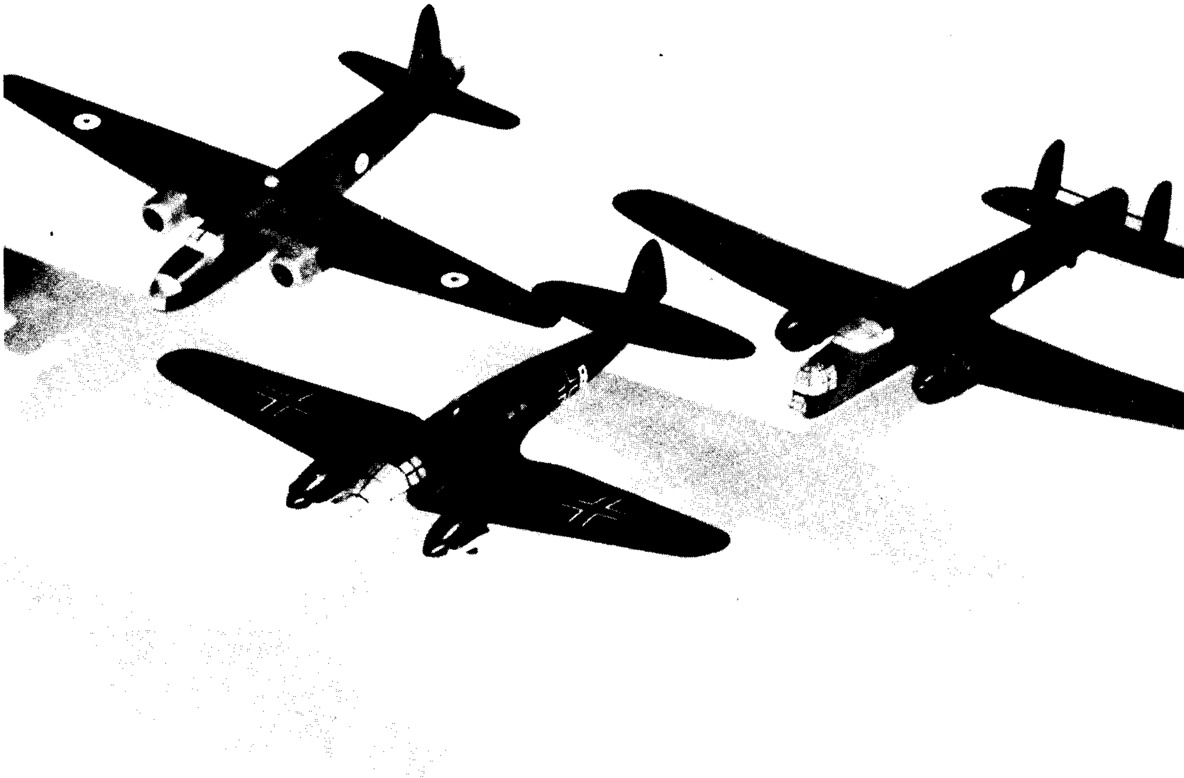
Because of limited facilities, and the fact that the Navy required fewer planes, the aircraft manufacturers filled Army contracts first. In order to ensure naval requirements being met, it was decided that a naval aircraft factory be built as soon as possible. Ground was broken on August 6, 1917; machinery was installed in October; and a factory,



Three warring light bombers. Built for similar purposes, the German Dornier Do. 215, British Bristol Blenheim, and American-built Havoc have little in common in design, construction, and performance. The Havoc has proved so successful that it has also been produced for the Army Air Forces as a fighter, called P-70.

400 feet square, stood entirely completed on November 28—just 110 days from the time first ground was broken. Shortly after the completion of the main factory, the aviation program of the Navy was quadrupled; additional space and machinery were required, and several additions covering four or five times that of the original plant were completed.

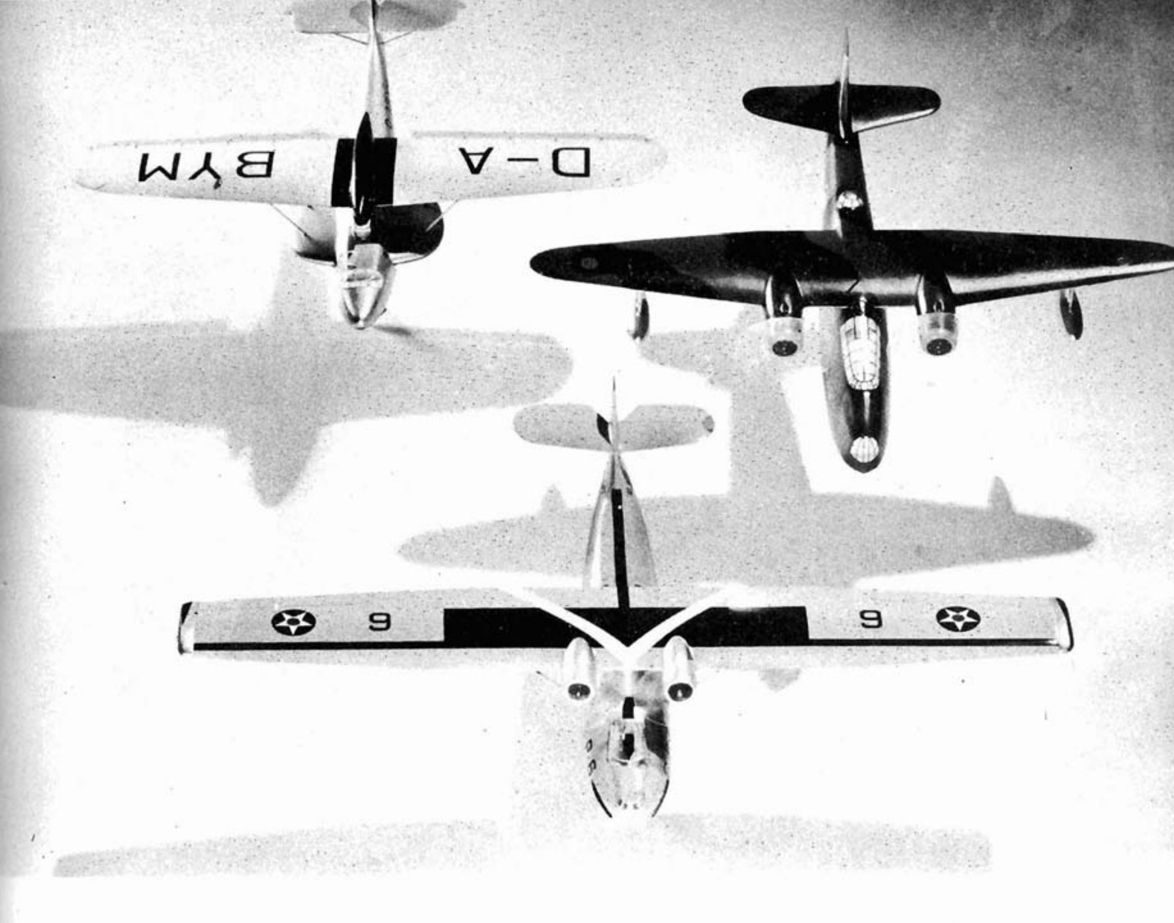
A few months later, 183 twin-engined flying boats had been de-



Early heavy bombers of the second World War. Though no longer in large-scale service, the Vickers Wellington, Armstrong-Whitworth Whitley, and Heinkel He. 111K were the mainstay heavies of the RAF and Luftwaffe until about 1941. The Whitley is now out for combat purposes, and the Wellington and He. 111K are used only for special work.

livered. By the time the Armistice was signed, many had been sent abroad.

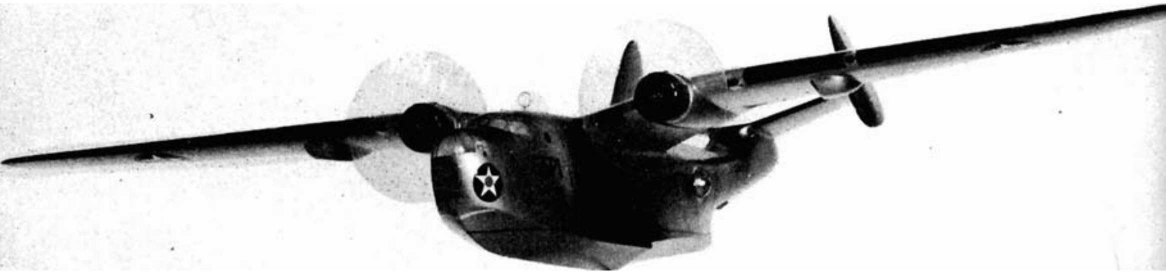
On the date the United States entered the first World War, the Navy had only one air station, located at Pensacola, Florida, and a total of 38 officers and 163 enlisted men. On November 11, 1918, there were 21 schools and stations in operation in the United States



American, British, and German patrol-bombers. The Consolidated PBY-5 Catalina has proved itself to be one of the greatest workhorses of the war, and reports from the war zones state that it has even doubled as a dive-bomber. Britain's Saro Lerwick at its inception was called one of the greatest flying boats, but for some reason the ship was never put into production. Dornier's Do. 18K, like the Catalina, has also proved dependable. Before the war it was used mostly for carrying mail.

and 2,835 officers and 30,683 enlisted men were attached to the aviation branch. In addition to this number, 3,881 student officers were undergoing aviation training. The Navy sent overseas during the war 1,237 officers and 16,287 enlisted men.

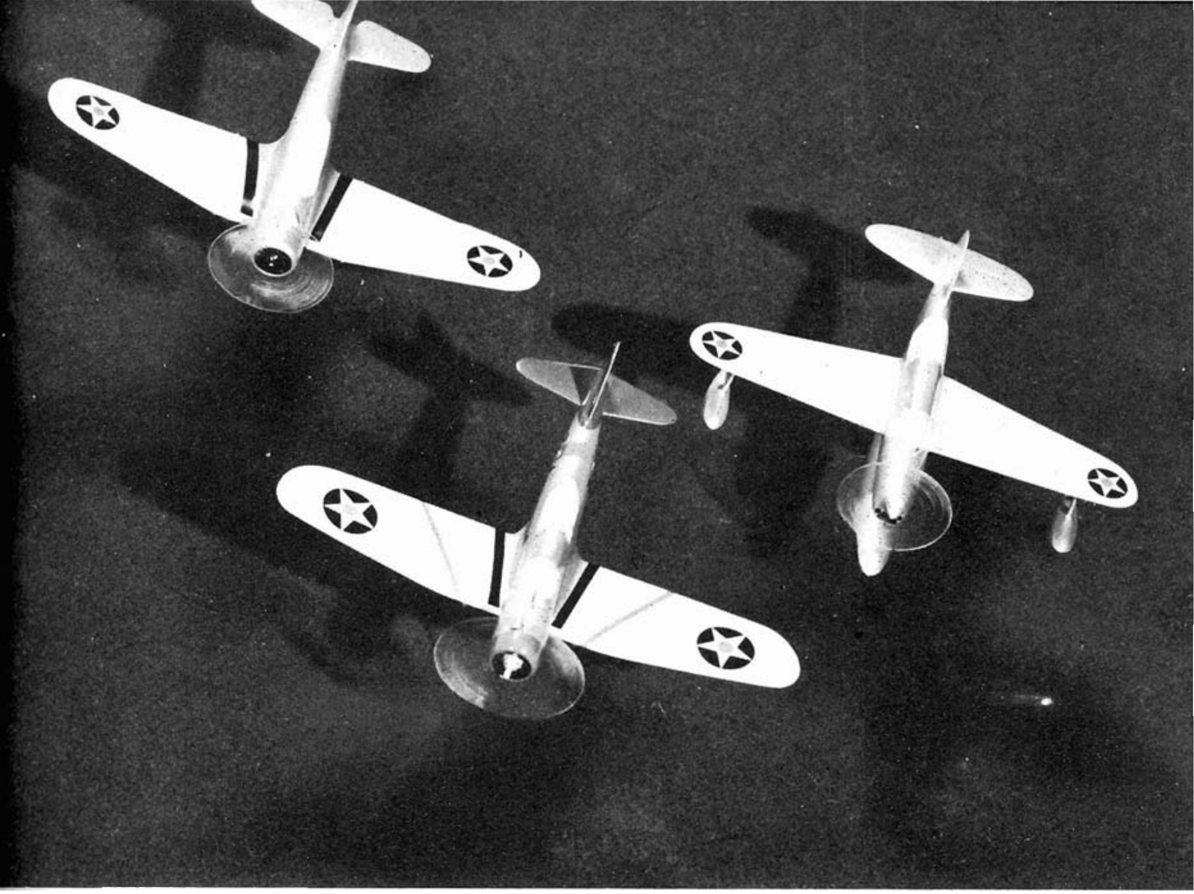
A total of 22 aviation bases were established abroad and several others were under construction during the war. Twelve of these were



Martin's PBM Mariner is one of the largest, fastest, and most efficient flying boats in the world. Carrying a normal crew of seven, it weighs about 20 tons and has a range of some 3,000 miles. This replica was made so painstakingly that even landing lights and air intakes are discernible.

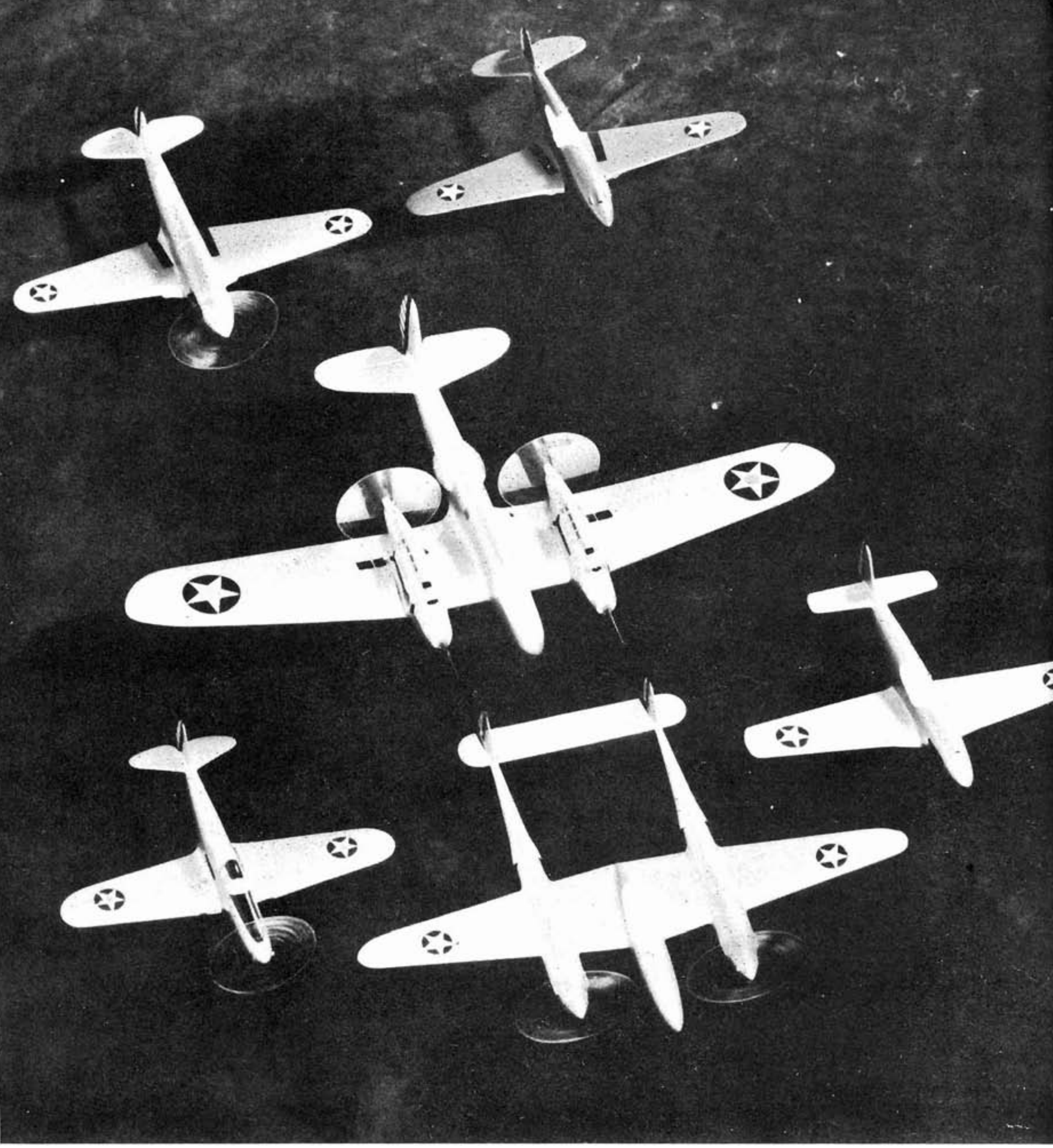
in operation in France and seven stations were established in the British Isles. Naval patrol planes flew a total of more than 40,000 miles from bases in England. In addition, three air stations in Italy were taken over by the U. S. Navy, one of them being a training base.

The U. S. Marines took the first step toward the inception of



Navy planes in review. The Douglas TBD Devastator (upper left), Curtiss SO3C-1 Seagull (upper right), and Vought-Sikorsky SB2U-1 Vindicator have all done their share in fighting the enemy. Though obsolescent, the Devastator and Vindicator chalked up good records in the Pacific against the Japs.

aviation in their Corps on May 21, 1912, when one lieutenant was ordered on duty which involved flying. At the outbreak of the first World War, the aviation branch of this service was composed of 5 officers and 30 enlisted men. At the cessation of hostilities, it consisted of 272 officers and 2,180 enlisted men.



The trend of American design is well portrayed by these six models. Upper left: the first fighter powered by the Allison engine, Curtiss' YP-37. Upper right: the Curtiss P-40, which was evolved directly from the YP-37. Center: Bell's strikingly different YFM-1 Airacuda, which was the first twin-engine multi-seat fighter tested by the AAF. Lower left: the Bell P-39 Airacobra, which has now been improved and redesignated. Center: the Lockheed P-38 Lightning. Lower right: North American's P-51 Mustang, which is one of the best fighters in the world. This model was recently revamped and called A-36 Invader, fitted for dive-bombing and attack duties.

CHAPTER II

ENGINE THEORY AND CONSTRUCTION

MINIATURE GASOLINE ENgines are divided into two distinct types, termed the "two-stroke cycle" type and the "four-stroke cycle" type. These are commonly referred to as the two-cycle and four-cycle engines. The two types are somewhat similar in appearance and performance, but there are the following differences:

Two Cycle—(1) Fires every time the piston reaches the top of its stroke; (2) ports are uncovered by the piston and thus act as valves; (3) has an airtight crankcase and compresses the gases in the crankcase before transferring them; (4) gasoline and oil are mixed and used as fuel; oil is not stored in the crankcase; (5) the piston has a specially shaped head, incorporating a baffle to guide the gases.

Four Cycle—(1) Fires every *other* time the piston reaches the top of its stroke; (2) has valves which act independently of the piston; (3) has a "breather" in the crankcase, permitting the compressed air to escape; (4) gasoline alone is used as fuel; oil is stored in the crankcase; (5) the piston head is usually flat, but in any case there is no baffle built in.

Although the two-cycle type has twice as many power strokes as the four-cycle engine, it does not have twice the power, because its power stroke is shorter, it must operate against crankcase compression, and there is usually a small remainder of burned gases in the cylinder due to incomplete exhaust.

The two-stroke engine develops about 1⅓ to 1½ times the power developed by a four-cycle engine of the same dimensions. Of course, since the oil is mixed with the gasoline and also because the two-cycle engine runs hotter, oil consumption is greater and cost of operation is higher. However, in initial cost a two-cycle engine is cheaper to build, because of the fewer number of parts required. Maintenance is cheaper, too, as there are less parts to replace.

Let us now consider the operation of the two-cycle engine, which is the type almost exclusively used in miniature gasoline engine work.

The first step in the operating cycle of a two-cycle gas engine is to take into the engine a proper mixture of fuel and air. Too little fuel in relation to air taken in will result in a "lean mixture" and too much fuel in relation to the air taken in will result in a "rich mixture," with varying performances. Inasmuch as most miniature gasoline engines have no way of varying the amount of air intake, it is very important that the needle valve in the carburetor be set accurately. Most engines have, either attached to the engine itself or in the instruction sheet accompanying the engine, directions stating the proper amount of turns to give the needle valve. Experimentation with your engine will soon familiarize you with the correct proportions.

Assuming that the correct settings have been made, how does the engine accomplish the actual intake of air and fuel?

Some miniature engines are fed by gravity, the fuel being controlled by a needle valve. In such cases another valve, usually part of the crankshaft or attached to the crankshaft, is so designed that it permits the gases to enter at the proper moment in relation to the stroke of the engine. The majority of miniature gasoline engines, however, are designed so that the air and fuel are drawn into the cylinder by means of a vacuum. This vacuum is caused by the upstroke of the piston in the cylinder. This is only a partial vacuum, of course, but the pressure in the crankcase falls below that of the air outside, and the air rushes through the air intake to equalize the pressure. The gases are then drawn up through the gas line, just as perfume is atomized, and a fine spray of mixture, both fuel and air, rushes into the cylinder, below the piston.

The gases (by which is meant the proper combination of air and fuel) now being in the crankcase, below the piston, the next step is to transfer them to the cylinder, above the piston. This is accomplished by the downstroke of the piston, which compresses the gases and at the same time opens suitably placed ports. The gases, released by the ports, rush through a small chamber, called the by-pass, into the cylinder. On some engines this by-pass chamber is brazed onto the cylinder, and in other cases it consists of a small plate, usually die-cast, held down by screws. It can be easily identified as it is always opposite the exhaust.

The gases are now in the top of the cylinder, and the piston is at the bottom of its stroke. The next step is to prepare the gases for the firing operation. If the gases were to be ignited in their present state, they would merely burn and exert no force, or at least insufficient force for their purpose. It is therefore important that the gases be sufficiently compressed before being ignited, in order to exert a sufficient force to perform the work of the engine. The piston, on its upstroke, compresses the gases for ignition.

There are a number of points in regard to the operation of a miniature engine that should be kept in mind. Remember that the piston not only compresses the gases on its upstroke but causes a partial vacuum in the crankcase, preparing the way for a new charge of fuel and air. It therefore performs a double function on its upstroke.

The question of compression is very important. An engine is usually figured in terms of "low," "medium," or "high" compression. A compression ratio of four to one is considered low; five to one or six to one is medium; and seven or more to one is considered high. The compression ratio is important because it determines: (a) the power of the engine, (b) its speed, (c) the strength of the component parts, (d) ease of starting, and (e) fuel consumption.

After the gases have been compressed in the cylinder they must be ignited. This is accomplished by means of the various ignition parts furnished with the engine, namely, the coil, condenser, wiring, timer, and spark plug. The timer, operating off a suitable cam attached to, or part of, the crankshaft, is so devised that it correctly "times" the spark from the high-tension coil to the spark plug in order that it shall fire the charge of gases at the right moment.

The timer is usually adjustable, even while running the engine, so that the timing of the spark may be retarded and advanced at will. This timing of the engine is very important, as it affects the ease of starting, the speed of the engine, the gas consumption, and the coolness or heat of the engine's operation.

The gases having been properly ignited, they expand and exert a downward pressure on the piston. As the piston moves downward, the exhaust ports are opened and the burned gases rush out of the exhaust. The piston, however, has not reached the bottom of its stroke, and continues downward.

Soon after the exhaust ports have been opened, the by-pass ports are exposed and the next charge of gases enters the cylinder. The baffle plate at the head of the piston now performs its task. It guides the new gases upward and away from the exhaust ports, which are still open. A small amount of the exhaust may remain and mix with the new charge and therefore cause the engine to lose a little power, or some of the new gases may escape with the exhaust gases, also resulting in a loss of power. The placing of the exhaust, by-pass, and intake ports is the governing factor for cases of this character, and the slightest variation in position will result in an entirely different performance.

The size of all ports is also of greatest importance, and any variation here will affect performance. The usual practice in the manufacture of modern miniature engines is to avoid having single large holes or ports, and to use ports consisting of many small holes. Incidentally, most model engines can be considerably improved in performance by enlarging the ports slightly. Before proceeding with such changes in design, however, it is preferable to obtain the engine manufacturer's comments.

We have seen how the gases are drawn into the cylinder and made to exert their pressure on the piston. How is this reciprocating action of the piston (its up and down strokes) converted into the rotary action of the crankshaft? And how is this rotary action carried on with the least resistance? These are the points we study next.

A small bar or piece of tubing, usually steel but sometimes brass, fits snugly on the inside of the piston, supported by small extensions called piston pin bosses. This small bar is called a piston pin or wrist pin. A connecting rod, usually bronze or aluminum with bronze bearings, extends from the wrist pin to the crankshaft throw. The connecting rod must be sufficiently strong to withstand the forces working on it, which are considerable.

The connecting rod, being joined to the action of the piston by means of the wrist pin, exerts its force on the crankshaft throw.

Since the crankshaft throw moves only in the form of a circle, the connecting rod must oscillate in order to permit the rotary motion of the crankshaft. However, if the crankthrow is at the top dead center, there is no reason why it should move or start to move in a rotary motion, unless another force is brought into play. This additional force is accomplished by means of the flywheel or propeller.

When a flywheel or propeller is spun rapidly, as in starting a motor, it tends to keep in motion until stopped by other forces, such as friction or gravity. This tendency to keep rotating is called inertia. The inertia of the flywheel or propeller turns the crankshaft throw past its dead-center point, and thus accomplishes the rotary motion.

In order to convert this available rotary motion of the crankshaft into power, such as the turning of a propeller, it is necessary to support it in such a way that no unnecessary friction takes place, and, at the same time, the escape of gases from the crankcase is prevented. These purposes are accomplished by fitting the crankshaft very carefully to a bronze bearing, sufficiently lubricated. The length of the bearing and the bearing material are important factors, as well as the accuracy with which the bearing is fitted to the crankshaft.

IGNITION

In discussing ignition, we are not going to dwell on those points which are already covered by the instruction sheet which accompanies your engine. Instead, we will try to make clear the principles on which ignition systems work, with the use of as little technical language as possible.

Magnetic lines-of-force are invisible waves that pass from one pole of the magnet to the other. The lines-of-force pass from the north pole of the magnet to the south pole outside a permanent magnet, and inside the magnet from south to north, thus forming a closed magnetic field.

If a bar of iron or steel is placed within the magnetic field of a magnet—that is, within the path of the lines-of-force—that piece of iron or steel will become a magnet. This method is called "magnetic induction."

Electro-magnetism differs from magnetism as described above in that the magnetism exists only while an electric current flows through the wire or conductor. If an electric current is sent through a wire, a magnetic field, similar to that set up in an ordinary magnet, is set up around the wire. Its intensity or strength is in proportion to the amount of electric current flowing through the wire or conductor.

Just as a bar of iron or steel placed within the lines-of-force of an ordinary magnet becomes a magnet, so does a bar of steel or iron, placed within the lines-of-force of a wire through which current is flowing, become magnetized. A bar of iron or steel thus magnetized is called an electro-magnet.

The strength of an electro-magnet depends upon the number of ampere-turns of wire on the coil. The number of amperes flowing through the wire, multiplied by the number of turns in the coil of wires, determines the magnetic strength of the core.

The principles of the electro-magnet are used in the manufacture of the spark coil in conjunction with miniature gasoline engines.

It has been discovered that when the electric current ceases to flow—that is, the circuit is opened—the magnetic lines-of-force collapse, generating a self-induced electro-magnetic force in the wires. The strength of the self-induced electro-magnetic force is much greater than the original current forced through the wires, and depends upon the following factors:

(a) The strength of the magnetic field.

(b) The speed or rate at which the lines-of-force cut through the windings or coil.

(c) The number of turns that are on the coil into which the electro-magnetic force is induced.

The self-induced electro-magnetic force or voltage in the low-tension windings of an ordinary spark coil run from 150 volts to 250 volts, depending upon the factors listed above.

In other words, a single coil of wire, properly designed and wound around a core of soft iron, can be made to develop from 150 to 250 volts. At one time coils of this nature were used to furnish the ignition spark for automobiles but they have been superseded by the high-tension type of coil, which we are primarily interested in here.

There are two types of high-tension coils—the vibrator type, and the non-vibrator type. The vibrator type is no longer commonly used, as it is mechanically inferior to the non-vibrator type and does not produce as hot a spark. We shall therefore confine our discussion to the non-vibrator type.

The coil (high-tension spark coil, non-vibrating type) consists of a core of soft iron wires, around which is wound about 200 to 250 turns of No. 18 to No. 20 B&S gauge insulated copper wire. Around this is wound from about 13,000 to 18,000 turns of No. 38 B&S gauge enameled silk-covered thin insulated copper wire. The ratio of the primary winding to the secondary winding is about one to sixty.

Just as the primary winding becomes self-induced to a voltage of about 150 to 250 volts, so there is induced into the very fine secondary winding a voltage of approximately 1,500 volts, depending upon the factors (number of turns, etc.) as stated before.

We shall now trace the circuit of a high-tension ignition system and then discover exactly what is taking place. The primary circuit is from the "plus" of the battery through the primary winding of the coil, through the timer, to the ground, and thence to the "minus" of the battery. A condenser is placed across the contact points of the timer, one end being connected with the insulated breaker, and the other end being grounded.

On the secondary winding, one end is grounded, the other end going to the spark plug, where it jumps the gap to the ground.

An ignition switch is usually placed somewhere in the low-tension circuit, to provide an easy and convenient means of shutting off the battery current.

We have learned that one of the factors controlling the amount of self-induced electro-magnetic force is the speed with which the lines-of-force cut through the windings of the coil—in other words, the speed with which the iron core is de-magnetized. A condenser is used for these purposes:

(a) To absorb the self-induced current of the primary, thus allowing the magnetic field to collapse as quickly as possible, and also eliminating, within certain limits, the spark at the contact points.

(b) To discharge back and forth into the primary circuit, thus neutralizing or de-magnetizing the iron core and preparing it for repeated action.

The condenser consists of a series of sheets of tinfoil separated from each other by an insulated material, such as mica or wax paper. The even-numbered sheets of tinfoil (2-4-6-8) are connected and form one terminal, and the same is done with the odd-numbered sheets. The two ends of the condenser are then used in a circuit as described before.

In usual practice the condensers are made in the form of a roll, with a heavy wire protruding at each end to facilitate hooking into a circuit. Never attempt to open a condenser, as this will spoil the insulation.

Again, in practice, the core of a spark coil usually consists of a number of thin iron (usually soft iron) strips or wires, which effectively prevent their becoming permanent magnets.

We now proceed to other units in the ignition system, of which the spark plug is an important element.

A spark plug consists of an electrode, or metal rod, which conducts the high-tension current from the coil. This electrode is separated from the metal base by an insulating material. The metal base screws into the cylinder head of the gas engine, and the plug is so designed that the high-tension current must jump a small gap between two sharp points in order to get from the electrode to the metal base.

Spark plugs are made in two types—the "separable" type, and the "integral." The "separable" type, as the name implies, can be taken apart, whereas the "integral" is a one-piece unit. The insulating material is usually mica or porcelain, but recent practice has developed new efficient insulators. The electrode, or high-tension metal rod, is made of steel or manganese nickel or a similar alloy, and is of approximately .050″ diameter and tapers down to a very fine point.

The choice of a spark plug is very important, inasmuch as faulty construction will result in loss of compression, hard starting, and "missing."

The timer assembly unit usually consists of a body on which the component parts are mounted; a fiber or insulated piece which moves on a cam; and a set of points (usually tungsten), one of which is adjustable. A study of the timing unit on your engine will quickly reveal its action. The important points to remember are that the contact points are made of a particularly hard material, such as tungsten or platinum, to avoid excessive wear; and that the entire mechanism is adjustable on most engines so that you can advance and retard the spark at will.

The cam which actuates the timing device usually consists of a round metal piece attached to the crankshaft. One section of this cam is flatted, permitting the timer to be moved back and forth by its spring. The amount of flatted area is worked out by the manufacturer with care as it greatly influences the ignition system.

Some cams are so designed that they have a raised section instead of a flatted section, but the principle is the same, the raised section moving the timer breaker back and forth. No matter which type of cam is used, it is important that the cam operate the timer in such a manner as to cause the spark to jump at the proper moment, which is shortly before the piston reaches top dead center.

The wiring used in ignition systems of miniature gasoline engines is of two types: the primary wire or cable, called the low-tension wire; and the secondary cable, called the high-tension wire.

The low-tension wire is used on miniature engines in all cases except for the carrying of high-tension current. It is flexible, consisting of several strands of No. 14 or No. 16 wire, covered with waterproof insulating material.

The high-tension wire is used to carry the high-tension current from the spark-coil secondary lead to the spark-plug electrode and is very heavily insulated. It is usually made in 7mm. and 9mm. sizes. The choice of wire used, particularly in the high-tension line, is most important, as too much resistance would result in loss of voltage.

Dry cells, usually of the flashlight type, are used exclusively in miniature engine practice for supplying the necessary engine current. The point to remember here is that the manufacturer's specifications regarding the amount of voltage should be followed very carefully and under no condition should an excess of voltage be used, as this may result in damage to the ignition system.

LUBRICATION

As applied to modern miniature gasoline engines, lubrication is a relatively simple matter, consisting merely of oiling the moving parts before assembly and providing a means of keeping them well lubricated during operation. As is the practice with outboard motors, oil is added to the gasoline before filling the tank, the oil subsequently fulfilling its lubricating functions. The proportion of oil to gasoline in miniature engines runs from one part of oil to two parts of gasoline all the way to one part of oil to fifteen parts of gasoline.

Our present-day hobbyist, however, is not satisfied with merely being told what to do. He wants to know why he is doing it, and he wants to learn as much as he can about the subject. For that reason, we will proceed to a study of lubrication in its more important aspects.

The purpose of lubrication is to prevent metal-to-metal contact. When two parts of a mechanism rub together, it is necessary to use some means of preventing excessive friction, and this is usually done by applying a film of lubricating oil. Without a lubricant, the friction would cause heating, and the result would be cuts or scratches on the surfaces of the two parts, resulting in excessive wear and loss of power, or in a case of excessive heating, a seizure, or binding, of moving parts.

Two parts intended to rub together, like a shaft and its bearing, should be made as smooth as possible, for roughness would cause friction that lubrication could not prevent. The more rapid the movement of the parts against each other and the greater the pressure, the more they must be lubricated. The kind of lubrication furnished must vary to suit these conditions.

Although miniature engine lubrication, called the "all-loss non-circulating non-pressure" type, is the only system used on miniature engines, we shall nevertheless make a brief summary of the various other methods, in order to acquaint ourselves with lubrication as applied to other devices.

Method one is the gravity-feed, all-loss system. This system feeds fresh oil to the friction surfaces in drops, which by gravity reaches the various bearings. No provision is made to splash the oil. This method is used mostly on stationary engines.

Method two is the non-circulating splash system. Fresh oil is supplied from a separate oil reservoir or tank to the crankcase, and in some instances to the main bearings, by means of a mechanical oiler, gravity oil cups, or adjustable feed pumps. The oil is not returned to the reservoir or tank for re-circulation.

Method three is the circulating splash system. Oil is supplied from the reservoir by means of a pump, or by the centrifugal force of the flywheel, to splash troughs or, in some instances, direct to the crankshaft bearings. After doing its lubricating work, the oil returns to the reservoir. Note that the oil is not forced by pressure to any of the bearings or parts; the pump or flywheel serves only to circulate the oil. The splashing of the oil is done by the connecting rod in its movements up and down.

Method four is the force-feed system. Oil is forced by pump pressure direct to the crankshaft's main bearings, then by means of drilled holes to the connecting rod, crank pin, and bearings, and thence through oil pipes attached to the connecting rod, or through holes in the connecting rod to the piston pin. The piston and cylinder are supplied with oil thrown off by the crankshaft and connecting rod bearings. The connecting rods do not dip into the oil.

Method five is the full force-feed system. Oil is forced by pump pressure direct to the crankshaft main bearings, thence through drilled holes in the crank web to the connecting rod, crank pin, and bearings. The piston pin, piston, and cylinder are supplied by oil thrown from the crankshaft and connecting rod bearings. The only difference between methods four and five is that in method four the piston pin is supplied direct with oil, while in method five it is supplied indirectly by the throwing of oil.

Method six is the force-feed and splash system. Oil is forced by pump pressure direct to all crankshaft main bearings. The oil then falls to splash troughs in the crankcase into which the connecting rod dips and splashes oil to all other parts.

All commercial engines use one or more, or a combination, of the above methods, and a careful study of the engine will enable you to identify the method used.

There are several factors which determine the lubrication requirements of an engine and it is important to know these: (1) operating temperatures; (2) method of oil distribution; (3) piston seal; (4) carbon sensitiveness. Each of these will be treated separately.

(1.) Operating temperatures: All oils tend to thin out with an increase of temperature, but the extent to which the oil will thin out depends not only on the temperature but on its original body and character. After heating, the oil regains its original body when cooled. It does not remain thinned out unless diluted by liquid fuel.

The heavier and more constant the load, as with airplane and tractor engines, the more fuel is burned, and consequently the higher the operating temperatures. Heavy-bodied, rich lubricants would therefore be required. This heat, which is usually greatest at the piston, must be conducted through the oil and metal walls before it reaches the cooling fins or water jacket. Automobile service seldom requires more than a small fraction of the available power for any length of time, and therefore an engine used for this purpose would operate under low temperatures and oils of a lighter body would be necessary.

The higher the engine speed, the more frequent will be the heat impulses and the higher the operating temperatures. Again, air-cooled engines operate at higher temperatures than water-cooled engines, so that high-speed air-cooled engines would require exceptionally heavy-bodied, rich lubricants.

(2.) Method of oil distribution: Systems in which the oil is distributed by splash must use an oil light enough so that it will readily atomize in order to reach all the parts to be lubricated. A heavy oil might fail to do this. Systems in which oil is forced to the crankshaft and connecting rod bearings by a pump could use a heavier oil, as it will be mechanically broken up into a fine mist. Other factors which affect oil distribution are the type of oil pump, design of oil screen, and dimensions and locations of the oil piping.

(3.) Piston seal: It is absolutely necessary for the lubricant to effectively seal the piston against loss of compression. The ability of a lubricant to spread, stick, film, and seal naturally varies with different oils.

(4.) Carbon sensitiveness: All oils and fuels, when burned in the combustion chamber of an engine, are likely to leave a residue which may not be entirely expelled through the exhaust, and becomes carbon. Carbon deposit from lubricating oil in the combustion chamber will depend upon four things: (a) the character of the oil; (b) the body of the oil; (c) engine operating temperature; and (d) the amount of oil reaching the combustion chamber.

Most engineers agree that the best oil—at least as far as viscosity alone is concerned—is that oil which suffers the least change of viscosity for a given change of temperature. Viscosity of an oil is the adhesive characteristic. In other words, the best oil, all other things being equal, is the one that under heat remains closest to its original adhesive condition when cool.

Standard brands of oil are usually sold in grades of S.A.E. 10, 20, 30, etc. These grades are arrived at by the adhesive properties of the oil. The presence of an S.A.E. number is, of course, no indication of the lubricating properties of the oil, and we will now consider several factors other than viscosity which affect this question.

The flash and burning points of an oil mean the temperature at which the oil, when heated, will flash and burn. Oil when heated generates gas, just as gasoline does. The best gasoline-engine oils generate little or no gas at ordinary temperatures, but at high temperatures—from 350 degrees to 450 degrees Fahrenheit—they generate a sufficient amount of gas so that it can be ignited with a match and produce a flash and go out instantly. This is termed the flash point. If the heat is increased to 500 degrees and the match applied, the generation of gas is so rapid that it would continue to burn, unless extinguished, until the oil was nearly all consumed. This temperature is termed the burning point.

The pour point or cold test of an oil is a test which determines the ability of the oil to withstand extreme low temperatures without becoming solid. Some oils finish with a cold test of as high as 60 degrees above zero, while others range from 15 degrees to 30 degrees below zero.

The testing of oil is naturally a technical matter and the methods cannot be covered in detail here. It is well, however, to bear in mind these factors which determine the quality of an oil: viscosity, flash point, burning point, pour point, and chemical content, the last named a subject not discussed here because of its technical nature, but nevertheless an important factor in lubrication.

Our advice to the miniature gasoline engine operator would be to buy only the more expensive grade of any standard brand on the market—and to follow the engine manufacturer's grade specifications and directions to the letter. The cheaper the oil the more expensive it will prove in the long run. And the operator who stints on oil will soon be saving oil altogether, because his engine will not stand up.

METALLURGY

The miniature gasoline engine enthusiast should make it his business to know not only the "why" and "how" of his hobby, but also the "what." For that reason the materials that go into a miniature gasoline engine will now be treated in some detail. The reader will notice that, wherever a choice of several materials is possible, each material has certain advantages and that the manufacturer has taken these advantages into consideration.

The heart of an engine—the piston and cylinder—is usually the manufacturer's first problem. Since the piston will depend on the choice of material for the cylinder, let us first consider what metal may be used for the cylinder.

In automotive and industrial practice there are several alternatives: first, a cast-iron cylinder block; second, a cast-iron cylinder block with a steel liner insert; third, steel cylinder; fourth, an aluminum-alloy block with steel liners. These four cover practically every type of gasoline engine made, although considerable experiment has also been made with die-cast zinc-alloy and aluminum-alloy cylinders, with and without liners.

The leading miniature gasoline engine manufacturers have selected two of the above methods in the manufacture of their engines—using either a cast-iron block or a steel cylinder. The advantages of the cast-iron cylinder are that it takes a better internal-wall finish, and consequently has a higher compression; it dissipates heat better than a steel cylinder does, and thus it is cooler running; it is more easily machined; and it is readily cast in its approximately finished form, saving machining operations.

The steel cylinder has several advantages of its own: it has a better appearance; because of superior strength and use of thinner sections it is lighter than a cast-iron cylinder of corresponding size; it adapts itself more readily to brazing and welding. In cost, the two materials run about the same.

Pistons for miniature gasoline engines are made from steel, cast iron, or aluminum with steel or cast-iron rings. The individual pistons are so small and light that the cost element of the material is submerged by the machining cost. For this reason, many of the miniature gasoline engines on the market today use permanent mold or die-cast aluminum-alloy pistons, with piston rings. The pistons require very little machining and, with the aid of the rings, secure very good results. Cast-iron pistons do not require rings to hold compression, but they do need considerable drilling, milling, and centerless grinding before they are ready for installation in an engine. The steel piston is used mainly in the higher priced engines, since a large investment in dies is required to fabricate the piston from the flat metal sheets. Once this huge investment is made, the stamping operations are automatic and no machining of any kind is required to bring the piston to finished shape, with the exception of centerless grinding to .0002″, after appropriate heat treatment. Although the manufacture of steel pistons is far more intricate than that of any other types, its cost in mass production compares favorably with other types, and steel pistons have the advantage of greater strength, uniformity, lighter weight, and better finish. In the selection of a miniature gasoline engine, study the manufacturer's choice of materials from his advertisements and literature and choose the engine which indicates that the manufacturer is giving full value.

Another important indication of an engine's value is the choice of material used in the crankshaft. The most commonly used crankshaft is one machined from solid steel or steel alloy. The manufacture of these parts is relatively simple, requiring very little set-up and tooling. Steel crankshafts have given very good service in miniature engines, due to the light load, although they are impractical for industrial engines. The composite crankshaft is also a common practice; it consists of the various parts assembled in one unit by welding or brazing, or by threading the part together, or, lately, by shrinking the parts together. This type, too, gives good service when properly made.

The drop-forged, one-piece crankshaft is now being used by the more progressive manufacturers, following automotive and industrial practice. The original die cost is considerable, and centerless grinding to accurate limits is also an important factor in making the cost of this type of crankshaft very high; but the advantages of far greater strength, accurate parts, and absolute uniformity compensate the manufacturer for his expense and labor.

Lastly, always consider the thickness of the shaft. Too many engines have resorted to shafts of minimum thickness, sacrificing strength for lightness. Remember, the thinner the diameter of the shaft, the less it cost the manufacturer. This is an important point.

The connecting rod may be made of any of several materials, all of which have given excellent results. Permanent mold or die-cast aluminum rods with bronze bushings are used extensively, as are solid bronze rods. In either case, it is important that the parts be strong enough for the purpose, but light, and they should be drilled, reamed, and honed accurately for fit and then checked for line-up at the factory.

Steel piston pins are almost universally used, although bronze ones are satisfactory. These consist of tubing or solid stock, centerless ground for long-wearing ability. No engine should be without piston-pin pads, which are inserted in the ends of the piston pins to prevent possible scoring of the cylinder walls; piston-pin pads are usually made of brass.

A good way to determine the effort a manufacturer has put into his engine is to study the bearing that supports the crankshaft. If it is an ordinary bronze bearing it should have lubrication grooves to prevent "seizing." The latest practice, however, is to use one of the new self-oiling bearings, a bronze bearing that is impregnated with oil and requires no outside lubrication. Thus, the failure of the owner to use the right type of oil, or even failure to use a sufficient quantity of oil, will not affect the bearing.

While studying the bearing, check up on its length. A manufacturer is naturally anxious to give as short a bearing as possible, and the length of the bearing is an indication of how much value the manufacturer intended to put into the engine. The average bearing length is about one inch, with some bearings as long as one and one-quarter inches.

Extensive use of aluminum for the crankcase, cylinder head, and carburetor is now the practice. Aluminum is light, easily fabricated, has a good appearance, and is heat-dissipating. It consequently has many advantages over other materials for these particular purposes.

However, there is a considerable difference in aluminum parts produced by sand-casting and those produced by die-casting. Sand-cast aluminum parts are weaker and frequently have blowholes, whereas die-cast parts have a higher tensile strength and are devoid of blowholes. In addition, sand-cast parts must be machined to fit the corresponding parts of the engine, whereas die-cast parts are cast to exact shape and size. Thus, you can expect far greater uniformity from die-cast parts than from sand-cast parts.

The die cost for the average miniature gasoline engine runs to more than $1,000, so that the presence of die-cast parts in an engine is an indication of the manufacturer's willingness and ability to impart real value in his product.

The carburetor should have a needle valve and valve body, sometimes called the jet, made of identical material so that any careless pressure on these parts will not result in spoilage or breakage. Brass is commonly used, although steel parts are possible. Steel, however, is subject to rust. Any material softer than brass is unsatisfactory, because of the excessive wear and the possibility of bending. The valve and body should have a very fine thread in order to ensure minute adjustment of the fuel flow. The gas line should be of metal tubing, as rubber and several other materials are subject to corrosion from gasoline.

The screws, nuts, and bolts present no special difficulty, as these are usually standard sizes. However, care should be taken not to use screws that will strip the threads in your engine. A stripped thread may ruin the engine completely, but a stripped screw can easily and quickly be replaced.

Too many gasoline engine operators neglect the choice of proper material for the engine's gaskets. The use of ordinary paper, cardboard, cloth, and so on, are fatal to an engine's performance. Automotive and industrial practice have developed suitable gasket material, and this is available for use in miniature gasoline engines. Heat resistance, compressibility, and strength are the foremost requirements of a good gasket. Moreover, the gasket should be accurately cut on automatic machines, using steel cutting dies. A good grade of pure orange shellac should be used to seal the gaskets in place. The use of various gasket pastes and cements is not advised, as these will have a harsh effect upon the engine in case a little gets into the moving parts.

PISTON AND CYLINDER FINISHES

The performance of any miniature gasoline engine depends largely upon the finish and fit of the piston and cylinder. This section deals with the various methods of finishing these parts and machining them together for best results.

There are numerous ways to finish a cylinder, and the finish given by a manufacturer is a good indication of the effort he is putting forth in order to give good value.

Rough boring is the process of machining a cylinder on a lathe with a boring bar. The subsequent finish of the cylinder is not suitable for use in an engine, as it will not hold compression and will result in quick wear on both the piston and cylinder.

The reaming of a cylinder was once considered as the final operation on a cylinder, and while the surface was better than that obtained by boring, just described, this surface is not acceptable today.

Grinding, the process of finish machining with the aid of a high-speed carborundum wheel, produces a fine finish which is suitable for use in miniature gasoline engines. Extreme care must be taken to avoid bellmouth and taper, and to allow for wear of the wheel. This method, while satisfactory, does not compare favorably with carbide-tool boring or with honing.

Carbide-tool boring, or diamond-tool boring, is accomplished by holding the cylinder in an accurate chuck jig or collet, and boring with the carbide or diamond tool. This method is fast and produces the best possible combination of finish and speed of production, and it is much in favor with miniature gasoline engine manufacturers.

Honing is the final and best method of finishing cylinders, although in cost it runs much more than any other method and requires a much higher investment for equipment. In addition, only very skilled workmen can operate a honing machine.

Before proceeding, we will outline a method by which a miniature gasoline engine operator can secure a good finish and fit on his own engine, without the necessity of purchasing expensive equipment. This method is called lapping. Because it is a long, tedious operation, lapping is not commercially practical. But for the owner who has only a single cylinder to lap, it is the ideal solution.

The lapping tool consists of an old piston (or a lead piece the same diameter as the piston) that has been mounted on a handle, or on an old connecting rod and wrist pin, if available. This piston is kept coated with a superfine lapping compound which can be obtained in various grades from any automotive or jewelry store. The tool is moved up and down inside the cylinder to be lapped, and at the same time it is given a rotary motion. Care must be taken to assure uniform lapping.

This work continues until the cylinder has been lapped to the proper size. The lapping compound must then be carefully and thoroughly removed, because any remaining compound will continue its cutting operation and soon ruin any fit. It is not practical to try to correct out-of-round or taper exceeding .003″, and a cylinder with this defect should be returned to the factory for refinishing and refitting with a new piston.

Because honing produces the ultimate in cylinder finishes, it is probably advisable to discuss the entire honing process. Its disadvantages are slow production, high-cost skilled labor, and expensive equipment. Its advantages are a finer finish, resulting in a better fit and less wear on the piston and cylinder, and the production of a cross-cut grain that holds the lubricating oil.

The honing machine consists of a spindle which is rotated by a powerful electric motor, mounted integral with the machine. This spindle, by means of an automatic mechanism, rotates and reciprocates, each operation in definite relation to the other, thus assuring perfectly uniform abrading action throughout the cylinder bore. Uniform acceleration is provided at both ends of the cylinder bore, without any jar or shock. Both the speed of the rotary motion and that of the reciprocating motion are adjustable, and the stroke of the reciprocation is also adjustable.

The necessary switch controls are conveniently located, and are manually operated by the attendant. An integral motor-driven pump is included with the honing machine and supplies a filtered flow of coolant (usually a mixture of kerosene and lard oil) to the work, serving the purpose both of carrying away the metal grains and of keeping the work cool.

The actual work of honing is done by a number of carborundum stones mounted in small metal holders, all part of a unit which fits into the spindle. A micrometer stop device is included, and the micrometer is set to the desired size. The entire honing machine weighs about two tons, the better to withstand vibration, and is capable of finishing about twenty-five cylinders per hour.

Pistons for miniature gasoline engines are now commonly centerless ground, this being the best method. It produces a fine finish, accurate as to roundness and taper to within .0002". Lapping of pistons can also be done, the lapping tool fitting on the outside of the piston.

Although great care must be taken in the finishing of the piston and cylinder, the fitting of these parts is a still more important operation. A piston and cylinder, even though each be perfect, will give poor results if machined imperfectly to each other. For that reason, many manufacturers go to great lengths to ensure good fits.

The best method, though the slowest and the most expensive, is to finish a cylinder to correct size and then hand-match a number of pistons to determine the best fit. A skilled operator soon develops a sense of touch and can produce better fits than any machine or equipment. The fitted piston and cylinder must be snug, but not binding at any point.

Another method of securing piston and cylinder fits is to assort the pistons by sizes, usually tens of thousandths of an inch, and finish the cylinder to each size, allowing the proper clearance.

Care must be taken in allowing the proper clearance, as an engine with improper clearance will seize up, the piston binding in the cylinder. This usually results in considerable damage to both piston and cylinder. Moreover, an engine intended for use in an airplane should not be used in any device where an equivalent airstream is not available, unless the manufacturer specifically states that such is the case. Because of the expansion properties of cast iron, engines with cast-iron cylinders may be used for any purpose without danger of seizing, except where matched to an aluminum piston, which has a greater expansion under heat than cast iron.

No matter how perfectly a cylinder and piston may be finished and fitted, proper lubrication is necessary before good performance can be obtained. Every manufacturer specifies on the instruction sheet that accompanies every engine the proper amount and grade of oil to be used, and these instructions should be followed carefully. Where No. 70 oil is specified, do not substitute No. 60 or any other grade, as this will result in loss of compression and excessive wear, as well as overheating of the engine.

In many instances where a piston and cylinder are perfectly made and fitted, and the proper amount of correct oil is used, the operator of the engine is surprised to find his engine has low compression, is wearing rapidly, runs hot, and frequently binds.

In a case of this kind, check the line-up of the parts, particularly the connecting rod. A connecting rod that is out of line only a few thousandths of an inch will provide plenty of trouble, in even the best engines. Connecting rods must be checked for absolute alignment, both vertical and horizontal, before installation in your engine.

Loose fits between the connecting rod and the crankshaft, as well as between the connecting rod and the wrist pin, are also a source of trouble. The parts should fit snugly without binding and should be well lubricated at the time of assembly.

Another important point that will baffle even the most experienced operator is the misaligmment of the bearing and shaft assembly. Frequently a main bearing is finished out of round or suffers some damage during the pressing-in process, as a result of which the crankshaft will not run true. This results in vibration, tightness, and friction between all the moving parts.

A factor affecting piston and cylinder performance to a great extent is the presence of foreign matter between the moving parts. Usually not much can be done to protect the engine against this, since the amount of dust and dirt in the air under ordinary operating conditions is fine enough to escape even the best filter. It is possible, however, to guard in some ways against this menace to performance. First, cover your entire engine with a snug-fitting hood, preferably silk or cloth, when not in use. Second, on a windy day place the engine so that the air intake does not face the wind. Third, carefully filter your gas and oil before filling the tank. These precautions will lengthen the life of your motor.

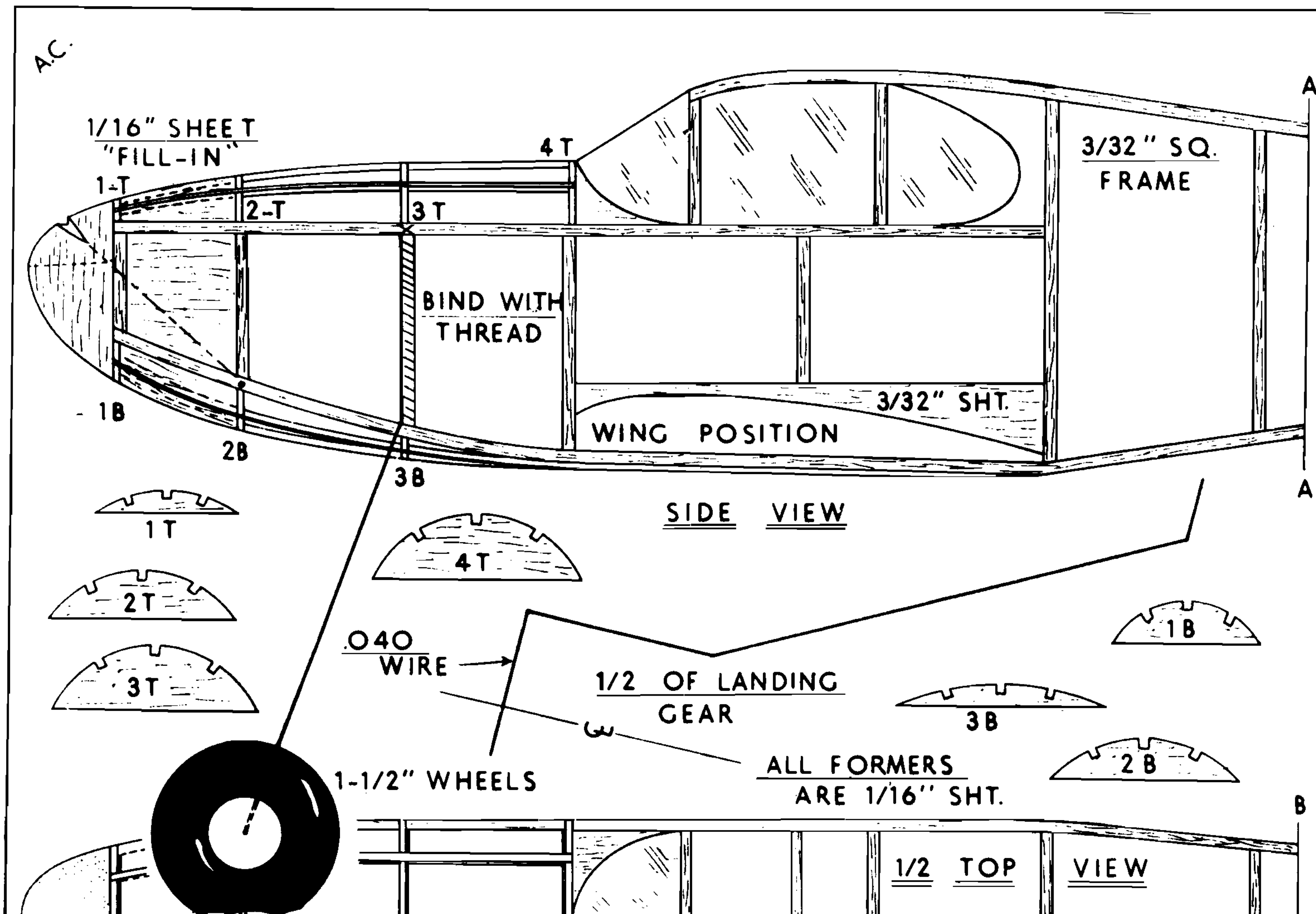
CHAPTER III

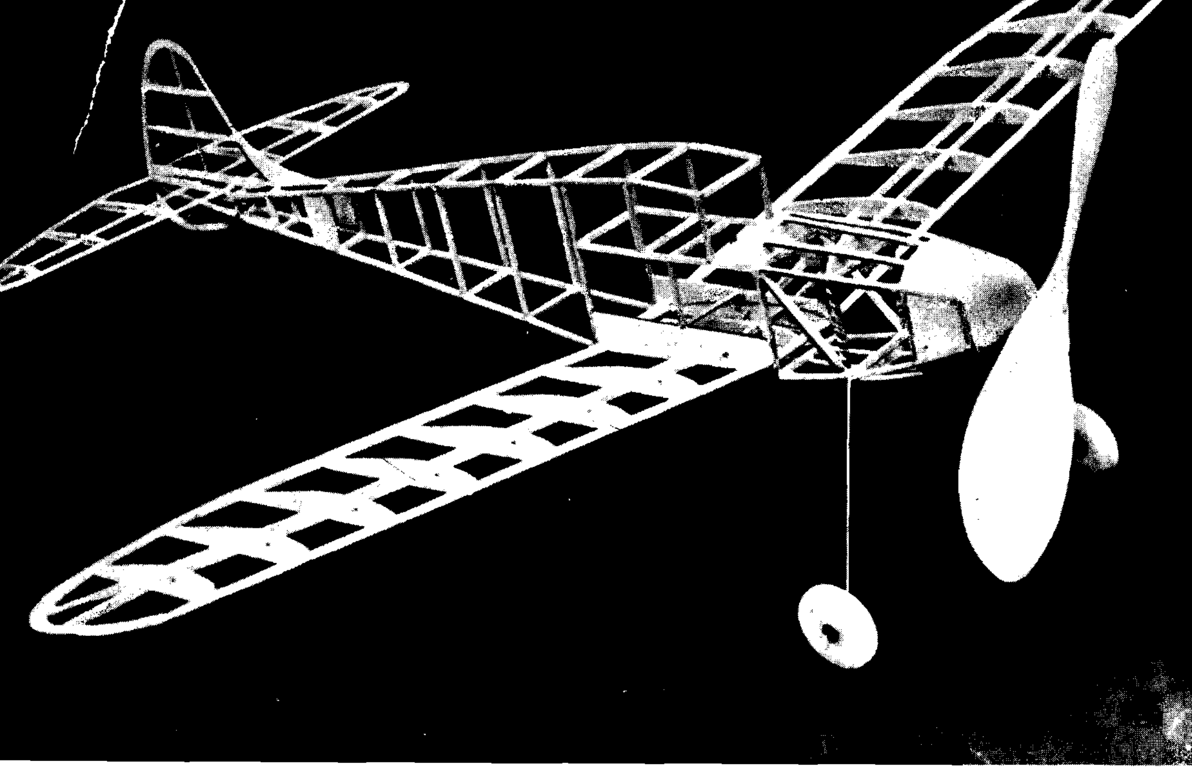
LOW-WING SWOOSE

THE LOW-WING SWOOSE is a splendid model with which the beginner can experiment to his heart's content. Alfred Cleave, the designer, is somewhat of a newcomer to the list of model engineers, but the ships he has produced so far have all proved good flyers. Also, they are easy to build and at the same time rugged enough to stand up under all but the most severe crash landings.

This model was not designed to break any records or to make spectacular flights of long duration. Instead, a snappy appearance and stable flying characteristics were the goals held in mind during the designing period. The material used is of common size and is obtainable at all model shops. Strips are all of a hard grade, with straight grain. Sheet wood is of a medium grade.

If the builder wishes bass or pine may be substituted for balsa. Because of its simple construction, the Swoose is very easy to build from hardwood, and with a few minor changes in the plans it can be built by even those with little or no experience in this type of construction.


A.C.
1/16" SHEET "FILL-IN"
1-T
2-T
3 T
4 T
1B
2B
3B
BIND WITH THREAD
3/32" SQ. FRAME
3/32" SHT.
WING POSITION
SIDE VIEW
A
A
1 T
2 T
3 T
4 T
1 B
2 B
3 B
.040 WIRE
1/2 OF LANDING GEAR
ALL FORMERS ARE 1/16" SHT.
1-1/2" WHEELS
B
1/2 TOP VIEW



Framework of the Swoose. Note the simple box framework of the fuselage and details of the nose. Though admittedly not a record-breaker, the Swoose gives good, long flights and will provide any builder with hours of enjoyment. Unlike many fuselage models, it is quite easy to build.

Fuselage

Before actual building of the fuselage is begun, it will be necessary to enlarge the plans to full size 7" by 10" border measurement and join the two drawings of the side view. It will not be necessary to do this with the top view, since measurements may be taken directly from the enlarged plans.

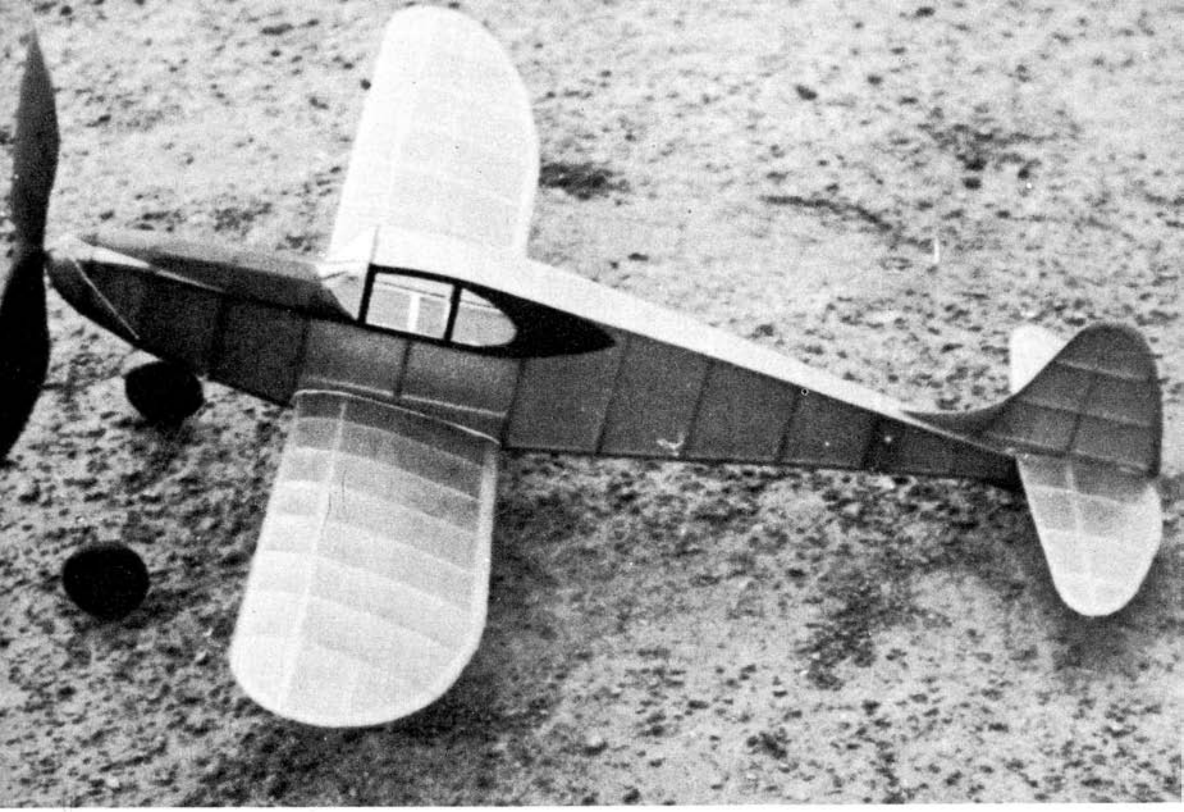
After a sheet of waxed paper has been placed over the working drawing, begin construction work by pinning the 3/32"-square longerons in place. Be sure the longerons are of the same hardness, otherwise the fuselage will pull out of line. If this does happen, however, the structure may be straightened by holding it over a jet of steam for a few minutes and bending gently. After the longerons have been pinned down, add the cross-members, taking care to cut the ends to fit the longeron curvature. If pine or basswood is used, the 3/32″ stock should be sanded to a smaller size. By building one fuselage side on top of the other, both sides can be made more accurately.

Two pieces of 3/32″ strip are cut as shown on the plans and cemented in place, one on each side of the fuselage, to form the outline of the wing slot. When the cement has hardened, lift the two sides from the plan. They will probably stick together, but they can be separated by slipping a razor blade between them at the cross-member points.

Cut cross-members to the length shown on the top-view drawing and cement them in their proper positions, starting at the widest point of the fuselage and working toward the rear. When this has been finished, add the cross-members to the forward part of the fuselage.

Before going any further, check to see if the fuselage is in line, looking from both the top and front. If it is, proceed by cutting the formers from 1/16″ sheet balsa or 1/32″ or 1/20″ hardwood; cement these in an upright position, making sure they are perpendicular to the thrust line. After the formers have been cemented in place, add the 1/16″-square stringers, noting that on the bottom they extend back even with the trailing edge of the wing.

Fill in the nose with 1/16″ sheet. This may at first seem difficult, but if a very careful job is done in shaping the pieces they will fit neatly and give a trim appearance. Then cut the nose block roughly to shape and cement it lightly to the front of the fuselage. After the cement has dried, sand the block so that it blends smoothly with the fuselage lines. It will later be removed from the fuselage, so do not use too much cement for this initial operation.

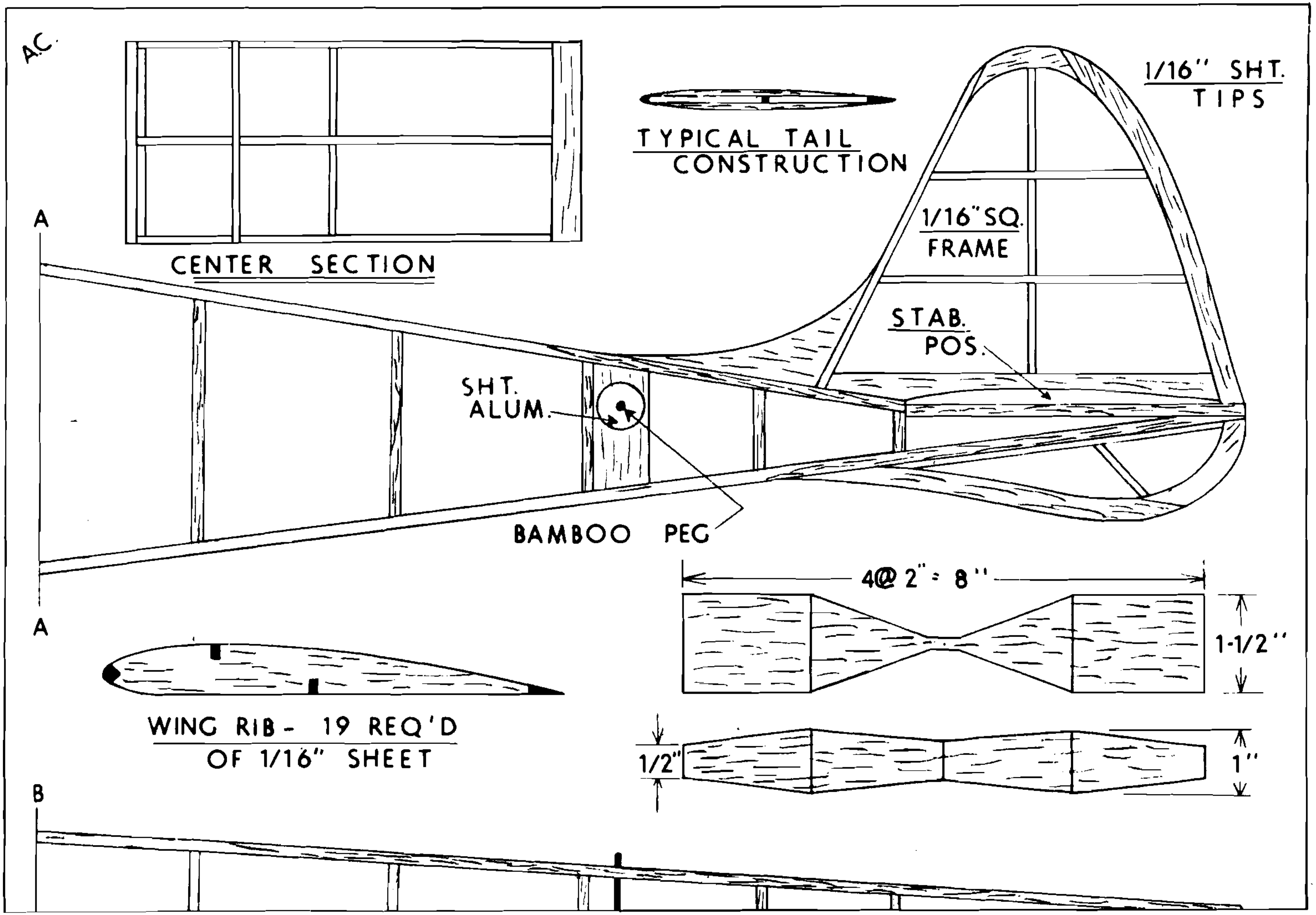


Completely covered and ready to fly, the Swoose is a very attractive model. Even the novice will have no difficulty in applying tissue, because of the model's flat fuselage sides.

Shape the landing gear from .040″ wire, cement it in place, and bind it to the fuselage with thread. Add the 1/32″ fairing around the front of the cabin and the 1/16″ sheet near the tail to hold the bamboo peg which serves as the rear anchor for the rubber motor. Then add the aluminum plates which prevent the peg from wearing the wood away.

Wing and Tail

Trace the wing sections and join them at C-C. After placing a sheet of waxed paper over the plan, construction is started by pinning


A.C.
CENTER SECTION
TYPICAL TAIL CONSTRUCTION
1/16" SHT. TIPS
1/16" SQ. FRAME
STAB. POS.
SHT. ALUM.
BAMBOO PEG
A
A
4@ 2" = 8"
1-1/2"
1/2"
1"
WING RIB - 19 REQ'D OF 1/16" SHEET
B

the leading and trailing edges in position. Form the ribs from 1/16″ sheet balsa or 1/30″ pine and cement them in place; then add the tips. The top spar may be formed from either 1/16″ by 1/8″ balsa or 1/16″-square pine. After cementing the spar to each rib, allow the adhesive to harden thoroughly before removing the structure from the plans. Then, when the wing panel has been lifted from the drawing, add the bottom spar.

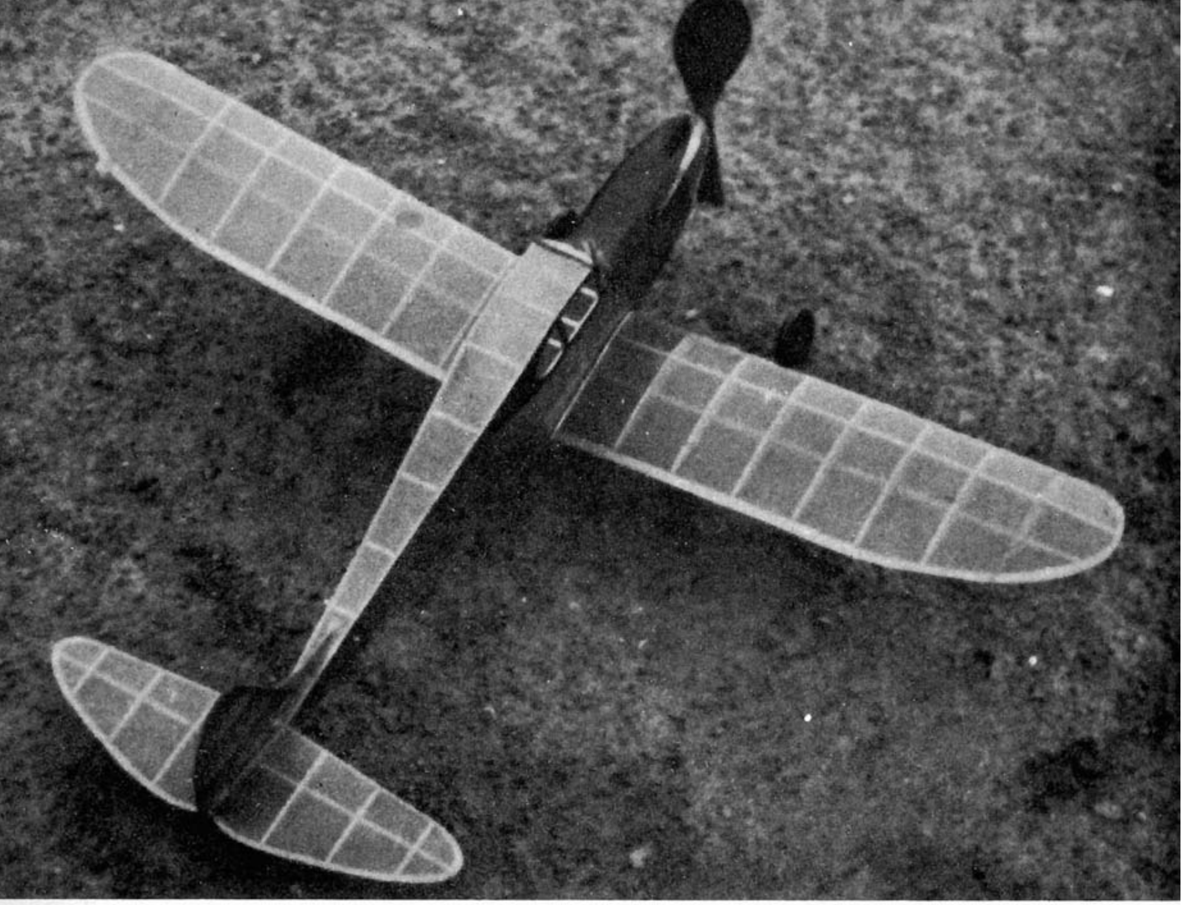
Join the right and left wing panels, with a 2″ dihedral at each tip. Sand the entire wing thoroughly, tapering the tips and trailing edge and rounding off the front spar.

Since only half of the stabilizer is shown, it will be necessary to make a drawing for the right half. The easiest way to do this is to place a sheet of carbon paper, face up, under the enlarged plan, and trace the stabilizer outline with a pencil. Then the entire segment will be reproduced on the back of the plan, in reverse. Build the left half of the stabilizer, leaving the rib extended, and then reverse your plan for the right half. Thus the stabilizer may be made in one piece with very little difficulty.

Begin building the stabilizer by pinning and cementing the 1/16″-square and 1/16″ sheet outlines in place. The same stock sizes of pine may be used if the wood is sanded beforehand to remove excess weight. Pin the spar in position and add the cross-members. After the structure has dried, remove it from the plan and cement the 1/16″-square cap strips in place. They are of a very soft stock and are sanded to a streamlined shape. Instead of balsa, 1/32″ by 1/16″ pine may be used. The rudder is constructed in the same manner as the stabilizer.

Assembly and Flying

Before covering is begun, remove excess cement from all joints and be sure there are no rough spots that might come in contact with the



Top view of the model. Clean in every detail and strong enough to withstand all but the most severe crack-ups, the Swoose is a good model for beginners, or for intermediate or experienced builders. When making the fuselage, remember to check the alignment constantly.

tissue, as these small items can ruin the appearance of an otherwise nearly perfect model. Add the cellophane windows before the model is covered.

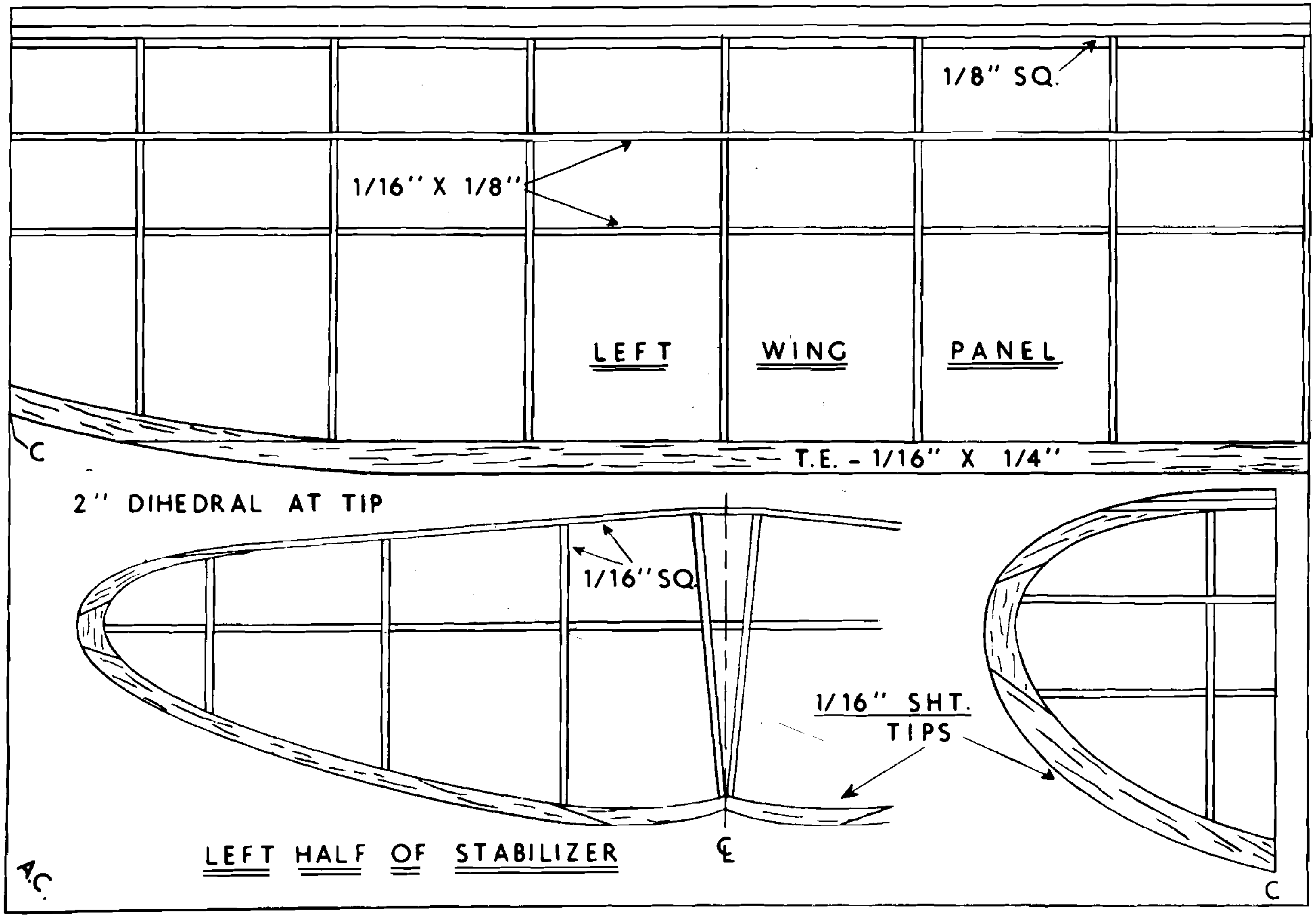
The flat portions of the fuselage are covered with a single sheet; when covering the curved areas use a separate piece of tissue between each former, working from the rear toward the front. The nose block may be covered with several small, carefully lapped pieces of tissue, and the tail is covered with a single sheet for each surface. The grain of the tissue should always run lengthwise.

Dope the tissue to the trailing edge of the wing and work toward the leading edge. Several small pieces will be needed to cover the

The finished model about to be launched on its first flight. It is frequently difficult to get good flights with low-wing jobs, but the Swoose is in a class of its own and has turned in some excellent hops.

tips, if a finished job is expected. Spray the entire model with a fine mist of water, and pin the wing and tail surfaces to a board to prevent warping. Give the fuselage three or four coats of rather thin dope, and the wings and tail two or three coats.

The propeller is carved from a hard block measuring 8″ by 1″ by 1½″. Take time and care in carving the prop, as this is the most important part of the model. After it is carved and sanded, balance carefully and then apply two or three coats of colored dope and one of clear. Cement brass or copper washers to the front and back of the prop and make sure that it revolves freely, as the glide depends on this after the free-wheeling takes over.


1/8" SQ.
1/16" X 1/8"
LEFT WING PANEL
T.E. - 1/16" X 1/4"
2" DIHEDRAL AT TIP
1/16" SQ.
1/16" SHT. TIPS
LEFT HALF OF STABILIZER
A.C.

Cement washers to the front and rear of the nose block, building in a few degrees of down and right thrust. Cement a piece of ⅛″ sheet to the rear of the nose block to keep it from slipping, and cut a notch in the tips to hold the rubber band which keeps the nose block in place. Use any simple free-wheeling device, and the glide will be improved greatly.

Cement the stabilizer securely to the top of the fuselage in the position shown on the plans. Attach the rudder and sub-rudder, making sure that they are exactly vertical and that the stabilizer is horizontal. Cement the celluloid windshield in place. Slip the wing into its slot and fasten it with a rubber band under the fuselage and over the wing. Add the rubber motor of six or eight strands of 3/16″ flat rubber. Hold the motor in place at the rear with a small bamboo peg through the fuselage. The wheels are built from three layers of ⅛″ laminated sheet balsa or from three layers of 1/16″ sheet pine. Cement washers to each side to prevent wearing. Slip the wheels on axles and keep them from coming off by placing a drop of solder on the tips of the axles.

Take your Swoose to the flying field and try some shoulder-high glides. Adjustments may be made by warping or adding weight until you are satisfied with the glide. If it stalls, cement a small piece of weight inside the nose. If it dives, first check the angle of incidence, and if this is correct add weight to the tail. Once a smooth glide has been obtained, do not use any extra weight for powered flights.

CHAPTER IV

PESCO SPECIAL

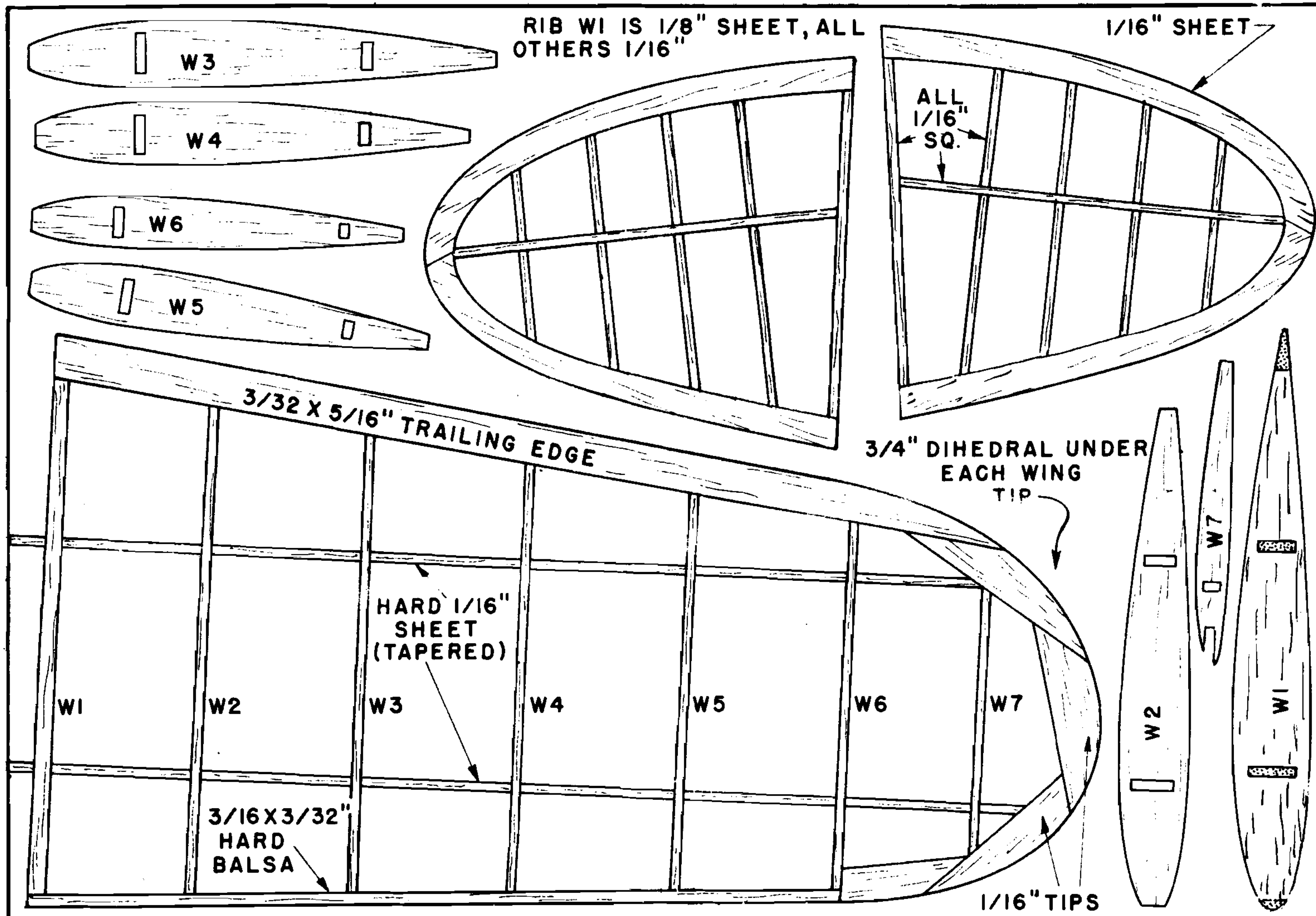
BEFORE THE PRESENT war one of the outstanding racers was the Pesco Special, in which Roscoe Turner won the 1938 Thompson Trophy Race. Averaging more than 283 miles per hour over the grueling 399-mile course, this ship was probably the fastest racer built incorporating a cantilever landing gear. Originally designed and constructed by Matty Laird, of Laird racing-plane fame, it was further worked on by Turner himself, with engineering assistance from Raoul Hoffman. This was one case in which too many cooks did not spoil the broth. Of several models constructed by the model designer, Paul Plecan, all showed plenty of speed, yet each was also a fine duration ship. Since the tail surfaces are ample and the fuselage so long, this model stands a good chance in contests when pitted against the ever-popular light plane flying scale models.

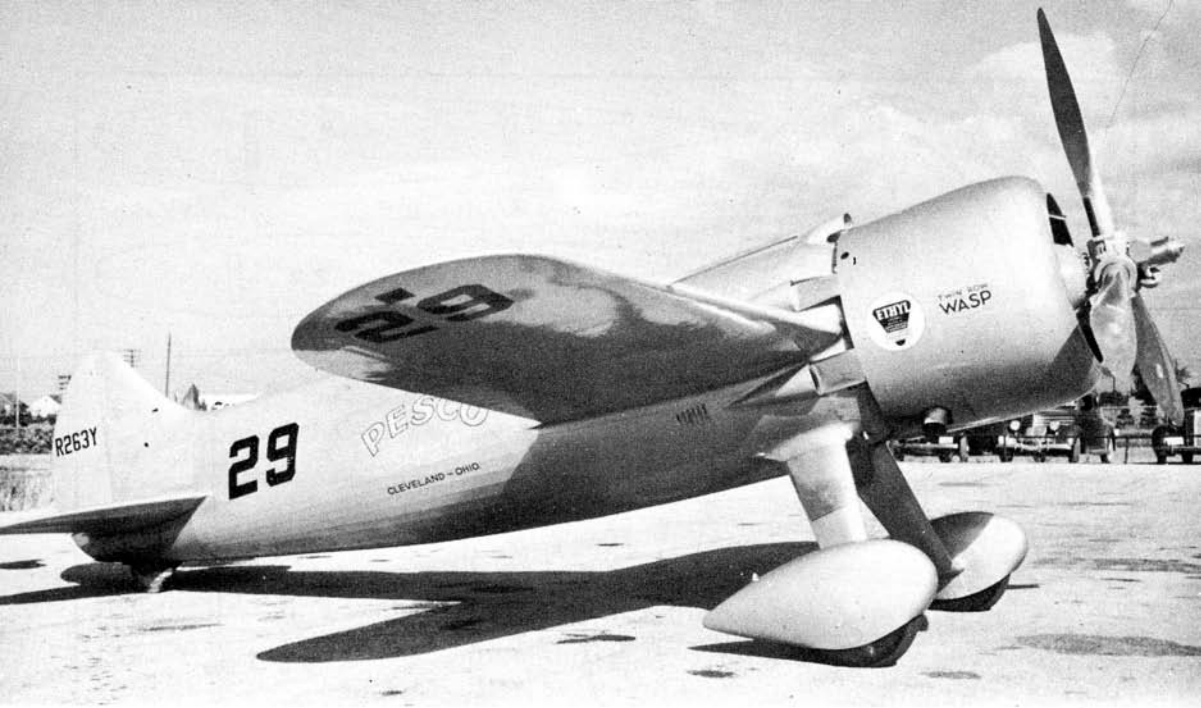
A folding propeller would improve the glide and, at the risk of losing a few points on appearance, an under-cambered airfoil could be employed. This is unnecessary, of course, if you just want a dependable flyer for your own pleasure.

The plans on the following pages may be brought to full size by enlarging them to 7″ by 10″, border measurement.

Fuselage

The first part necessary is the bottom keel strip, which is cut from 1/16″ sheet, as shown on the plans. Two of each indicated former, F-1 to F-10, are cut next. The fuselage may be constructed much more easily if the "half-shell" type of building is employed. This


RIB W1 IS 1/8" SHEET, ALL OTHERS 1/16"
1/16" SHEET
ALL 1/16" SQ.
W3
W4
W6
W5
3/32 X 5/16" TRAILING EDGE
3/4" DIHEDRAL UNDER EACH WING TIP
HARD 1/16" SHEET (TAPERED)
W1
W2
W3
W4
W5
W6
W7
3/16X3/32" HARD BALSA
1/16" TIPS
W2
W7
W1



Two views of Colonel Roscoe Turner's famous Turner-Laird Pesco Special racer. Powered with a Pratt & Whitney Twin Row Wasp engine of 1,250 h.p., this ship has been a consistent winner in air races. The upper picture shows details of the landing gear and cowling, and in the lower the cockpit arrangement and fuselage shape may be seen. *(William F. Yeager photos)*

means assembling the left half of the fuselage directly on the plan and then adding the other half. Stringers of 1/16″ square are added to the fuselage according to the spacing indicated by former F-6 plans.

Allow the cement sufficient time to harden before removing the half-shell fuselage from the drawing, as hurrying at this stage will invite warping. Once the fuselage has been assembled, attach the landing gear before covering the frame with tissue. The tail hook should also be secured to F-9 before covering.

The cowling is the next item to be made. The front portion is laminated from several rings of sheet balsa and then rounded off. Spacers keep F-1 and F-2 apart while 1/16″ sheet is wrapped around them for covering. The nose plug should be removable to allow winding the motor with a hooked hand drill. It should be stressed that when adding the landing gear, care must be exercised to keep both legs true so that the wheels will "track" evenly on take-offs.

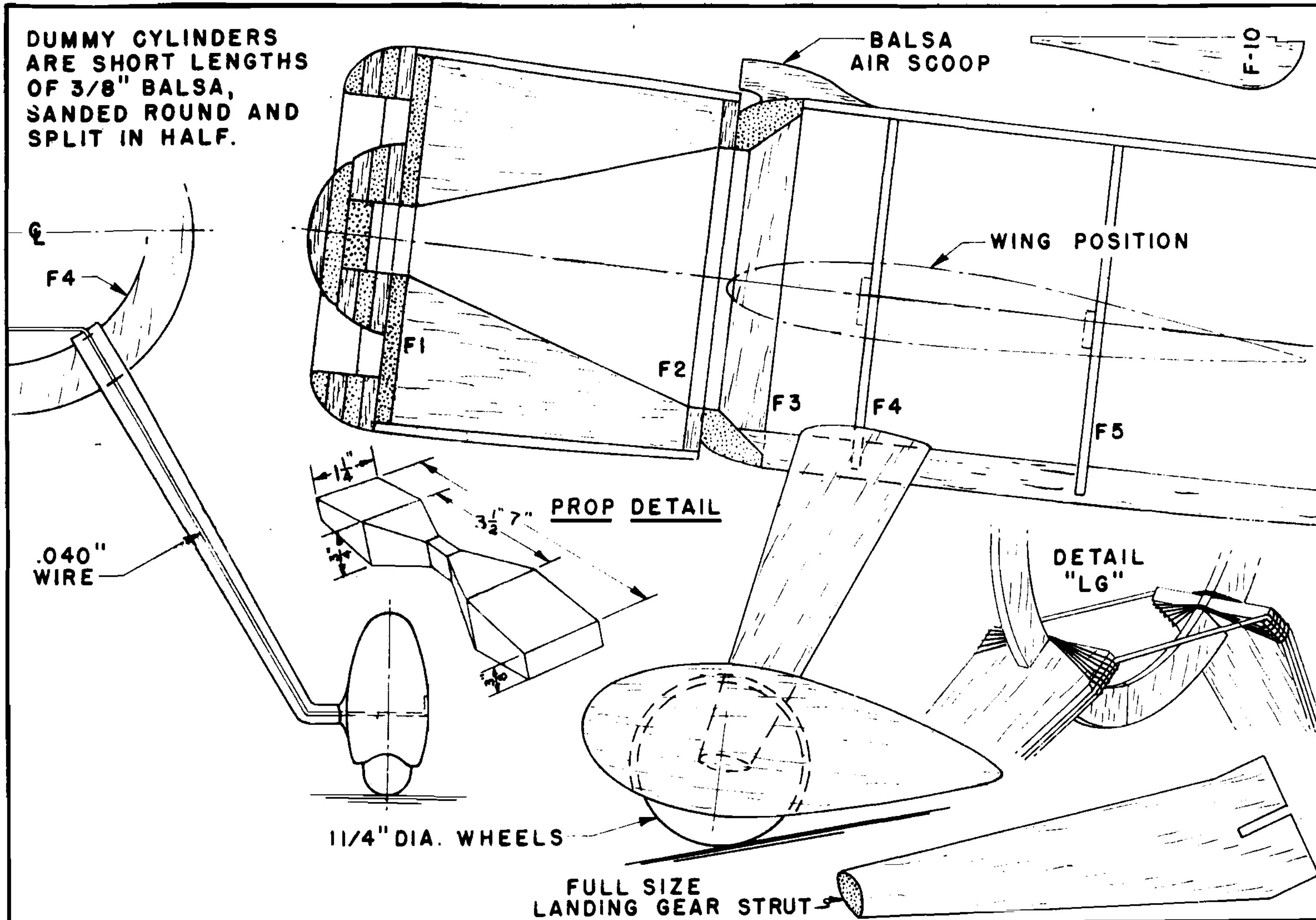
Wing and Tail

The wing is constructed in the usual manner, by sliding the ribs onto the spars. Watch for warpage when spraying the wing panels and, if necessary, weigh them down with a few tools to keep perfect alignment. Do this when doping the tail surfaces also.

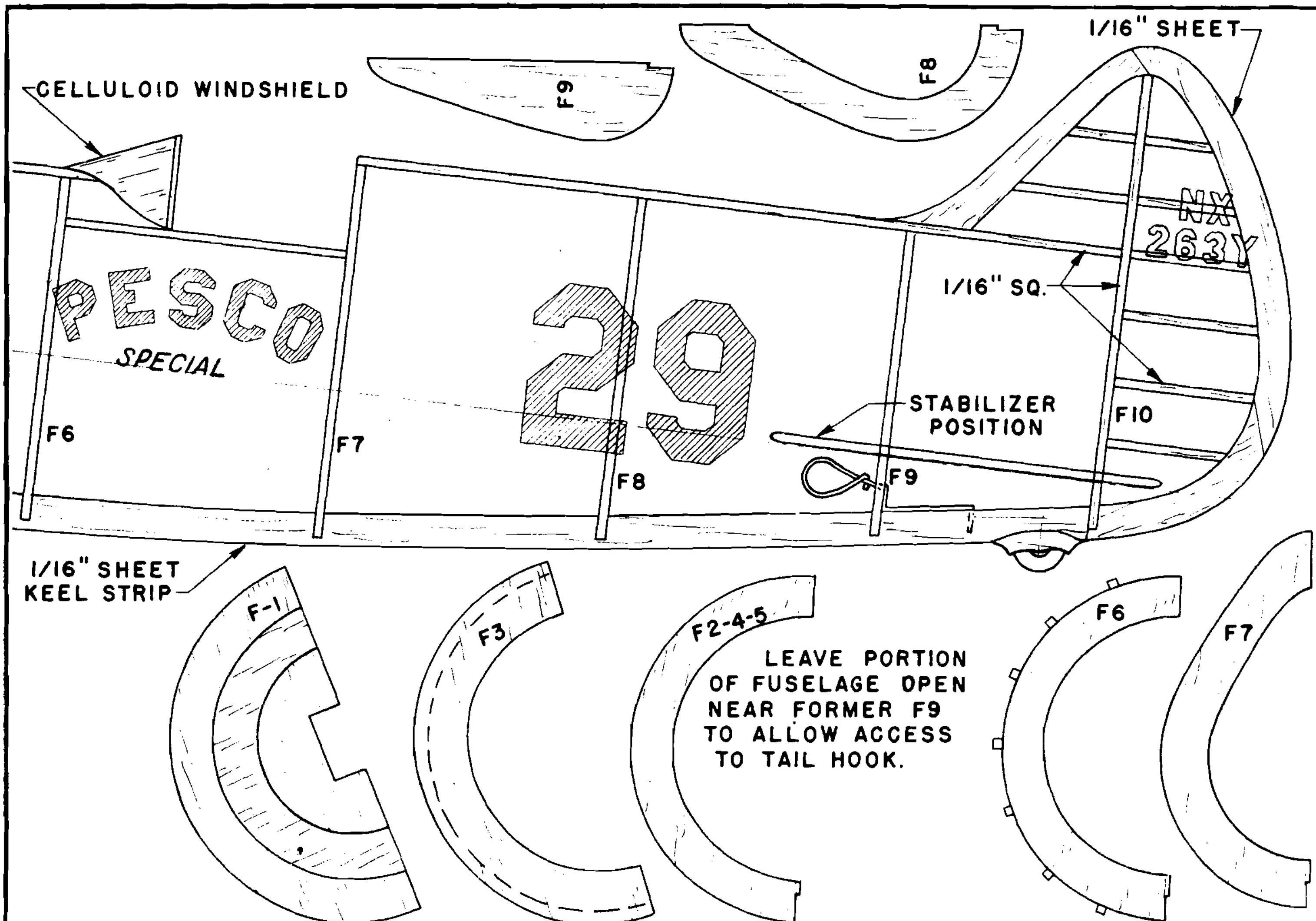
Two or three coats of silver dope are necessary, and when the appearance is satisfactory and alignment has been checked, slip the wings into position and cement securely.

The tail surfaces are so simple that little explanation is needed. Use 1/16″ stock, and when all trailing edges have been sanded, covering may be started.

A small air scoop is carved from soft stock and mounted on top of the fuselage directly behind the cowling. Engine cylinders may be added for a realistic effect, but they can be dispensed with in a flying model. Paint the cowling interior (and cylinders, if used) a



DUMMY CYLINDERS ARE SHORT LENGTHS OF 3/8" BALSA, SANDED ROUND AND SPLIT IN HALF.
BALSA AIR SCOOP
F-10
F4
F1
F2
F3
F4
F5
WING POSITION
.040" WIRE
PROP DETAIL
7"
DETAIL "LG"
11/4" DIA. WHEELS
FULL SIZE LANDING GEAR STRUT



CELLULOID WINDSHIELD
F9
F8
1/16" SHEET
NX
263Y
PESCO
SPECIAL
29
1/16" SQ.
STABILIZER
POSITION
F6
F7
F8
F9
F10
1/16" SHEET
KEEL STRIP
F-1
F3
F2-4-5
F6
F7
LEAVE PORTION
OF FUSELAGE OPEN
NEAR FORMER F9
TO ALLOW ACCESS
TO TAIL HOOK.

dull black. The nose block, representing the crankcase of the prototype, should be gray. Then add numerals to both sides of the fuselage, the top of the left wing, and the bottom of the right wing tip. The numerals should be "29" in each instance, in the style shown on the plans. Ink or black dope may be used, and for a neat job a draftsman's ruling pen should be employed.

The propeller is carved from a blank the size indicated in the drawings. A free-wheeling attachment is necessary, unless a folding prop is used. And if a "folder" is used, have the blades fold directly against the sides of the cowling.

Flying

Because of the model's stability, flying should be easy. First, test-glide the ship from a height of three to four feet. With the incidence correct, and balanced at the ⅓ chord position, the model should glide fairly well from the start. If it stalls, a little weight placed inside the fuselage will do the trick. And if the model dives, a bit of weight can be fastened near the tail. If the stalling or diving is very bad, raising the leading edge of the elevator will cure the stall, and lowering it will even out the dive. If the model glides well, give the propeller a few turns and try a take-off. Increase the number of turns until the model finally gets off.

Watch the model for eccentric behavior on each successive flight. A little down-thrust will cure stalling tendencies. If the model circles too tightly, check the incidence of each wing panel to make sure both are equal. Off-setting the propeller will control the circling under power, but warping the rudder will be necessary if a circling glide is desired. When you become familiar with the model's tendencies, adjust it for straight flight, just to see how fast it will go. More rubber can be used for high-speed flights, provided a narrow-bladed prop of higher pitch is used in conjunction with the extra rubber.

CHAPTER V

LILLIPUTIAN LIBERATORS

WHEN HOWARD AND Harvey Doering, 23-year-old twins operating a unique production department in an American aircraft plant, were twelve years old they were nicknamed "the Wright brothers" by their schoolmates because of their skill in building flying and non-flying airplane models. The nickname stuck as they progressed through high school, winning one model-plane contest after another. Once they finished in a tie for first place, the prize being free flight instruction, and the contest heads were compelled to give them both flying training.

On another occasion they made a plane that had a complete lighting system, engines, and upholstered seats in which there were 22 separate pieces of fabric. They spent thirteen months building the model and sold it for $1,500.

Their hobby resulted in the twins being engaged by Consolidated Vultee Aircraft Corporation's Field Division plant at Downey, California, to build Consolidated Vultee models in a department of their own in the huge factory.

Thus it is that, three years after leaving their father's machine shop for the aircraft plant, the twins have eight helpers on the world's most unusual assembly line, on which they turn out miniature Con-

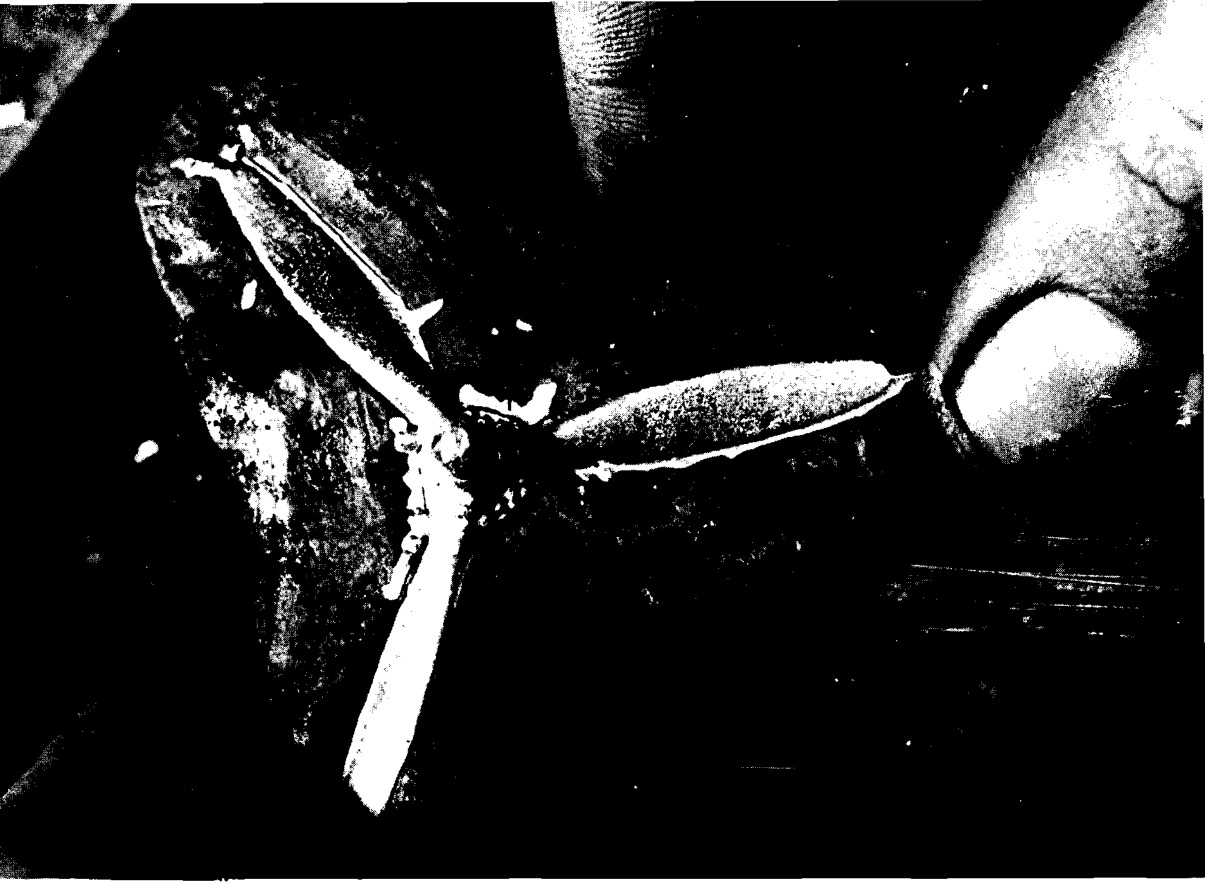
Harvey and Howard Doering, the 23-year-old twins who are in charge of Consolidated Vultee's model airplane department. The replicas they and their helpers turn out on their miniature assembly lines are exact in every detail. Harvey and Howard are shown here working on scale propellers for their models.

solidated Vultee Valiant trainers, Liberator bombers, Catalina and Coronado flying boats, and Reliant and Sentinel trainer and liaison planes.

These models are sent to Vultee representatives everywhere in the world for demonstration purposes, and to Army and Navy flying instructors who find them extremely useful in preflight courses to demonstrate theory of flight. The models are all-metal, like their big counterparts.

To prevent errors and eliminate all possible guesswork, blueprints are made of each design before actual construction work is begun. From these working drawings, the Doering twins make dies, jigs, and templates, following virtually the same procedure as employed in full-scale construction.

Furnaces improvised from oil cans and baling wire are used when molding the tiny propellers. The burner at the right is used to melt the metal, which is held above it in a special tray. Above the burner at the left is the mold into which the molten metal will be poured.

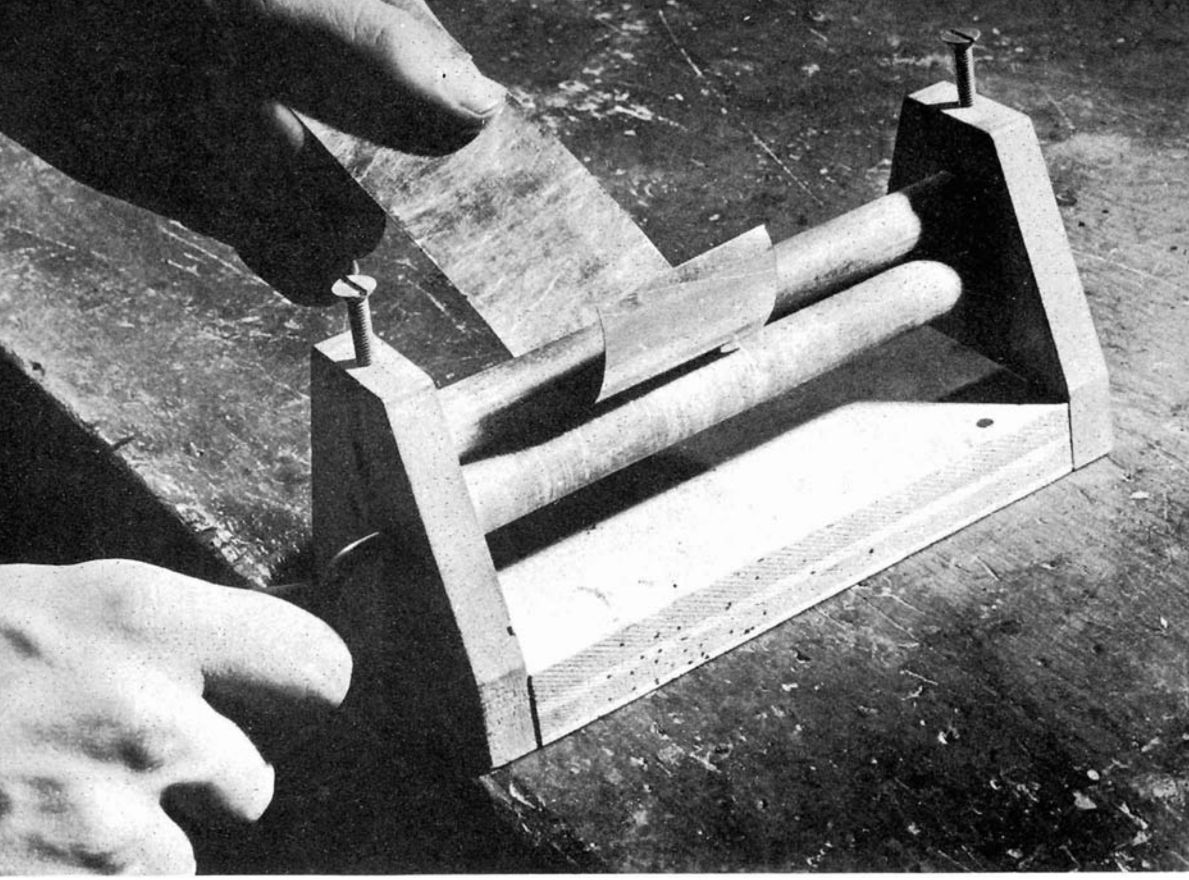


Bottom half of the mold into which the metal for the propeller was poured. After being removed from the mold, the propeller is filed to remove excess metal and other irregularities. Like other tools in the workshop, the propeller mold was also made by the Doerings.

"Ye Model Shoppe—Restricted Area" reads the sign over the door of the twins' department, and the "restricted area" is not just for a laugh, because a visitor would have no more chance of entering the twins' workroom than he would of getting inside the guarded experimental engineering department of Vultee Field Division, where new military plane designs are being built.

The twins get their materials from scrap heaps. Tin cans, motion-picture film containers, and scraps of sheet iron provide the metal.

Harvey illustrates how one of the tools he and his brother made enables them to make a straight cut on a large sheet of metal. The models that are turned out by the twins are used by the Army and Navy for instructing flying cadets; Consolidated Vultee representatives throughout the world also use them.



One of the unique tools built by the Doerings is this miniature roller, which is used to shape flat metal into curves. By turning the bolts on either side of the roller, different diameter curves may be made. More than 500 detailed models have been turned out by the department.

From designing board to final assembly, the production of the little planes is patterned after that of their big sisters, the models ranging in size from 2½ inches to 4 feet in span. More than 500 models have been turned out by the Doerings since they began work at Vultee Field Division.

In producing model planes, the twins first translate blueprints into a scale mock-up, a model whittled from wood. Then plaster casts are made of the parts of the ship which can be formed, such as

After preliminary shaping with the roller, some units are finished off by use of a forming block and mallet. The part being worked on here is an engine nacelle for installation on the left wing panel. Such close tolerances are used that many parts are interchangeable from plane to plane.

When fuselage parts have been completed, they are soldered together on the fuselage block. Ample solder is used in order to secure good joints, but later the excess is filed off so that a completely smooth surface is presented. Wing panels are made in like manner.

fuselage halves. From these, kirksite dies are poured, just as are the big dies used to make bulkheads or formed parts for full-size ships.

Tiny templates, exact even to allowances for the stretching of the metal in its bending, provide patterns for cutting the parts from flattened tin cans. It is just like a big plant's sheet-metal department, except that tin snips and paper cutters are used instead of circle shears and punch presses.

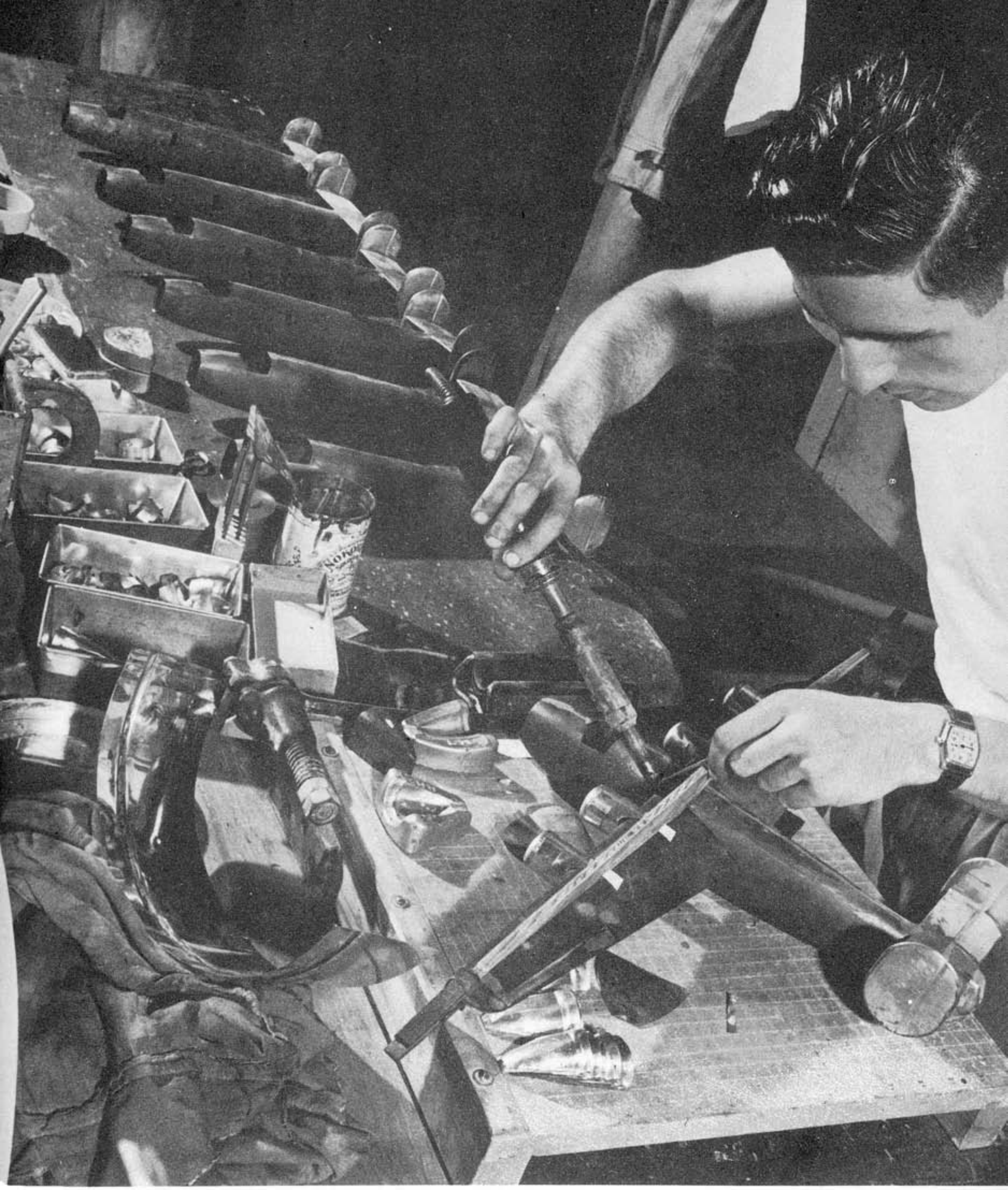
Into the miniature dies go the little blanks, to be squeezed into

Bench vises provide the pressure for forming many of the assembly units. Here sheet sponge rubber, like that used on giant hydro-presses for full-size airplane parts, aids in the forming operation. Note also that a curved wood block is used behind the rubber.

The model shop at Consolidated Vultee has grown from a two-man proposition to a ten-man department. Two of the eight helpers are shown here; one is working on B-24 Liberator models, and the other is putting final touches on Vengeance dive-bombers with Royal Air Force markings.

shape between the jaws of a vise. Some of the model-plane parts cannot be formed that way, however, so the dies are bolted into place on drop hammers and units are made on the same machines that turn out parts for the big ships. Other parts are formed by hand on wood blocks.

After the forming comes the trimming, and then the assembly. Soldered together piece by piece, the planes take shape. Wing panels are added to the fuselage, tail sections are assembled and put in place, and engines, propellers, wing tips, and ailerons are added.



Wing panels and engine nacelles being soldered in place on the final assembly line. The worker is using a jig made of a strip of plywood and two clothespins to hold the wing in its correct position while soldering.

Artists' airbrushes are used to paint the models, which are faithful to the real airplane even to such details as exact layout and shade of camouflage. A helper is here doing a final touch-up on a completely assembled and finished model.

Finally the joints are smoothed with file and emery paper, and the models are painted with small spray guns. The models are so detailed, in fact, that even ripcord rings are discernible on parachutes accompanying each ship.

The Doering twins have been classified 1A in the draft. Both tried for the Air Forces and failed, since they were too short for the requirements. Each has ten hours of solo flight to his credit. They plan to build full-size planes of their own design at some future date.

CHAPTER VI

MARTIN B-26 MARAUDER

ONE OF THE MOST OUTstanding medium bombers of this war is the Martin B-26 Marauder. Super-streamlined, the B-26 slices through the air at better than 350 miles per hour and is one of the fastest bombers in service with any nation. Needless to say, plenty of power is required, and under her sleek cowlings roars a total of 3,700 horse power—more than has ever before been packed into a ship of the Marauder's size. But in their quest for speed, Martin engineers did not overlook other important factors. A substantial bomb load and range go along with plenty of defensive power in the form of large-caliber machine guns placed advantageously. Reports from active war zones indicate that these winged Marauders can maul and batter their way through virtually any number of opposing interceptor fighters.

Novel in design, the B-26 introduced many new ideas in the medium-bomber class, most outstanding of which are the twin-gun turret, tail-gun position, and four-bladed "cuffed propellers" of 13 feet 6 inch diameter. The large props are necessary to absorb the high power of the engines and provide adequate blade area at high altitudes, where the air is thin.

Since this is a solid model, you can save your very scarce supply of balsa for flying jobs. Sugar pine is easy to obtain, and there are always enough fruit crates from which the enterprising modeler can gather material.

Our model B-26 Marauder was designed by Paul Plecan, that extremely popular and versatile model engineer who has presented so many fine models of all types to the building market.

Fuselage

Start by choosing a block of ample size for the fuselage, depending, of course, on the size model you contemplate. After tracing the side view onto the block, by using carbon paper, cut the outline to shape with a jig saw. Using the same system, trim the top outline shape. It is suggested that the wing opening be cut in the fuselage before actual carving is started. If done on an engine-driven jig saw, the opening can be cut accurately to ensure a true line-up later when the model is assembled. In any case, be sure to get the proper contours of this opening, so that the wing will fit snugly. If you wish, you can make a set of templates to assist in carving the cross-section of the fuselage more accurately.

The fuselage is nearly round in cross-section, so take care in sanding so that the finished product is smooth and does not contain humps or hollows which will become more noticeable when the model is painted. And since it is quite difficult to make a celluloid turret unless you have a lathe and a block of the extremely scarce celluloid, you can get by with a smooth wood turret painted white and finished off with gloss solution until it glistens like the original Plexiglas.

Wing and Tail

The wing is simple to make, as it need only be cut to outline and then sanded to shape; the cross-sections for sanding are shown on the plans. Again you will have to exercise care, as the joint between the wing and fuselage should be very neat. If you should err a bit here and there, a little Plastic Wood will fill in where necessary after the wing has been attached to the fuselage.

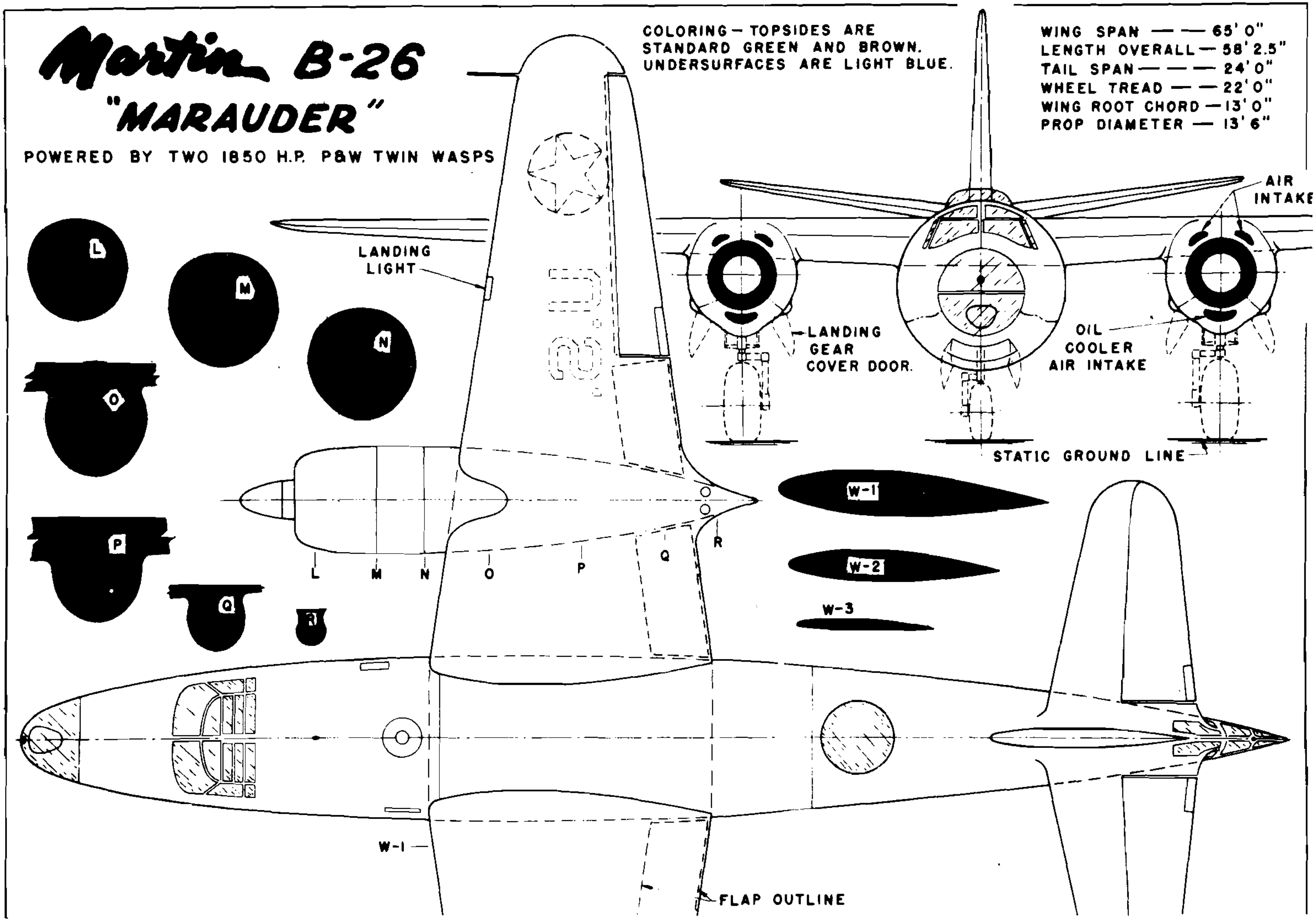
The tail surfaces are easy to make inasmuch as they are plain in shape. After tracing the outlines onto wood of the necessary thickness, sand to a streamlined cross-section. Note that when the stabilizer is cemented in place each tip should be propped up slightly to obtain the necessary degree of dihedral. As the cement dries, check the line-up to see if the shrinking cement has pulled the tail surfaces out of alignment.

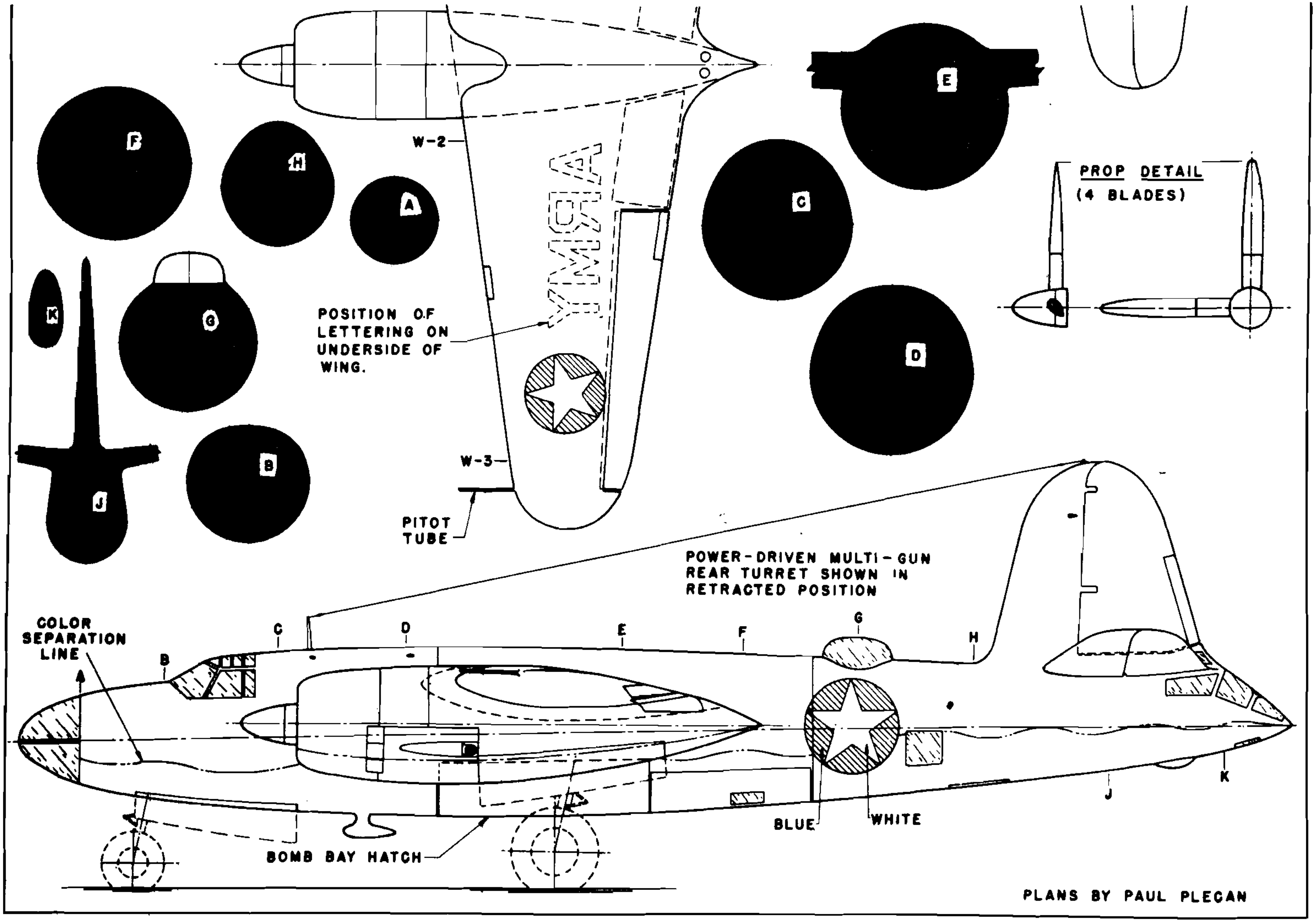
Assembly and Painting

The cowlings are the next parts to roll off your production line. Construction is similar to that of the fuselage, but a little more difficult and tricky as the parts are smaller and of irregular cross-section. Although the cross-sections would ordinarily be round, the air scoop on the bottom and the two on the top change the appearance so that the tops of the cowlings are nearly flat and the bottoms rounded to a slight bulge. Cementing of the nacelles will have to be done carefully as there are several things to watch out for.

First, be sure that both nacelles point directly forward without any "toe-in" or "toe-out." This can be checked by looking at the model from directly above or below. Next, watch for the up-thrust or down-thrust, as both nacelles should point forward with possibly a little up-thrust to the center line of the fuselage.

The rest of the construction depends largely on whether you intend hanging the model up to simulate flight or whether you want to set it on a base. If the model is to be suspended with fine wires or thread, leave off the landing gear and use celluloid discs in front


Martin B-26
"MARAUDER"
POWERED BY TWO 1850 H.P. P&W TWIN WASPS
COLORING — TOPSIDES ARE STANDARD GREEN AND BROWN. UNDERSURFACES ARE LIGHT BLUE.
WING SPAN — — 65' 0"
LENGTH OVERALL — 58' 2.5"
TAIL SPAN — — — 24' 0"
WHEEL TREAD — — 22' 0"
WING ROOT CHORD — 13' 0"
PROP DIAMETER — 13' 6"
AIR INTAKE
LANDING LIGHT
LANDING GEAR COVER DOOR.
OIL COOLER AIR INTAKE
STATIC GROUND LINE
L
M
N
O
P
Q
R
W-1
W-2
W-3
FLAP OUTLINE



PLANS BY PAUL PLECAN

of the nacelles to simulate revolving propellers. However, if you are one of those modelers constantly seeking detail, include your four-bladed props, landing gear cover doors, machine guns, radio aerial, and so on.

A few hints on finishing are also in order. All portions that are glass-covered on the original aircraft are painted white. Finished off with a gloss solution, they should be made to glisten and gleam before you can consider them finished. Then they should be put aside while the model itself is being colored.

If you do not have a spray outfit of some sort among your tools try to borrow one, as spraying is the best way to get the colors to blend gradually from the olive-drab topsides to the light blue necessary for the undersurface of the model. Be sure that the paint has been thinned sufficiently before spraying, as a thick mixture will not come out in a fine, misty spray.

If you have used hardwood in constructing the model the appearance will be smooth without too much effort on your part, but if balsa has been used be sure to use a wood filler to hide the pores.

The only items remaining on the production schedule are insignia and lettering. Decal insignia, now readily available at the larger hobby shops, will simplify this phase of decoration. Merely soak in water and slip them on the model at the correct positions. Lettering is done best with pen and ink, but it may be necessary to rub a little talcum powder on the surface before the ink will stay put where you want it.

All control areas can be simulated by scribing them with a knife or other sharp object. They can also be indicated very neatly if you are adept at handling a ruling pen and triangle. And after you have removed the masking tape from your model, you should have something to display with understandable pride.

CHAPTER VII

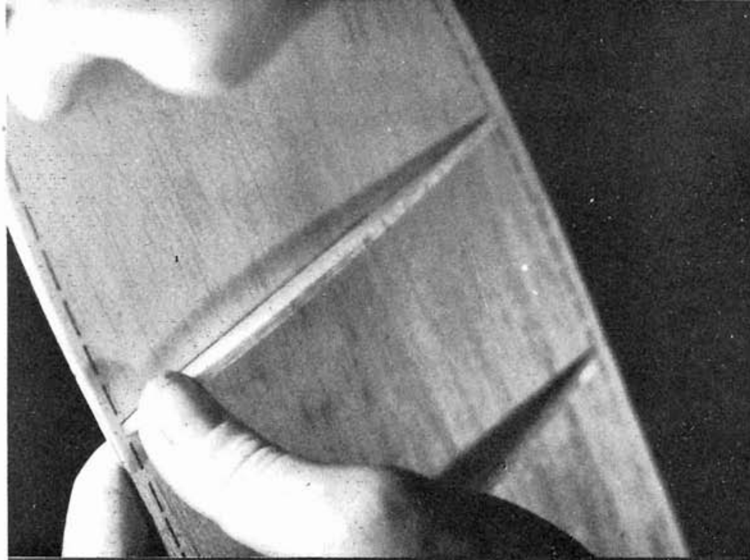
AMERICAN JUNIOR FIREBALL

JIM WALKER, OF PORTland, Oregon, designed a remarkable model airplane in the American Junior Fireball. An entirely new type of plane in both design and construction, its U-control system of operation is as far removed from usual model-airplane flying as an obsolete twin pusher is from a Wakefield winner. A slight turn of the wrist makes the Fireball climb, power dive, hedge hop, or loop. With U-control, a model builder can fly anywhere at any time—daylight or dusk, windy weather or calm—for he is the actual pilot. Instead of leaving the model to the whims of thermals and wind currents, the builder can stand in one spot and make the Fireball obey virtually his every wish. Moreover, the ship can fly at speeds of from fifty to ninety miles per hour—and with a model that's really stepping!

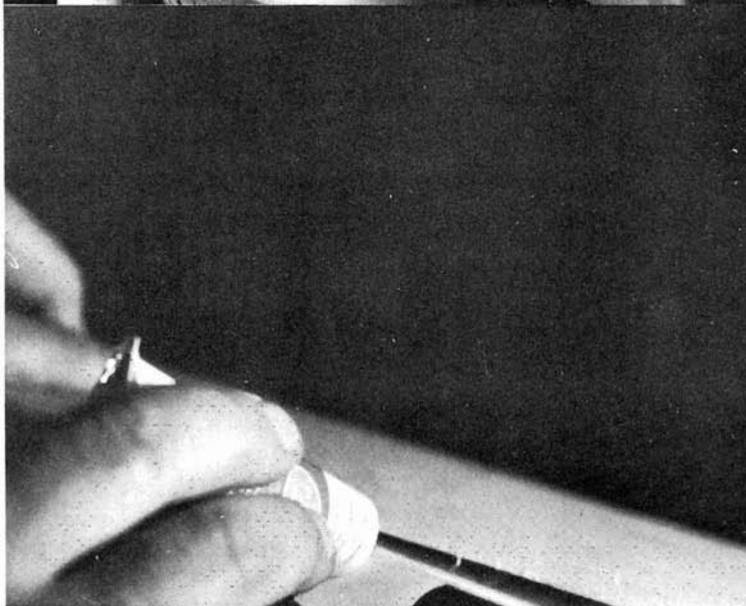
Because the Fireball is a specialized type of model airplane, it is necessary to utilize the detailed kit and follow a special construction procedure in building. Therefore it would be at best a difficult task to build the plane from only working drawings as they could be presented here. This chapter, instead of actually giving plans for the model, is for the express purpose of familiarizing the reader with the ship. The drawings on the following pages were prepared by the American Junior Aircraft Company for inclusion in the Fireball kit, and they are reproduced here by special permission.

Jim Walker, designer and builder of the Fireball, flying his amazing little model upside down. With U-control, the Fireball can be put through a series of maneuvers which are impossible with the average model. Either a Class B or C engine may be used.

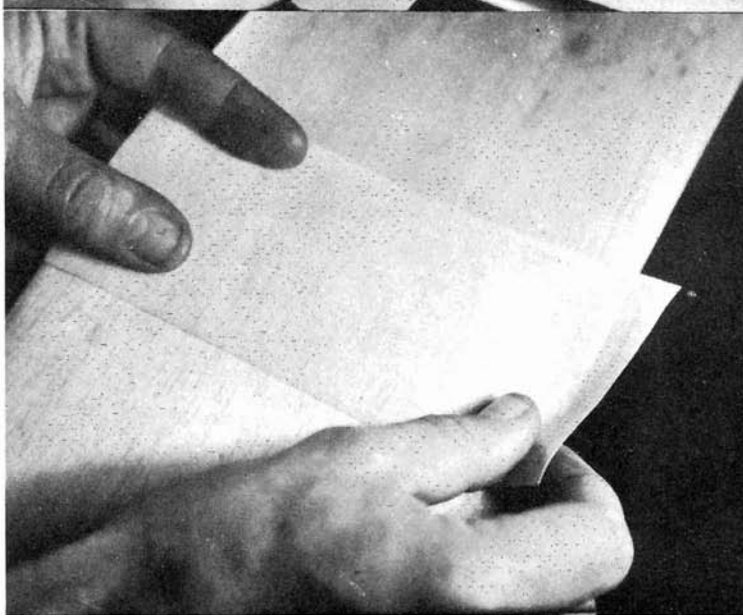
In the complete Fireball kit all construction units are ready-made. This photograph shows a rib being cemented to one of the wing panels. Made completely of balsa, the model is able to attain speeds of up to 90 m.p.h.



After all ribs have been cemented to one side of the wing, the top of the wing is added. The last step in finishing the panel is fastening down the leading edges. This picture illustrates the correct procedure in adding cement.



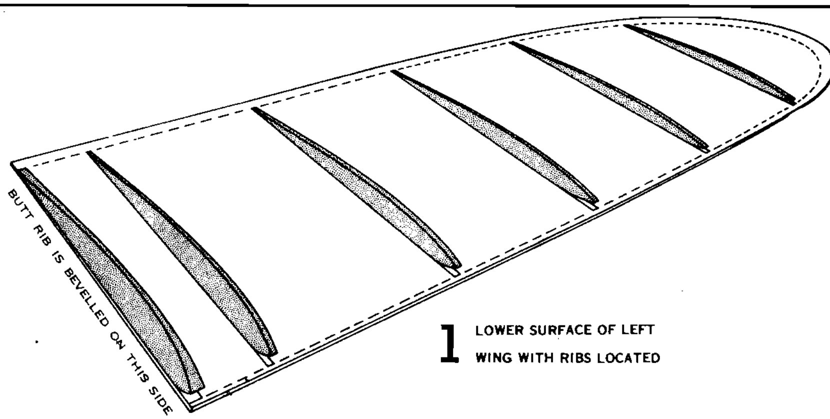
The two wing panels are joined at the butt ribs, with the tips at the correct dihedral angle. After the joint has dried, a strip of crinoline is cemented across the wing to make for greater strength.



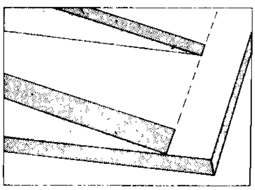
Jim Walker, designer and builder of the Fireball, flying his amazing little model upside down. With U-control, the Fireball can be put through a series of maneuvers which are impossible with the average model. Either a Class B or C engine may be used.

Jim Walker inspects the pylon and control lines before making a flight. Since this is more or less a remote-control arrangement, it is necessary that all details be in perfect operating order. Otherwise, crack-ups at high speed may be expected.

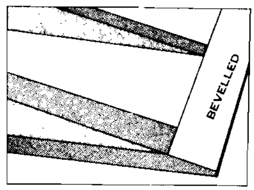
With pylon control, a model flyer may stand on the outside of the flight circle and direct the Fireball. This system does away with the necessity for the builder, as the center of the circle, to turn constantly in his tracks.



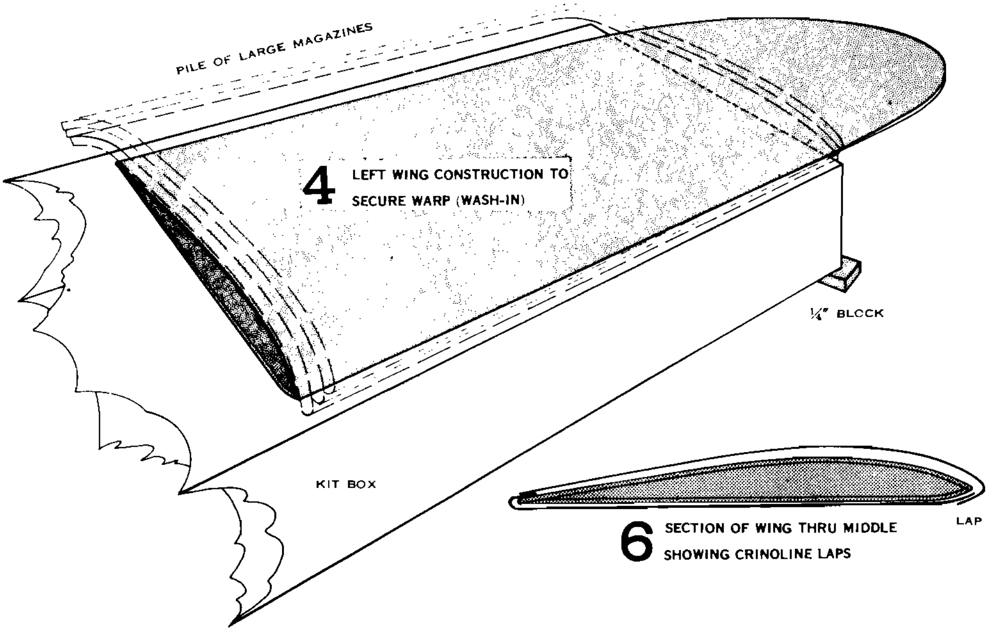
1 LOWER SURFACE OF LEFT WING WITH RIBS LOCATED



2 DETAIL OF RIBS CEMENTED TO WING SURFACE BEFORE BEVELLING



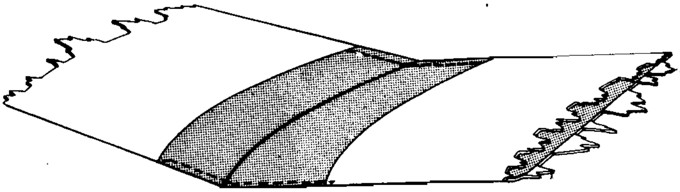
3 EDGE OF WING AFTER BEVELLING



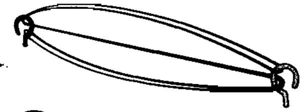
4 LEFT WING CONSTRUCTION TO SECURE WARP (WASH-IN)

6 SECTION OF WING THRU MIDDLE SHOWING CRINOLINE LAPS

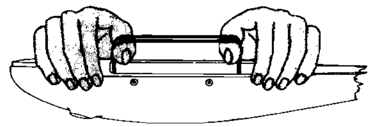
5 METHOD OF CEMENTING WING HALVES, SHOWING BLOCKS TO HOLD TIPS 2¼" HIGH



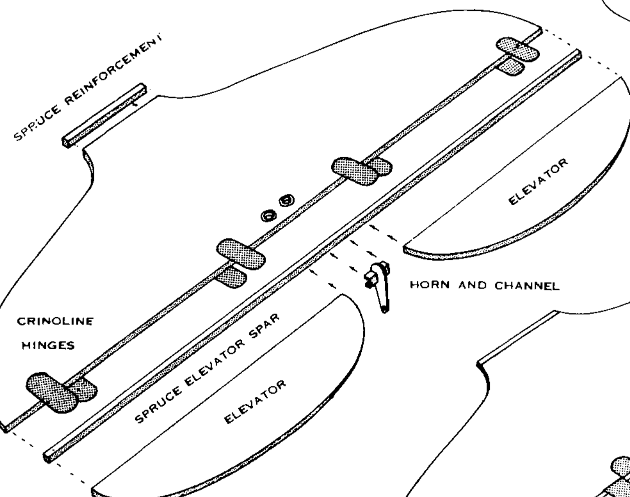
7 MIDDLE PORTION OF WING SHOWING CRINOLINE REINFORCEMENT



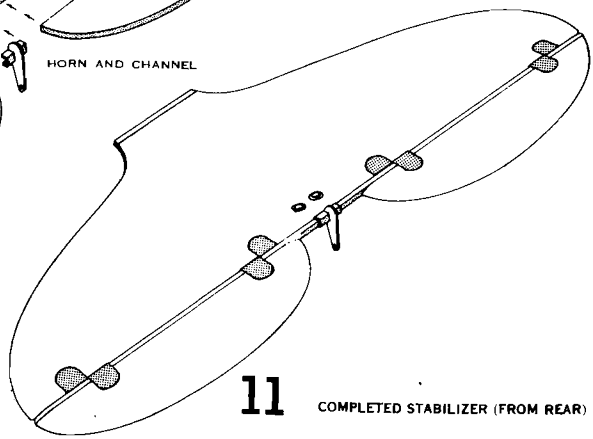
8 DIAGRAM OF LOOPING RUBBER BANDS TO ATTACH WING TO BODY



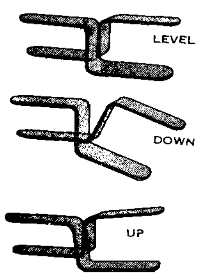
9 HOLDING RUBBER BANDS TO ATTACH WING TO BODY



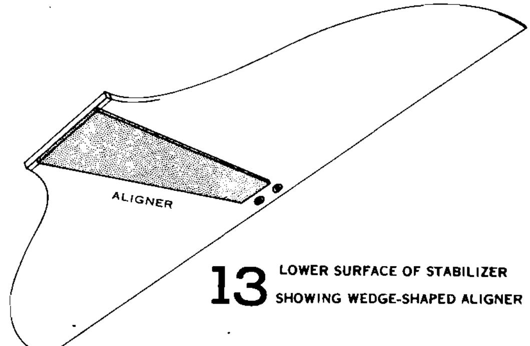
10 ARRANGEMENT OF PARTS FORMING STABILIZER (FROM REAR)



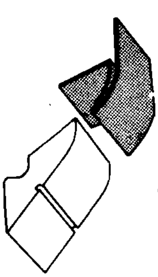
11 COMPLETED STABILIZER (FROM REAR)



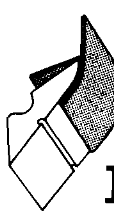
12 ACTION OF CRINOLINE HINGES



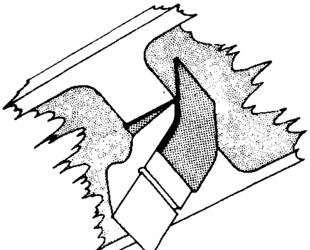
13 LOWER SURFACE OF STABILIZER SHOWING WEDGE-SHAPED ALIGNER



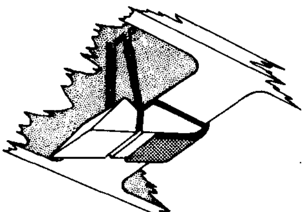
14 SNAP-CATCH BLOCK AND FOLDED CRINOLINE



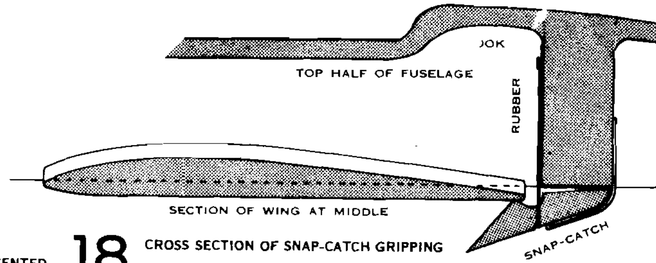
15 CRINOLINE HINGE CEMENTED TO SNAP-CATCH BLOCK



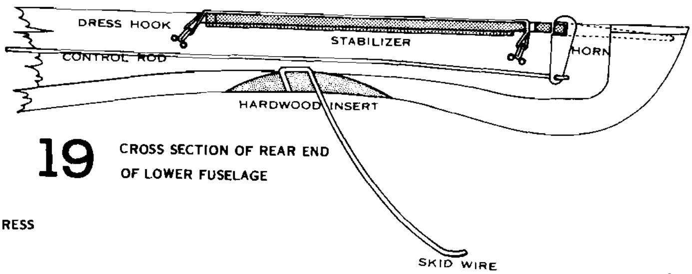
16 SNAP-CATCH BLOCK WITH HINGE CEMENTED TO BOTTOM AND REAR OF BULKHEAD



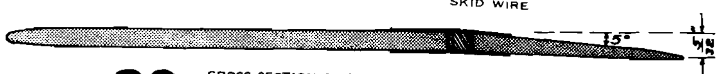
17 SNAP-CATCH COMPLETE WITH DRESS HOOKS AND RUBBER BANDS



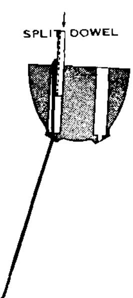
18 CROSS SECTION OF SNAP-CATCH GRIPPING TRAILING EDGE OF WING



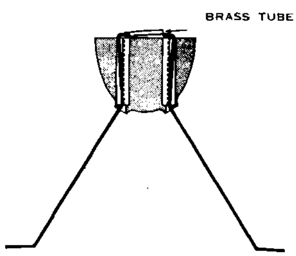
19 CROSS SECTION OF REAR END OF LOWER FUSELAGE



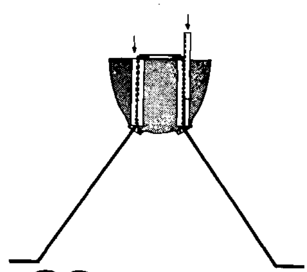
20 CROSS SECTION OF STABILIZER. SHOWING MEASUREMENT FOR MAXIMUM DOWN ANGLE OF ELEVATORS



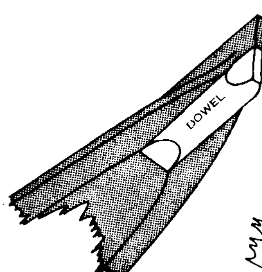
21 SECTION OF BODY SHOWING ASSEMBLY OF LANDING GEAR



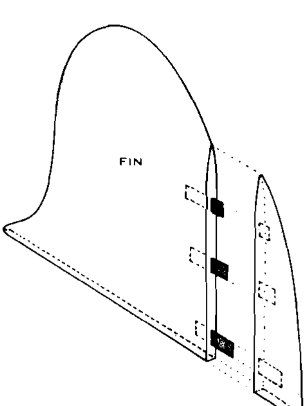
22 INSERTING WIRE ENDS INTO BRASS TUBE



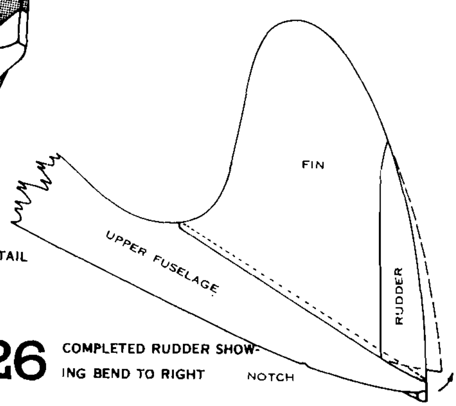
23 INSERTING LAST DOWEL TO LOCK LANDING GEAR



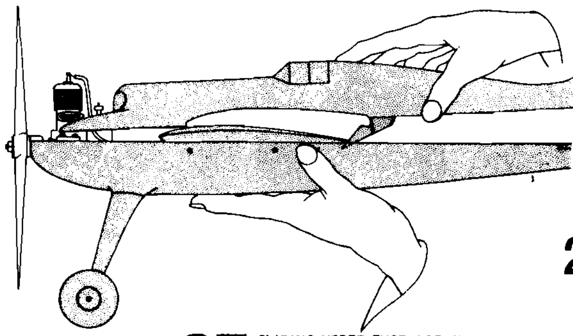
24 DOWEL CEMENTED TO TAIL OF FUSELAGE (TOP)



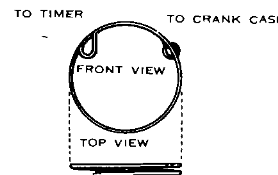
25 DIAGRAM OF RUDDER SHOWING STAGGERED HINGES



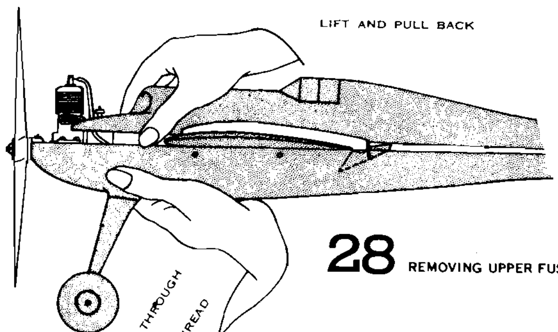
26 COMPLETED RUDDER SHOWING BEND TO RIGHT



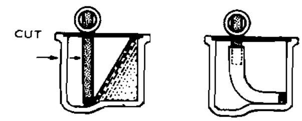
27 SLIDING UPPER FUSELAGE IN PLACE ON BODY. NOTE TIP OF SNAP-CATCH SLIDING BELOW WING



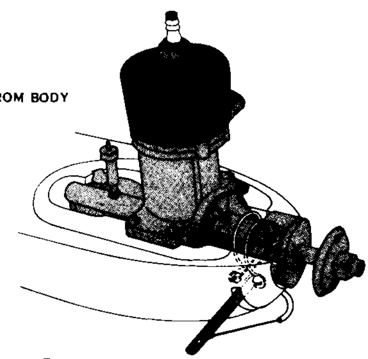
29 TWO VIEWS OF MOTOR CONTROL SPRING, SHOWING HOOK AND EYE FOR ATTACHMENT TO OHLSSON 23



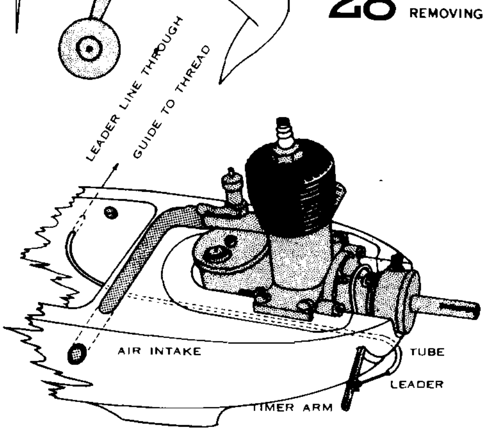
28 REMOVING UPPER FUSELAGE FROM BODY



30 SECTIONS OF GAS TANK BEFORE AND AFTER INSTALLING DUPRENE TUBING



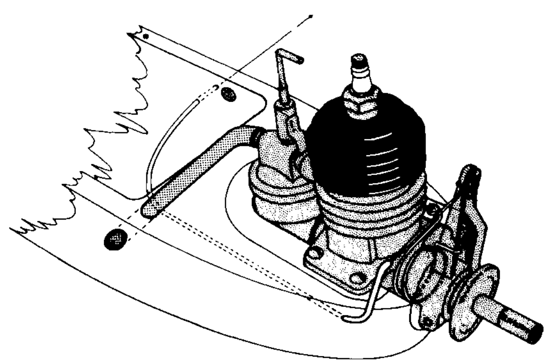
33 INSTALLATION OF FORSTER MOTOR WITH MOTOR CONTROL



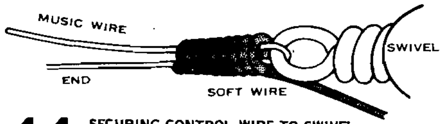
31 INSTALLATION OF OHLSSON MOTOR WITH MOTOR CONTROL AND INTAKE TUBING

Specifications

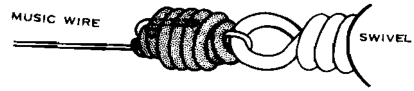
Wing Span	36″
Fuselage Length	25¼″
Flying Weight	20 oz.
Motor	Class B or larger
Flying Speed	50-90 M. P. H.



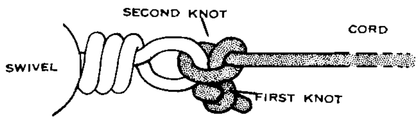
32 INSTALLATION OF BROWNIE MOTOR WITH MOTOR CONTROL AND INTAKE TUBING



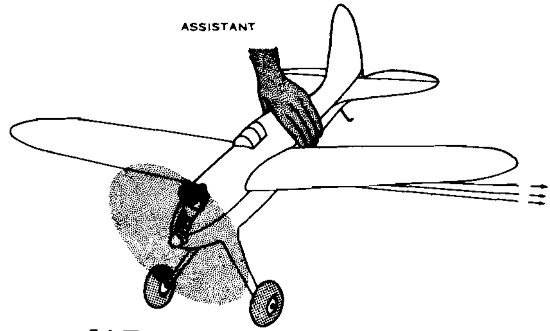
44 SECURING CONTROL WIRE TO SWIVEL
FIRST LAYER OF IRON WIRE



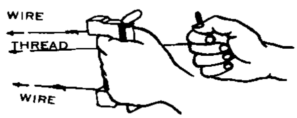
45 SECURING CONTROL WIRE TO SWIVEL
SECOND LAYER OF IRON WIRE



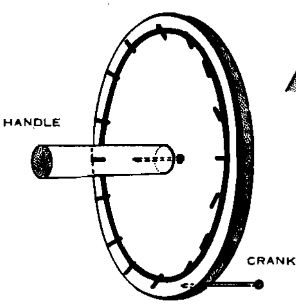
46 SIMPLE METHOD OF FASTENING
CORD TO SWIVEL EYE



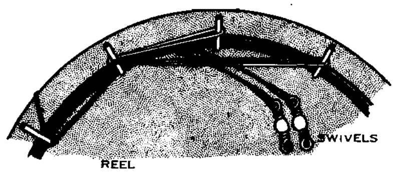
47 ASSISTANT HOLDING PLANE FOR TAKE-OFF



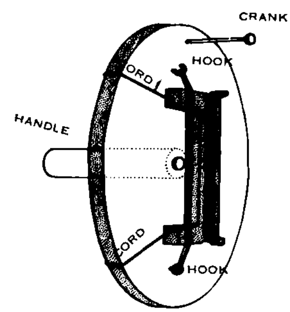
48 "U-CONTROL" IN LEFT HAND, MOTOR
CONTROL LINE IN RIGHT



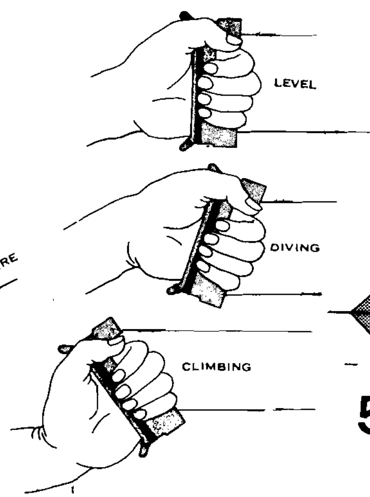
49 REEL FOR CONTROL
WIRES (HANDLE SIDE)

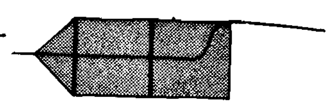


50 DETAIL OF REEL SHOWING RUBBER
BAND HOLDING ENDS OF WIRES

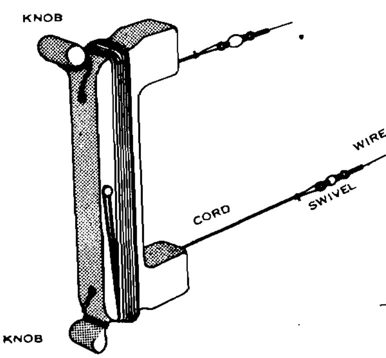


51 REEL FOR CONTROL
WIRES (CRANK SIDE)





54 WINDSHIELD ASSEMBLED



53 "U-CONTROL" HANDLE WITH CORD
ATTACHED TO TWO CONTROL WIRES

52 FLYING POSITIONS OF HANDLE: FOR LEVEL
FLIGHT, DIVING, AND CLIMBING

CHAPTER VIII

PIPER HE-1 AMBULANCE

ONE OF THE LATEST additions to our Navy's air force is the Piper ambulance plane, officially designated as the HE-1. This plane was developed from the commercial Super Cruiser, and it is powered by a 100-h.p. Lycoming engine. The only visible difference between the naval and the civil versions is the hinged section of the fuselage on the Navy ship, which is removable to admit a stretcher. On later models the cowling appears to have been altered slightly. However, this model, which was prepared by Alfred Cleave from factory plans, is a replica of the original. If the builder wishes to use the newer cowling, it is a relatively simple matter to make the minor necessary changes by consulting photographs.

The model presented here is of simple, orthodox construction, and if a good job is done in building it will give its owner many hours of realistic flying pleasure. Before construction is begun, trace the plans on a single sheet of paper, after scaling-up or having photostats made, joining the sections at the proper places. After selecting the wood to be used in building, you are ready to start work on your replica Piper HE-1.

Fuselage

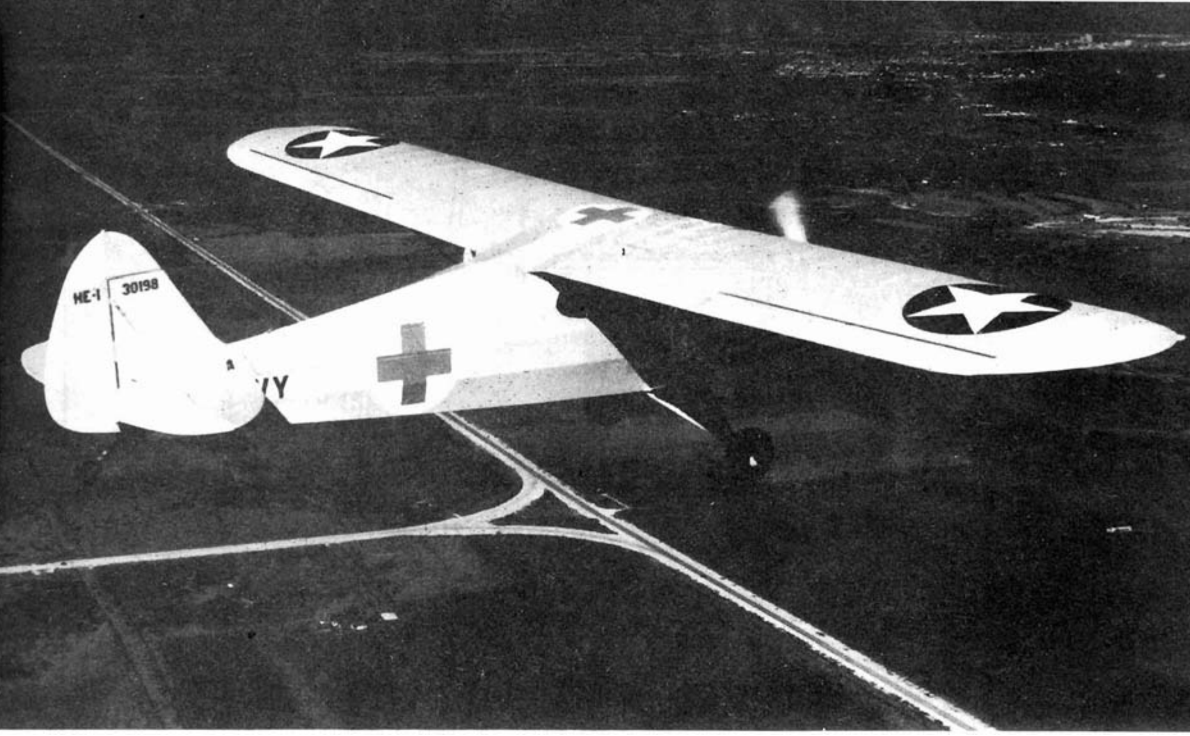
Pin the 3/32″-square longerons in place on the side-view plan and cement the cross-members in their positions. The basic framework is shown by the shading of the members on the plans. It is better to construct both sides at one time, one on top of the other, to ensure the sides being identical. Be sure to place a sheet of waxed paper over the plans to prevent the cement from adhering to them. After the cement has dried thoroughly, lift the fuselage sides from the plans and separate them.

Cut the cross-members from the top view to the proper length and assemble the two sides, starting at the widest point and working toward the front and rear. Check constantly to be sure that the structure is aligned correctly. Then cut the formers to shape from 1/16″ sheet and cement them in position. After the joints are firm, cement the 1/16″-square stringers in place, taking care to make neat joints where they touch the formers.

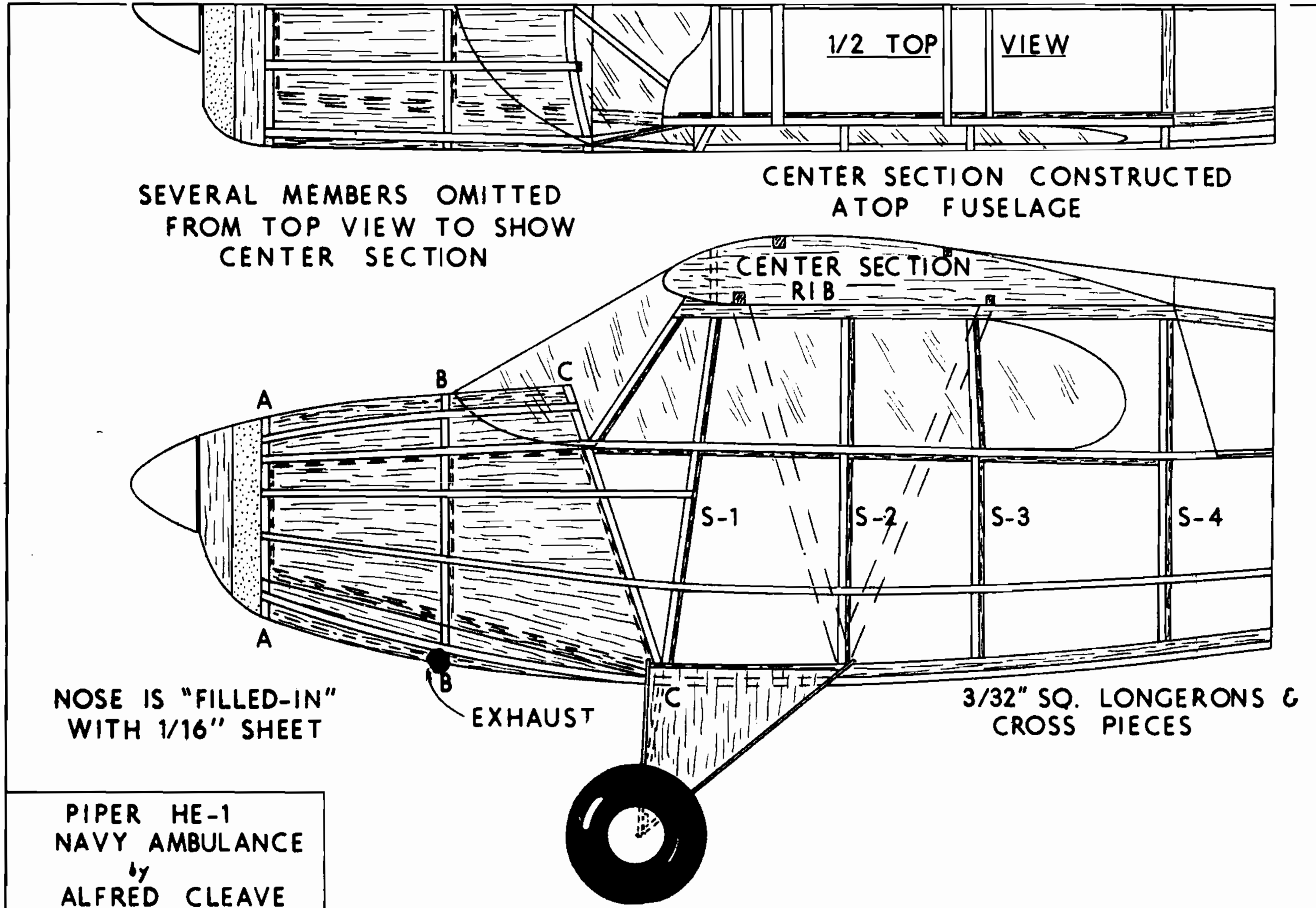
The top stringer, from the wing back, is cut from 1/16″ sheet but is not cemented in place until the wing center section has been built. This is constructed directly atop the fuselage, and since the wing alignment depends on it, be sure it is correct.

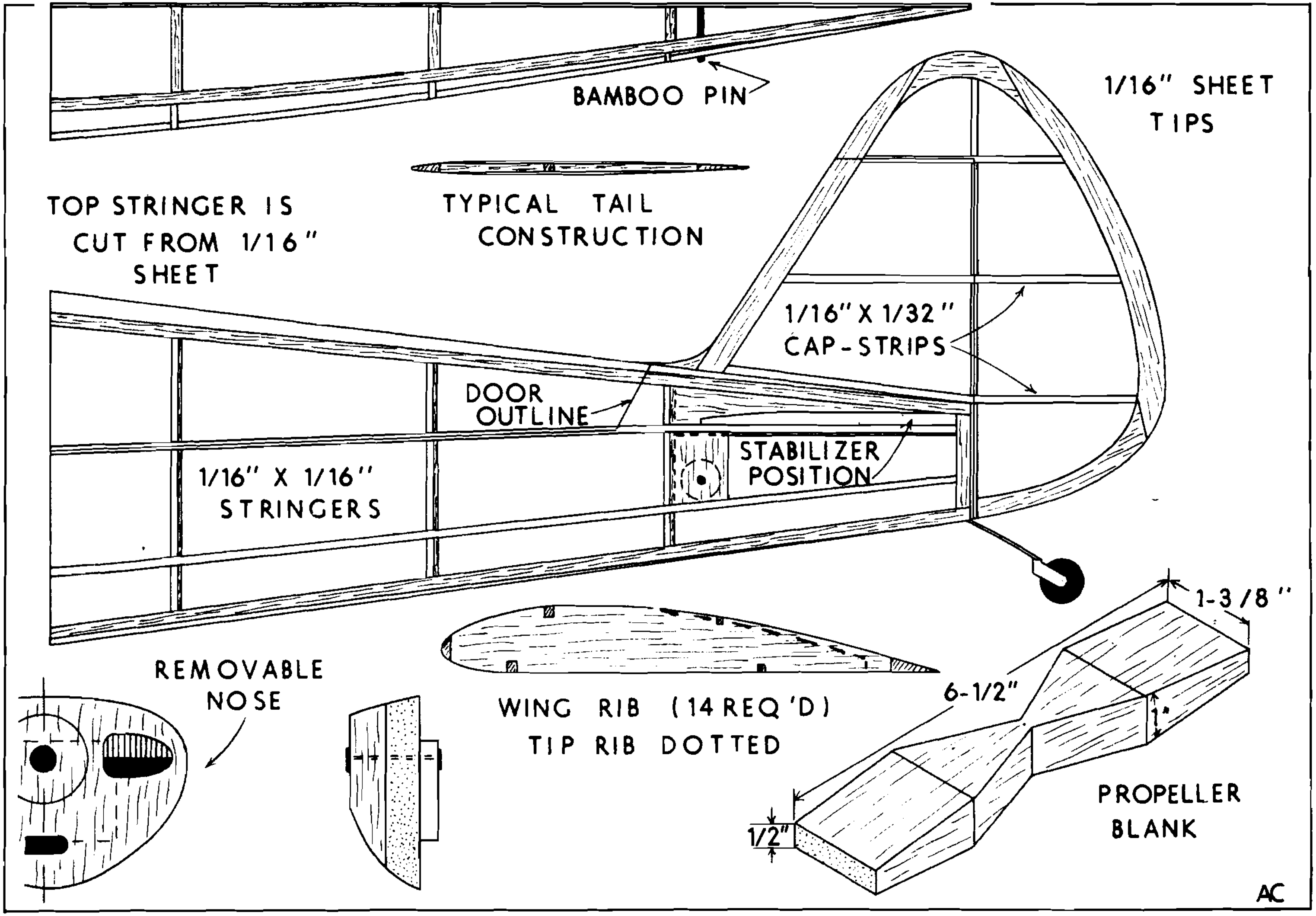
Note that the leading edge of the center section consists of a piece of 1/16″ sheet, the position of which is shown by dotted lines on the side view of the center section. Also note that on the bottom the center stringer extends back only as far as section C-C, and that the two other stringers extend the length of the fuselage. Cut sections of very soft 1/16″ sheet to shape and cement them in their places to form the "fill-in" of the nose, being careful that the pieces fit neatly.

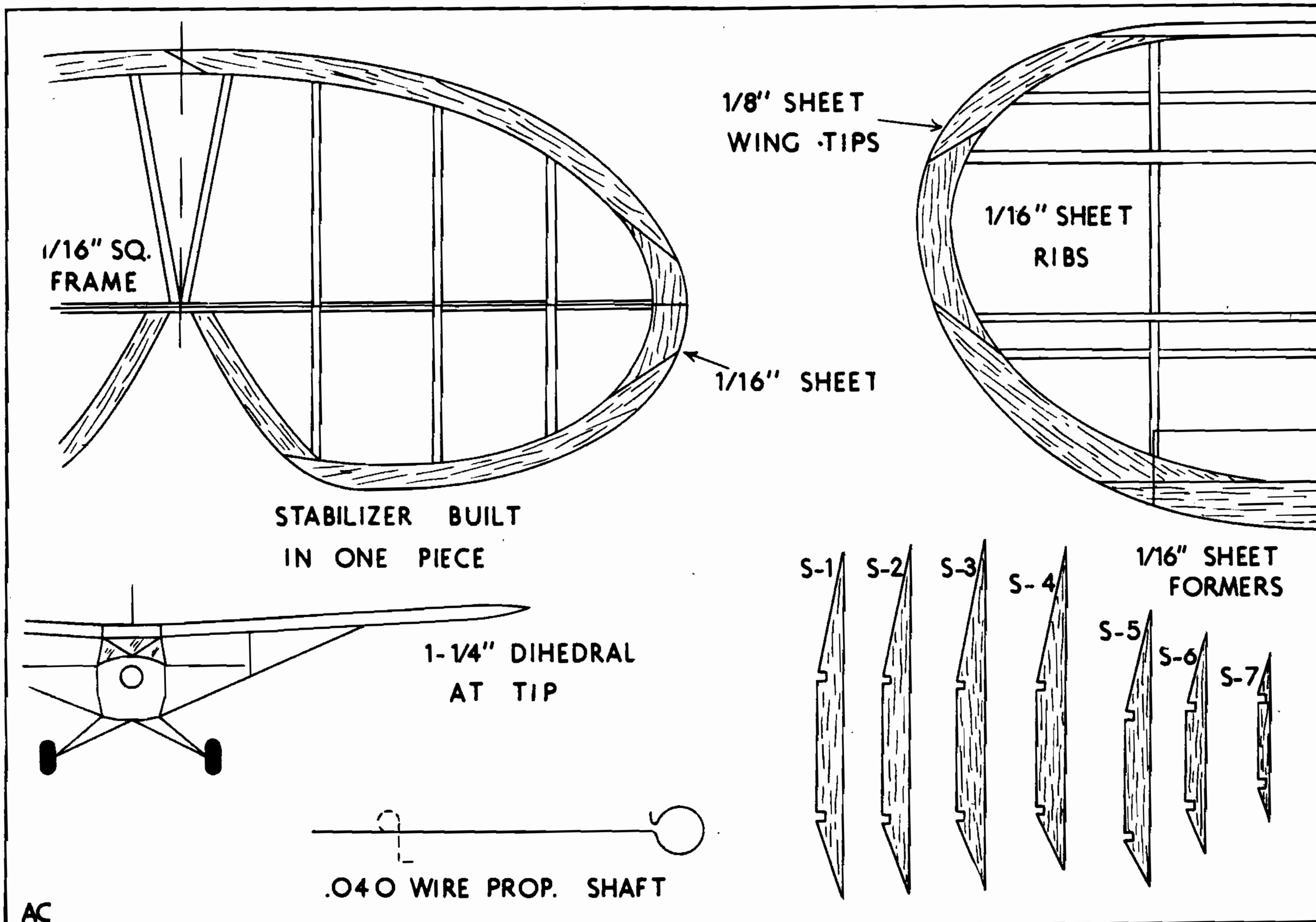
Next, carve the nose block roughly to shape and cement it lightly in place. When the cement has dried sufficiently, cut and sand the entire nose to a smooth contour, using various grades of sandpaper.

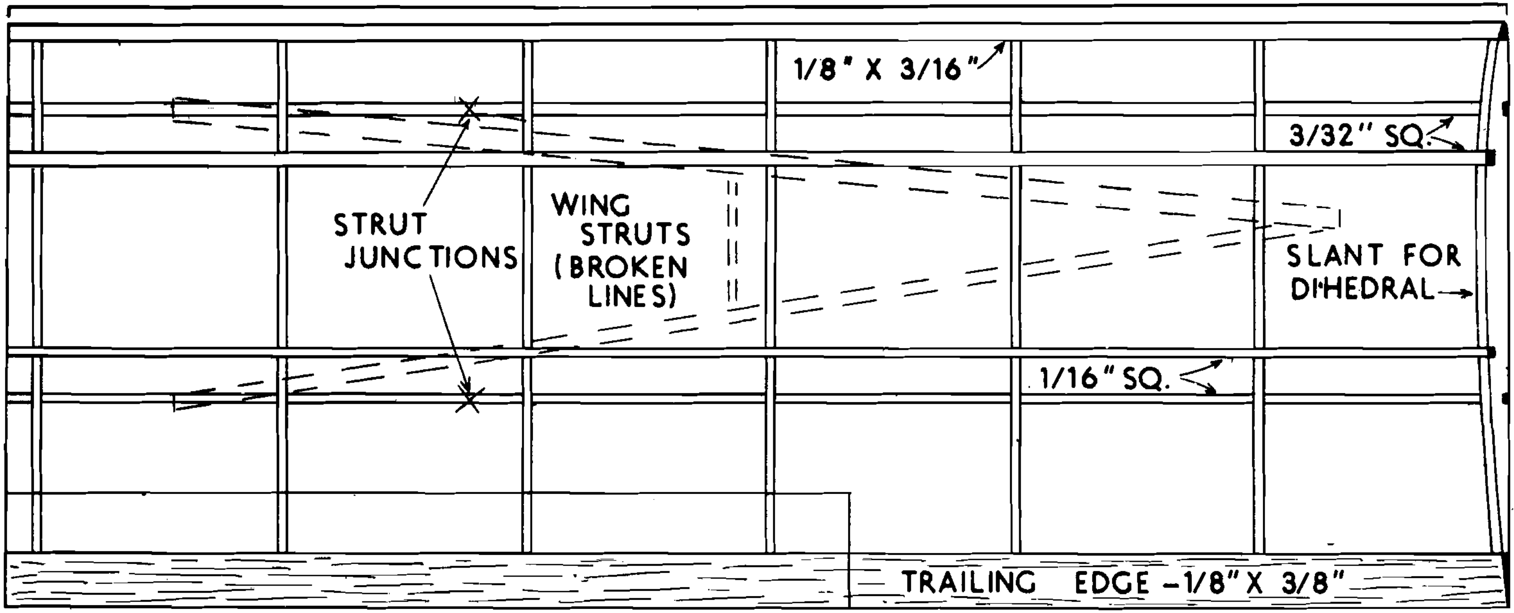


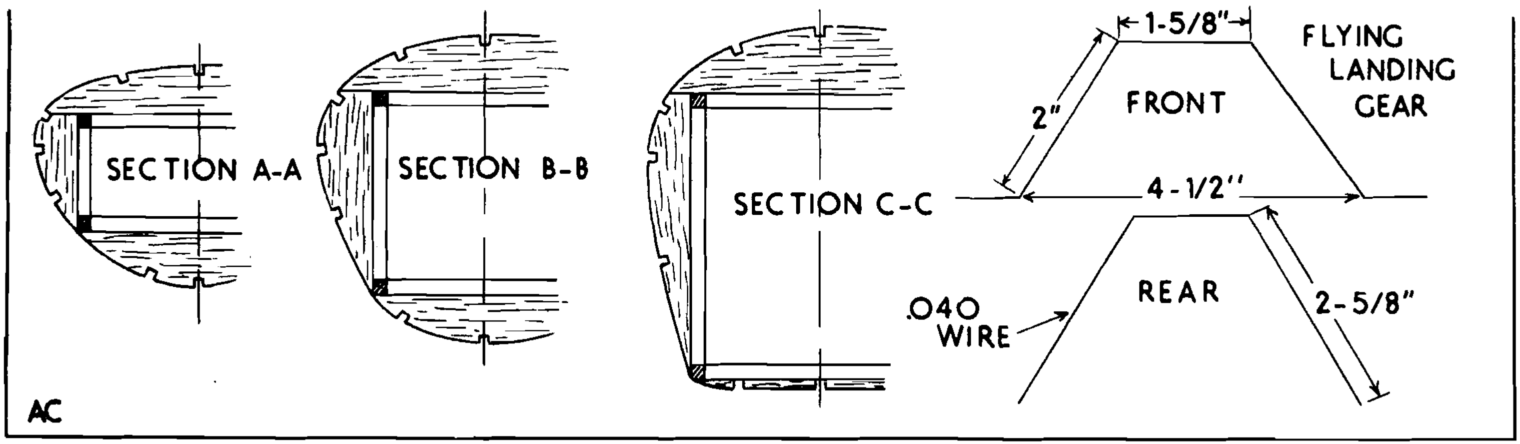
The Piper HE-1 is the only plane of its type in the Navy. When adequate care cannot be given on the spot to an injured man, he is transported to a base hospital in a machine of this sort. Note how the Stokes stretcher is carried under the turtle deck of the ship. The HE-1 model built by Alfred Cleave was a dependable flyer, and with care any modeler can make one just as good.


1/2 TOP VIEW
SEVERAL MEMBERS OMITTED FROM TOP VIEW TO SHOW CENTER SECTION
CENTER SECTION CONSTRUCTED ATOP FUSELAGE
CENTER SECTION RIB
A
B
C
S-1
S-2
S-3
S-4
A
B
EXHAUST
C
NOSE IS "FILLED-IN" WITH 1/16" SHEET
3/32" SQ. LONGERONS & CROSS PIECES
PIPER HE-1
NAVY AMBULANCE
by
ALFRED CLEAVE


BAMBOO PIN
1/16" SHEET TIPS
TOP STRINGER IS CUT FROM 1/16" SHEET
TYPICAL TAIL CONSTRUCTION
1/16" X 1/32" CAP-STRIPS
DOOR OUTLINE
STABILIZER POSITION
1/16" X 1/16" STRINGERS
1-3/8"
6-1/2"
1"
1/2"
REMOVABLE NOSE
WING RIB (14 REQ'D)
TIP RIB DOTTED
PROPELLER BLANK
AC


1/16" SQ.
FRAME
STABILIZER BUILT
IN ONE PIECE
1/16" SHEET
1/8" SHEET
WING TIPS
1/16" SHEET
RIBS
1-1/4" DIHEDRAL
AT TIP
.040 WIRE PROP. SHAFT
S-1
S-2
S-3
S-4
S-5
S-6
S-7
1/16" SHEET
FORMERS
AC


1/8" X 3/16"
3/32" SQ.
STRUT JUNCTIONS
WING STRUTS (BROKEN LINES)
SLANT FOR DIHEDRAL
1/16" SQ.
TRAILING EDGE -1/8" X 3/8"


SECTION A-A
SECTION B-B
SECTION C-C
1-5/8"
FLYING LANDING GEAR
2"
FRONT
4-1/2"
REAR
.040 WIRE
2-5/8"
AC

Bend .040″ music wire to the shape shown for the landing-gear struts and cement in position on the fuselage. Bind the legs to the longerons with light thread for additional strength, and bind and cement the two struts together at the bottom. The 1/16″-sheet fairing of the landing gear is not added until after the fuselage has been covered.

Wing and Tail

Before starting the actual construction of the wing, cut the ribs to shape from 1/16″ sheet, making fourteen regular ribs, two tip ribs, and three center-section ribs. Pin the ribs together and sand until they are uniform in shape. Cut the notches for the spars and remove the three ribs to be used for the center section. Then sand the remaining ribs as shown on the plans.

Pin the ⅛″ by ⅜″ strip trailing edge in place on the plan. Cement the rear of the ribs to it, using pins to hold them in place. Add the leading edge of ⅛″ by 3/16″ to the front of the ribs, and then cement the ⅛″-sheet tips in place. Cement the top spars in their notches, lift the wing structure when dry, and add the bottom spars. Sand the entire structure thoroughly and lay it aside until you are ready to cover it.

Since only half the stabilizer is shown on the plans, it will be necessary to make a tracing to get the complete structure. Cut the outlines of both rudder and stabilizer from 1/16″ sheet and pin them in place on the plan. Use 1/16″-square wood for the rest of the frame, taking care to keep it as light as possible. Cement the 1/32″ by 1/16″ cap strips in place and sand them to an airfoil section.

Assembly and Flying

Sand all parts thoroughly before assembly, and then cover with colored tissue with the grain running lengthwise. At this point cement the landing gear fairing to the wire parts. Do not cement it to the fuselage, as that will not allow it to spring freely and absorb the shocks of landing.

The wheels are made from four laminations of ⅛″ sheet with ¼″ washers cemented to each side to prevent the axles from wearing the wood. Carve the tail wheel from scrap balsa and bend a piece of .020″ wire to the shape shown and cement it to the fuselage.

All details such as ailerons, rudder, elevators, and ambulance door are put in by using thin strips of black tissue doped to the positions shown on the plans. Details of the front of the cowling are also made from black tissue, and the outlines of the windows are made from scrap tissue doped over the cellophane. Make two wing struts and sand and color them before cementing in place.

Cut the nose block from the fuselage and cement to it the ¼″ washers and a piece of 3/16″ sheet to keep it from slipping. If the nose block fits snugly, it will not be necessary to have any other means of holding it in place during flight. Bend the propeller shaft from .040″ wire and assemble the nose unit.

The rubber motor of six or eight strands of 3/16″ flat rubber is held at the rear by a bamboo pin inserted through the sheets on the fuselage. It is kept from wearing the wood by aluminum panels (as shown on the plans in dotted lines), which are inserted and cemented prior to covering.

For the first flights, select a patch of deep grass and try some shoulder-high glides. Make adjustments to obtain a smooth, flat glide. The original model needed a little weight in the nose, so don't think something is wrong if you find it necessary to add weight to your ship.

The model should climb and glide in gentle right-hand turns. When you are satisfied with its performance under low power, wind it up to maximum capacity, launch it into the wind—and you will be rewarded for your time and effort by a good flight.

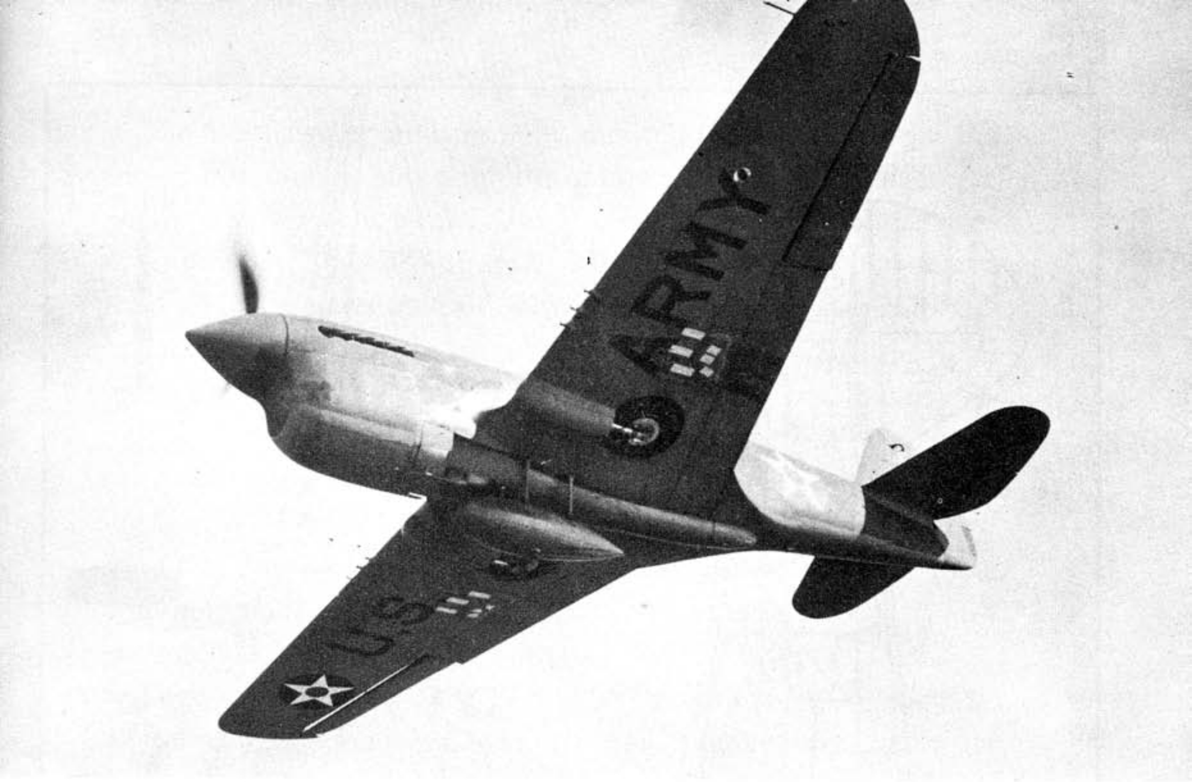
CHAPTER IX

CURTISS P-40F WARHAWK

THE CURTISS P-40 is the most widely known fighter in service with the Army Air Forces. It has seen action on every front and is being used by the Chinese, Australians, Russians, and British, as well as the AAF. The ship made its greatest name in the hands of the Flying Tigers—the American Volunteer Group—operating from China and Burma under the command of General Claire L. Chennault. In the hands of the Tigers, the P-40 destroyed 272 enemy machines in the air and 225 on the ground—a total of 497 Nipponese aircraft, at a cost to the AVG of but thirteen pilots killed in action.

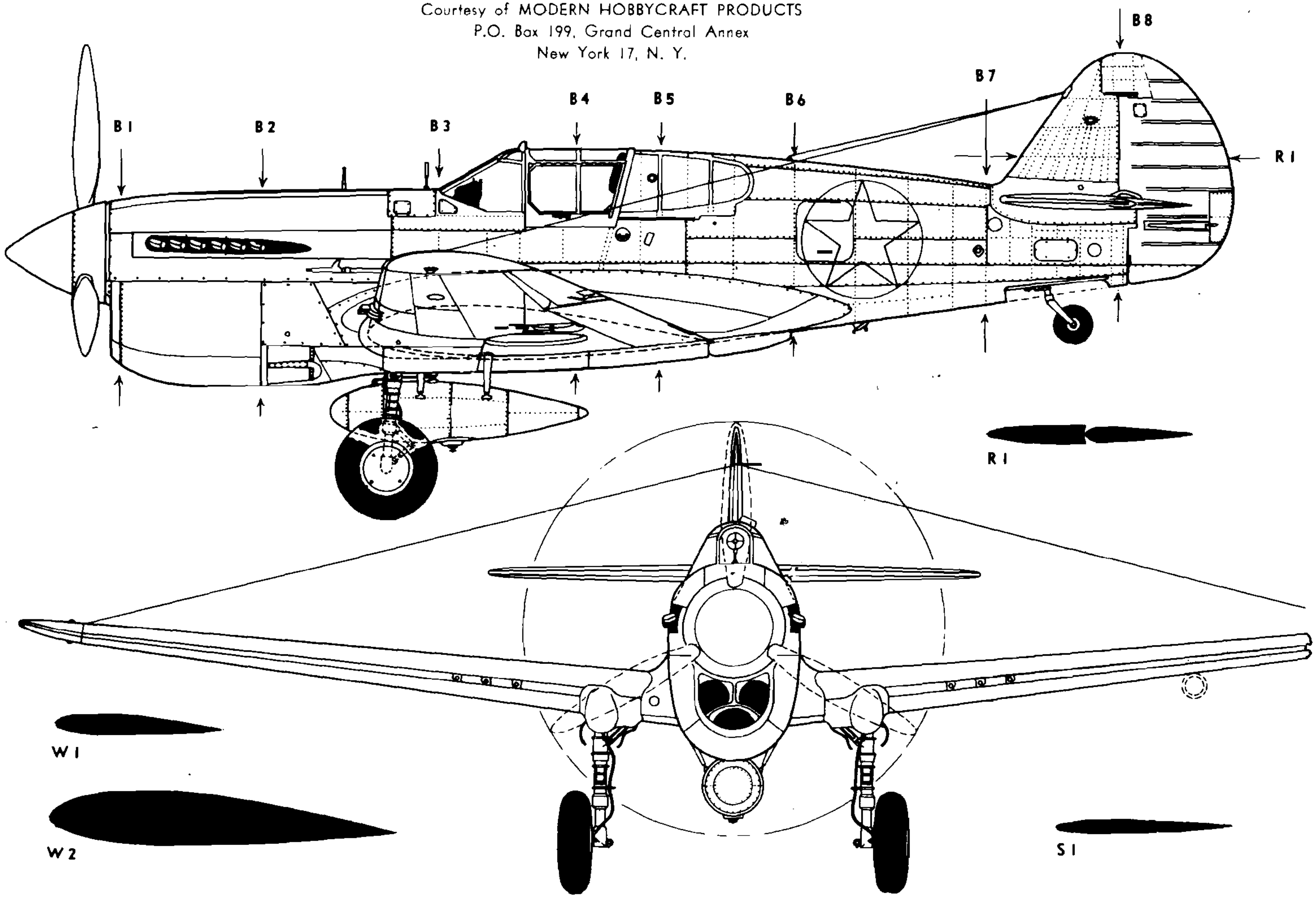
The machine, according to Curtiss-Wright, hung up a similar record in North Africa against the Nazis and Italians. For in that theater of action, it is said, twelve enemy planes were shot down for every P-40 lost in action.

General H. H. Arnold, Chief of the Army Air Forces, in a speech at West Point some time ago said that the P-40 was rated as no better than an advanced trainer, and that remark started a long line of discussion as to the assets and drawbacks of the plane. However, it should be pointed out that General Arnold was referring to the *original* model of the plane and not the P-40F or later versions.



Similar in general outline to earlier fighters in the P-40 series, the P-40F Warhawk is much better as regards speed, firepower, and range. Six .50-caliber machine guns comprise the armament, set three guns in each panel. Army pilots flying from India have fitted the Warhawk with 1,000-pound bombs, calling them "B"-40's.

Courtesy of MODERN HOBBYCRAFT PRODUCTS
P.O. Box 199, Grand Central Annex
New York 17, N. Y.



The Warhawk is fundamentally similar to earlier models in the series, with the exception of the substitution of the Rolls-Royce Merlin engine for the former Allison. The ship has a listed top speed of 380 m.p.h. (the British place it at only 355 m.p.h. at 20,000 feet) and a firepower increase of 450 per cent over the original P-40; armament consists of six .50-caliber machine guns set in the wing leading edge.

In addition to fighting, the P-40 has also recently won much fame as a bomber, affectionately called "B"-40. Warhawk squadrons operating from India, harassing the Japs in Burma, have had their ships fitted to carry 1,000-pound bombs instead of 500-pounders. With these bombs, they are able to demolish completely installations which with 500-pounders would be only damaged.

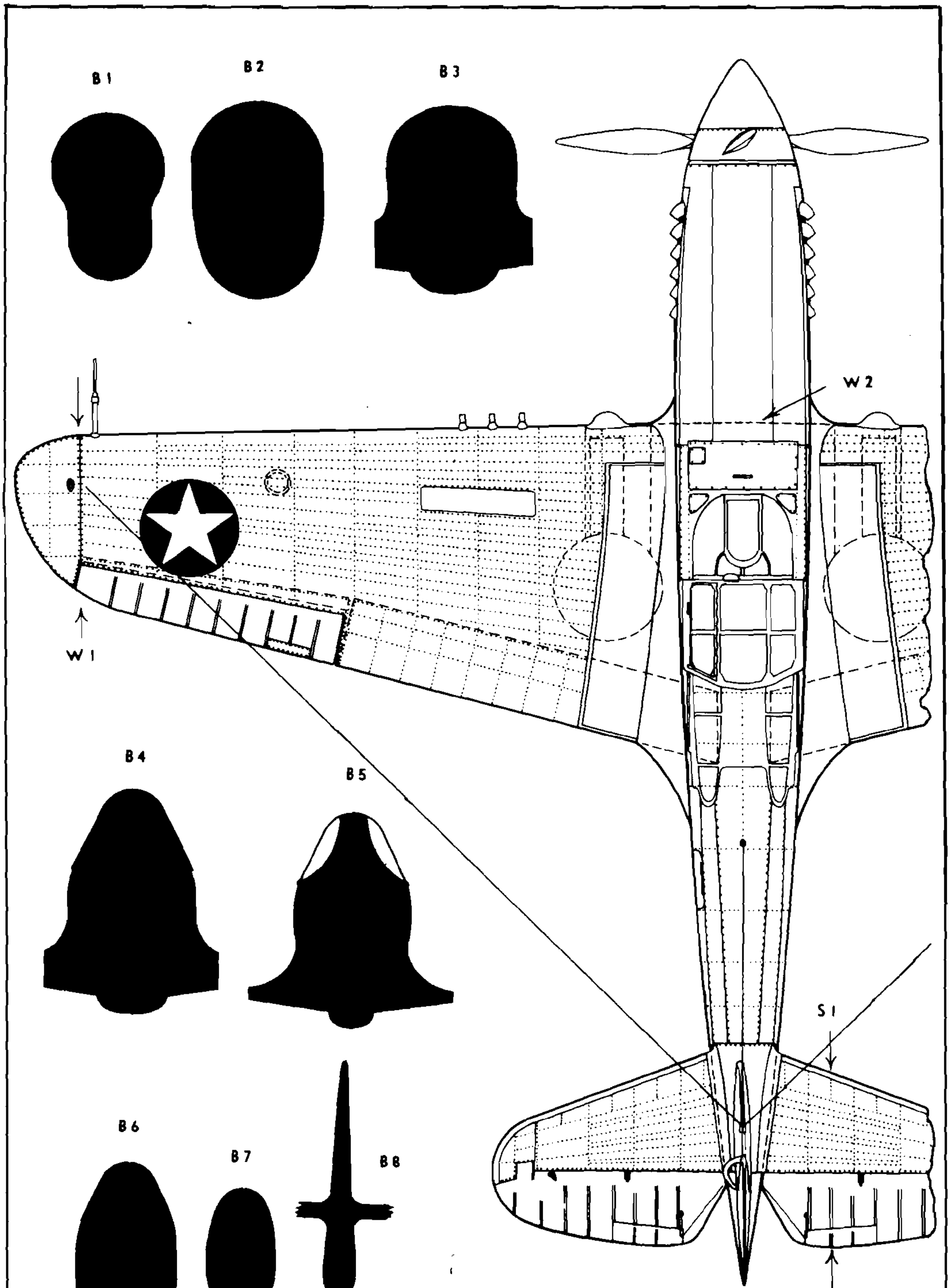
The Warhawk has a wing span of 47 feet 3¼ inches, a length of 31 feet 8 inches, a height of 10 feet 9 inches, a wing area of 236 square feet, an empty weight of 3,500 pounds, and a loaded weight of 7,000 pounds.

Fuselage

The body side outline is shown on Plate 1, and the cross-sections are on Plate 2. The first step, after enlarging the plans to working size, is to trace the cross-sections onto a sheet of heavy paper or cardboard; the most durable substance for this is the cardboard which comes with laundered shirts.

Select a block of suitable size, of balsa or other wood which can be easily worked, and trace the side view of the fuselage. Cut the block to shape with a band or coping saw or knife. Then trace the top view and proceed in similar manner.

After the fuselage has been worked roughly to shape, whittle with a model-making knife or other sharp instrument until the cross-section



Courtesy of MODERN HOBBYCRAFT PRODUCTS
P.O. Box 199, Grand Central Annex
New York 17, N. Y.

stations are reasonably accurate. When carving, work from the front of the body toward the rear. Then, with coarse paper, sand the fuselage to accurate shape. If you are a discriminating model builder, you may cut the fuselage block to make place for a hollowed-out cockpit; this, however, is not recommended unless the builder has had some experience with this construction procedure. If it is attempted by an inexperienced modeler, the chances are that an otherwise good replica of the Warhawk will become only a half-finished job. After the coarse sanding, use medium paper to smooth down the job, and then lay the fuselage aside until assembly.

Wing and Tail

The wing may be built in one of two ways. It may either be made as one unit (in which case a slit will have to be cut through the fuselage to accommodate it); or it may be made in two units with their roots flush with the fuselage sides. The latter is the easier method of construction, and if the wing is cemented and filleted properly it will be strong enough for all but the most severe handling.

Cut the wing to plan outline, as shown on Plate 2, and carve and sand to the correct airfoil, the templates of which are on Plate 1. Finish with medium sandpaper and place with the fuselage.

The rudder and elevators are made in the same manner as the wing. The control horns are not essential, and they are difficult to make because of their small size.

Details

The auxiliary fuel tank is simple to make. It is carved from a solid block of wood and is round in cross-section (see front view, Plate 1). Rummage around in your miscellaneous material for a pair of wheels of the correct size. If these cannot be found, wheels may be made from laminated sheet or solid block and turned down to size. Make the oleo struts from dowels. Machine guns may be made from dowels or wood matchsticks. Use thin sheet for the propeller blades.

Assembly and Painting

Add the wing panels and tail to the fuselage, and set aside to dry. Place blocks under the tips to give proper dihedral, and be sure that the fuselage is lined up perfectly. For greater strength, small dowels may be inserted into the wing and glued into holes drilled in the fuselage.

After the joints have dried, make a fillet material from cement and sawdust and pack this in place; commercial products may also be used, if the builder wishes. Small blocks and pieces of sheet may be used instead of the cement and sawdust, but this is a slightly more difficult, though better, job.

Finish off the entire model with fine sandpaper and add the auxiliary fuel tank and other details, and then you are ready for painting. A better surface may be obtained if the model is given several coats of filler, sanding between coats.

The model may be painted either spinach green and light brown, all olive drab, or purple-blue above and cream-blue below. Color may be added by painting the prop spinner yellow or red. The prop blades themselves are silver in front and black behind.

When painting, use three coats of lacquer and sand lightly between coats to remove fuzz. The last coat should be applied with extreme care, and if camouflage is used the last coat should be done with a spray gun.

Rudder, ailerons, and elevators should be indicated by marking with India ink. Be very careful with this job, for if not done properly it can spoil the entire paint job. Decalcomania are best for insignia, and these can be purchased very reasonably and added to the model with only a minimum of trouble.

CHAPTER X

MODEL BUILDING TIPS

IN LAST YEAR'S edition of *The Model Plane Annual* a chapter was devoted to workbench tips, and this material proved so popular that this year we are adding others for your use. And as suggested previously, on that next model it would be a good idea to refer again to this chapter—it might save you not only time and headaches but also money.

Washer Cutter

In these days of priorities and scarcities of various metal it is often difficult to obtain washers at all, much less the exact type you need. But this can be easily rectified, and in just a short time you can make enough of these to last until balsa and rubber and engines and manufactured washers are again available on the open market.

Select a sheet of discarded metal from your scrap pile and lay it on a smooth board surface. Then drive an old phonograph needle through a bottle cork, so that the point extends to the end of the cork but not quite through; cut off the needle or cork, whichever is longer, so that the rear of the needle and cork are even. Then, by striking the cork a firm but not too hard blow with a hammer, clean holes will be driven through the metal sheet. Space the holes so that there is sufficient area between them for the washer.

After this first operation has been accomplished, punch out washers with a paper punch—and you will have a stock of washers that will last for the duration. It is a good idea to test the metal sheet with the punch before beginning operations, to be sure that the metal you have selected is not too thick.

Conservation of Cement and Dope

If stored upside down when not in use, cement and dope will not evaporate or harden to any degree. After stopping the bottle or can as tightly as possible, invert the container on the shelf and leave it undisturbed until the next use.

Use of Soda Straws

The common straw through which you sip sodas or other drinks has more practical uses in model-plane making than is generally realized by even old-time builders. It can, for instance, be used as undercarriage struts on scale jobs, wing spars, struts, machine guns, gun troughs, and rudder posts.

And the straw may be streamlined with but little effort. To do this, insert a small dowel into the straw and hold tightly against one side. Then merely squeeze flat the far section of the straw. This will give you a realistic streamlined tube that is quite durable. To make it stronger still, the trailing edge may be cut and then glued back together again. This will prevent the straw from ever making another physical change under ordinary circumstances.

Preserving Plans

Most model builders have difficulty keeping plans in place and, after a day or so away from the bench, often find working drawings missing. Sometimes, too, they are so carefully put away for future use that one forgets exactly where they are hidden, and a mad hunt is consequently necessary.

There is a very simple cure for this. Simply procure a common window shade and hang it in front of your bench in the conventional manner. Your plans may be mounted on this-with scotch tape, and you will always be sure where they are. And, most important, they will be available for reference but not in your way or under a pile of material when working on a model.

Wing Ribs

On small solid models a realistic rib effect may be obtained by cementing thread over the wing before painting. Extend the thread from the trailing edge over the upper surface of the wing, and then back over the under surface to the trailing edge again.

Medicine Capsules

Aside from using medicine capsules for storing very small metal parts, you may also use them for propeller hub tips, navigation and tail lights, and various other purposes. A little experimental work and ingenuity will pay great dividends in adapting these containers to model-building use.

Motor Stick

Models are ordinarily designed with the line of thrust parallel with the motor stick. Therefore always make sure that the tail hook and thrust bearing are the same distance above the motor stick. Otherwise, the line of thrust will be accordingly altered and difficulties will arise.

Preserving Rubber

Model rubber should be stored in an airtight container in a dark place, as it is affected by both light and air and will lose its elasticity. A fruit jar painted black, with a little talcum powder inside, is ideal for this. And if you have enough rubber on hand for current use but are saving for future possibilities, it is a good idea to cement around the cap of the jar. This will prevent any possible air from entering.

Wing Joints

Many modelers, either in haste to finish their job or through just plain thoughtlessness, cement struts to paper or cloth wing covering without further thought. This makes an insecure joint, and the struts will either pull away or damage the wing covering in nose-overs or bad landings. The best policy is to scrape away the covering at the rib, and then cement the strut directly to the rib; this wood-to-wood joint is much stronger than a wood-to-covering joint could possibly be.

Sanding Sticks

Although time is necessary to make good sanding sticks, such sticks in the long run will save more time for the builder than the original manufacturing effort. In spare moments it is a good idea to make concave, convex, triangular, round, square, and tapering sanding sticks. Once made, sandpaper should be glued to the sticks; this, of course, can be replaced in a matter of minutes once the sanding surface has worn smooth.

Rib Camber

Instead of steaming thin wood when making ribs for small, light indoor models, you can make ribs more easily by rolling a round pencil or dowel over the uncut wood stock. The more pressure you apply, the greater the camber. And these easily made ribs will frequently hold their shape for the entire life of the model.

Smoother Fuselage

After assembling a fuselage, cut the wood away from between the stringers in a shallow arc. This will not only make the model lighter but will also make the paper covering lie smoother and more streamlined. Attach the covering to the stringers only, and not to the bulkheads.

Covering Hint

Cover your model from the rear of the fuselage toward the front for a better, smoother, and neater job. Use paper wide enough to extend only from one bulkhead to another, never wider than two bulkheads. Lap the next strip only the width of the bulkhead, and the finished job will be a model that has the appearance of being covered with only one piece of paper. Also, this system leaves the edges of the paper toward the rear and eliminates the possibility of wind catching under them.

Balanced Wings

Do not wait until a model has been finished before testing it for correct balance. When the wing framework has been completed, stick a needle into the center rib and dangle from a string looped through the needle's eye. You will be able to determine immediately which side is heavier and make corrections by trimming inside the heavy tip or by removing excess cement.

Propeller Holes

It is often difficult to make a truly straight hole through a propeller block, but this is one of the easiest of operations if there is a sewing machine in your house. Simply place the prop block in the sewing machine, under the machine foot, and slowly lower the needle until it has completely pierced the block. Withdraw the needle, and you have a perfectly straight hole for your propeller shaft.

Sanding Balsa

When sanding balsa sheets or strips, hold down one end and sand away from yourself in smooth, even strokes. By sanding in only one direction the possibility of buckling is removed.

Protected Props

Many modelers are upset to find that their carved propellers break in half after one or two bad crack-ups, but the problem is really an easy one to remedy.

Give your propeller a few coats of banana oil and sandpaper well between each coat, in the usual manner. Then cut grooves from the hub to a point about one-third of the way up each blade, and on each side. Insert bamboo splints into the grooves and cement thoroughly. You will find that this will not make the prop much heavier, and it will be able to withstand all but the most severe crashes.

A Celluloid Source

When you need celluloid for windows, windscreens, or other parts of your model, old camera negatives are a good source. The black emulsion on the negatives will easily wash off in hot water, leaving a thin, clear sheet of celluloid.

Vibration Remover

To take the vibration out of your gas engine, cut pieces of rubber tape to a size that is large enough to fit your motor mount and nose block. Take one piece of this tape, put it between your motor block and motor mount, and glue a piece on the bottom of the motor mount. Then cut a piece of metal the same size as the rubber and drill two holes in it—the same size as the bolts used to fasten the engine to its mount. After the engine has been mounted, you will find that this makes a cushion affair that will lessen vibration.

A Handy Tool

Model builders often have need of some sort of tool to cut round holes in various parts of their models. While this may be done by burning, drilling, or tediously cutting with a balsa knife, there is a much easier and cleaner way.

Heat a single-edge razor blade to a cherry red, then plunge it into cold water to remove the temper. Break off the heavy back with a pair of pliers and bend the blade into a circle the size of the hole desired. Mount this on a hollow reed and use a dowel to eject the excess wood. Operate the tool with a twisting motion.

Leading Edges Simplified

When you make a model that calls for leading edges to be covered with thin sheet, apply a strip of adhesive tape to the sheet, allowing part of the tape to overlap. Then, by sticking the tape to the ribs, the leading edges may be held firmly in place while the cement is drying, and thus the use of pins is avoided.

Realistic Engine Finish

If you have made a scale radial engine and want to color it to resemble the real thing, use the following system: Mix one part of black drawing ink with three parts of blue ink and shake well. Coat the engine with this solution and allow it to dry thoroughly; then dip the engine into clear, thin dope. This will give the exact blue-black finish to make for realistic effect.

Miscellaneous Hints

Dope center sections and the first few sections of fuselage with thin cement to prevent slackening of tissue due to rubber tension.

When applying bamboo paper, always use a half-and-half mixture of cement and dope, since ordinary adhesives usually do not hold well enough.

Microfilm solution may be used as a tissue adhesive and as a very glossy dope. However, it requires a bit more time to dry.

Use an old toothbrush to clean the points on your gas engine. Never use sandpaper, as it scratches the surface and will ruin the points in time.

A paper clip may often be used as a counter-balance on a small, one-bladed propeller if forced into the prop stub and glued well.

Sometimes when spraying tail surfaces, the tissue on each side sticks together. In order to separate the sheets, put your lips to the stuck section and draw gently. The surfaces will then come apart.

As a rubber lubricant, a solution of one part tincture of green soap and one and a half parts glycerine is excellent. If green soap is not available, any good liquid soap may be substituted.

Wheels made of sponge rubber balls may be colored with liquid black shoe polish. Apply six to eight coats and sand gently. Rub in the final coat to bring out a shine.

File Drawers

A dyed-in-the-wool modeler needs scores of small parts in building planes, and these are constantly being misplaced or so scattered around in drawers that they are difficult to find. With just a few minutes' work, however, this can be rectified, and you can make a good, neat file cabinet for these various tiny units.

To make this file cabinet, obtain several penny matchboxes and fasten them together, side by side and three or four deep. A drop of cement on each corner will be sufficient to anchor them together. Then glue a piece of white paper on the front of each box, and in black ink label them for washers, pins, nails, lead weights, thumb tacks, needles, and so on. As supplies of new units are necessary, it will be a simple matter to add a new box to the top of this cabinet.

Handy Bottle Rack

Bottles of cement, dope, and paint are constantly just out of reach on the usual workbench. For a neat and efficient system, take the top of a candy box and cut circular holes the same diameter as the bottles. Stand the box top, open side down, and place the bottles in their respective holes. This makes a good rack and keeps all liquids within easy reach at all times.

"Magic" Drawing

When only one half of a wing panel is shown on model plans, a reversal drawing may be obtained by rubbing a very small amount of grease on the plans. This makes the paper translucent, and thus the black markings may readily be seen on the reverse of the paper. And not only does this method give you outlines for the opposite wing, but at the same time it makes it unnecessary to lay wax paper over the drawings, since cement will not adhere to the greased surface.

Regarding Propellers

Many models do not turn in their full degree of efficiency because propeller blade areas are not sufficient for the plane's size. A propeller, to be efficient to its fullest degree, should be between 10 and 15 per cent of the wing area. If your model is trimmed correctly but does not fly as well as anticipated, make this propeller check and you may discover the source of your trouble.

Treating Tissue

If your model tissue has become wrinkled or otherwise rendered unfit for use, smooth it out with a warm electric iron, with a piece of cloth between the tissue and the iron. After such ironing, wait until the tissue has cooled down to room temperature before using.

Salvaging Scrap

With balsa wood at such a premium today, all scraps which in normal times would be discarded should be retained. Even warped sheets may be restored to their original shape with but little difficulty. To do this, steam the sheet and then weight it down with heavy magazines until dry.

CHAPTER XI

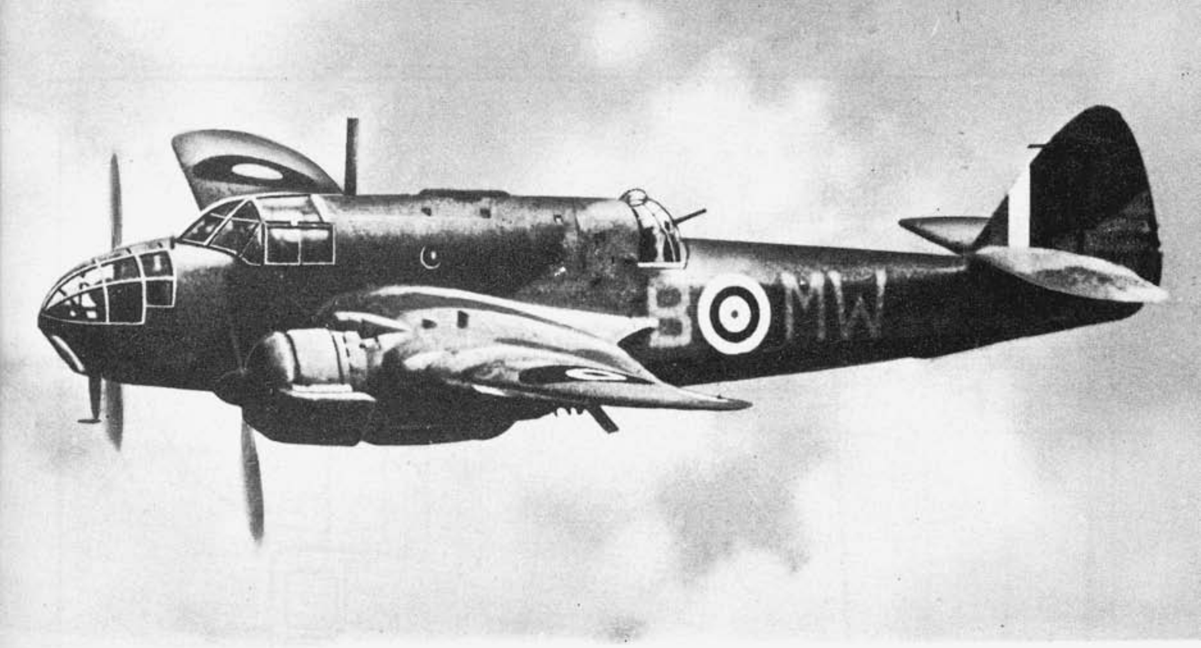
BRISTOL BEAUFORT

ONE OF THE MOST formidable torpedo bombers in the RAF, the Bristol Beaufort is a mid-wing monoplane with a body typical of two-seat fighters. Armament consists of one forward-firing gun and two guns in the amidships turret. Three men comprise the crew: pilot, navigator-bombardier, and radio operator-gunner.

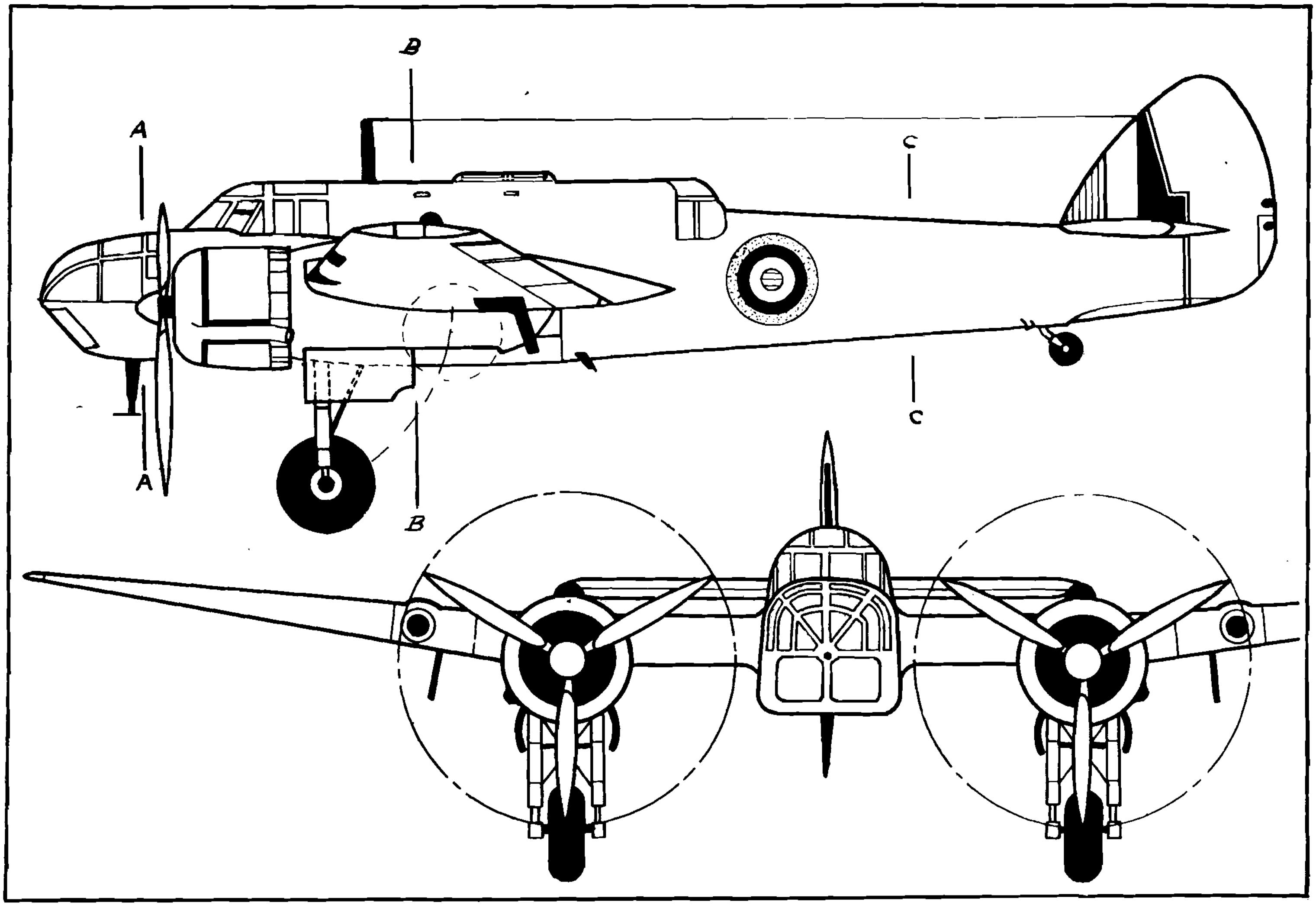
The Beaufort is powered by two air-cooled radial Bristol Taurus engines of 1,065 h.p. each and has a top speed of about 275 m.p.h. It has a wing span of 57 feet 10 inches, a length of 44 feet 2 inches, and a height of 14 feet 3 inches; all other data are restricted by the Royal Air Force.

Fuselage

The fuselage of the Beaufort is extremely easy to make. First, carve the block roughly to shape, from the side- and top-view plans, and then trim and sand until the sections at A-A, B-B, and C-C are as indicated. Then lay the finished unit aside.



Used as a torpedo-bomber, the three-man Bristol Beaufort is powered by two air-cooled radial Bristol Taurus engines of 1,065 h.p. each and has a top speed of about 275 m.p.h. The model is not at all difficult to build, and if finished properly it will make an excellent display piece. For details, refer to these pictures often.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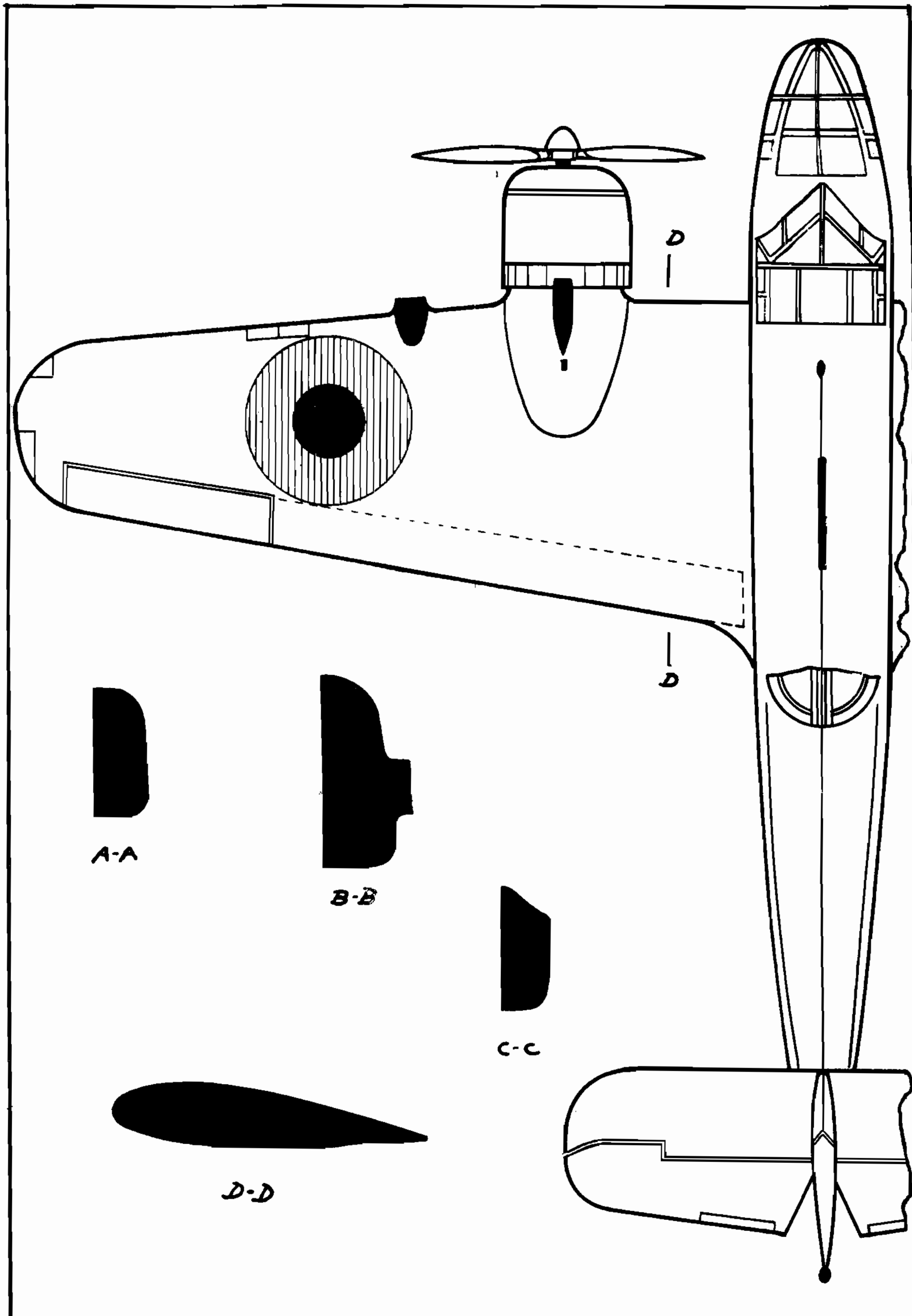

D
D
A-A
B-B
C-C
D-D

Wing

The wing is made in four parts. The two center sections and outer panels make up the wing. Make two full wing panels, working the outlines to the size shown by the top view. Then cut these panels in two with a saw, making the break just outboard of the engine nacelles (see front view). It is necessary to make the wing in this fashion because the center section is straight, while the outer panels are dihedraled. Sand the butt ends of the outer panels until the correct dihedral angle is obtained, and then cement the units together securely, using blocks under the tips.

Engine Nacelles

Two engine nacelles are required for this model. Make them as cones, round in front and tapering to a point at the rear. To add the nacelles to the wing, either notch the nacelles or the wing, cutting away only enough wood to make for a good fit. After the notches have been carved, finish shaping the nacelle in the rear. Then cement the units in place, being sure that they are located correctly and that they point straight ahead.

Rudder and Elevators

The tail units are very easy to make. Cut the rudder from a sheet of wood to the correct outline and then taper it to a streamline shape. The elevator is made in one piece. Make the entire unit, without the trailing edge notch, and streamline in section. After the final sanding, carefully notch as shown on the top-view plan.

Details

The antenna mast is formed from a piece of scrap sheet, with the edges rounded off. Make the pitot tube in similar fashion, and cement part of a straight pin to its lower section. Prop spinners are not necessary, but if the modeler wishes to add them to his replica, they may be made by rounding off the tips of a dowel and then cutting off the required length. The propeller blades may be made from either scrap sheet or light cardboard.

Even the landing gear on the Beaufort will offer no problem. Cut two small dowels to the indicated length and mount the wheels between them, using straight pins as axles.

Assembly and Painting

Cement the wing panels to the fuselage, making sure that the center section is horizontal and that each tip has the correct amount of dihedral. When dry, add the elevator and the rudder assemblies. Fillet at all joints and sand with fine paper until the entire model has a satin finish. Cement the landing gear and other details in place.

Paint the entire model with sand and spinach camouflage colors, using at least three coats. Unless scale engines have been used, paint the front of the engine cowlings black, and use black ink to indicate the ailerons, rudder, and elevators. For a realistic effect, the cockpits may be painted silver and the various windscreen sections indicated with black ink. Mount the propeller assemblies on straight pins and push them into the exact center of the nacelles. If the modeler wishes to simulate turning propellers, celluloid discs may be used in place of propellers. In this case, do not use an extended undercarriage on the model; instead, have the wheels retracted and mount the Beaufort on a stand.

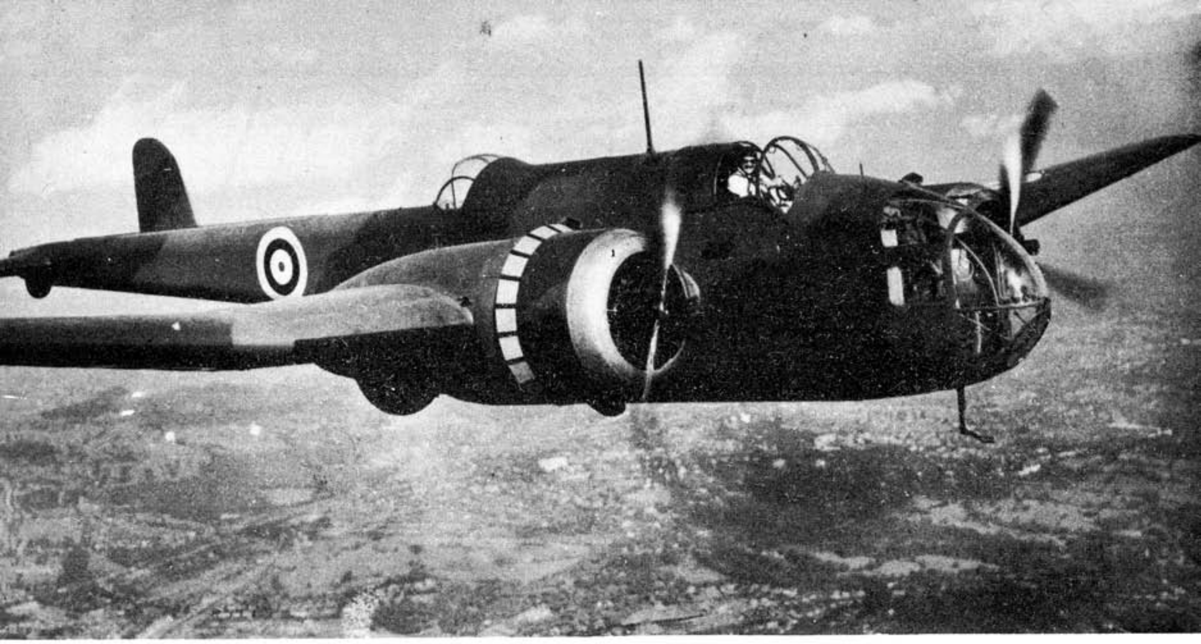
CHAPTER XII

HANDLEY-PAGE HAMPDEN

PREVIOUSLY CALLED Britain's best medium bomber, the Handley-Page Hampden was used with outstanding success in the early days of the war. Because of its unique ability for being thrown around in high-speed maneuvers, it attacked Nazi installations from very low altitudes, braving all the flak the defenders could put into the sky. But since the Royal Air Force is now banking its entire bombardment weight on heavy night machines, the Hampden has been relegated to mine-laying duties, and as such it has probably accounted for a large number of German surface vessels and submarines. The exact number, of course, will never be known, but we may be sure that the machine is still doing much to win the war for the Allies.

A mid-wing monoplane with a "frying-pan" appearance (note side view), the Hampden is powered by two air-cooled radial Bristol Pegasus engines of 980 h.p. each at 2,250 r.p.m. at 4,750 feet, giving a top speed of 265 m.p.h. at 15,500 feet. It has a wing span of 69 feet 2 inches, a length of 53 feet 7 inches, a height of 14 feet 11 inches, a wing area of 668 square feet, a cruising range of 1,725 miles, a loaded weight of 18,756 pounds, and a service ceiling of 22,700 feet.

The crew consists of a pilot, navigator-bombardier, wireless operator-gunner, and a lower rear gunner. There are five flexibly mounted



Now used for mine laying, the Handley-Page Hampden was previously the RAF's best medium bomber. Its "frying pan" fuselage appears difficult to make, but actually the model is easier to make than one with a smoothly tapered body. The most difficult part of the ship, as a matter of fact, is the top rear turret. With patience, however, this can be formed realistically.

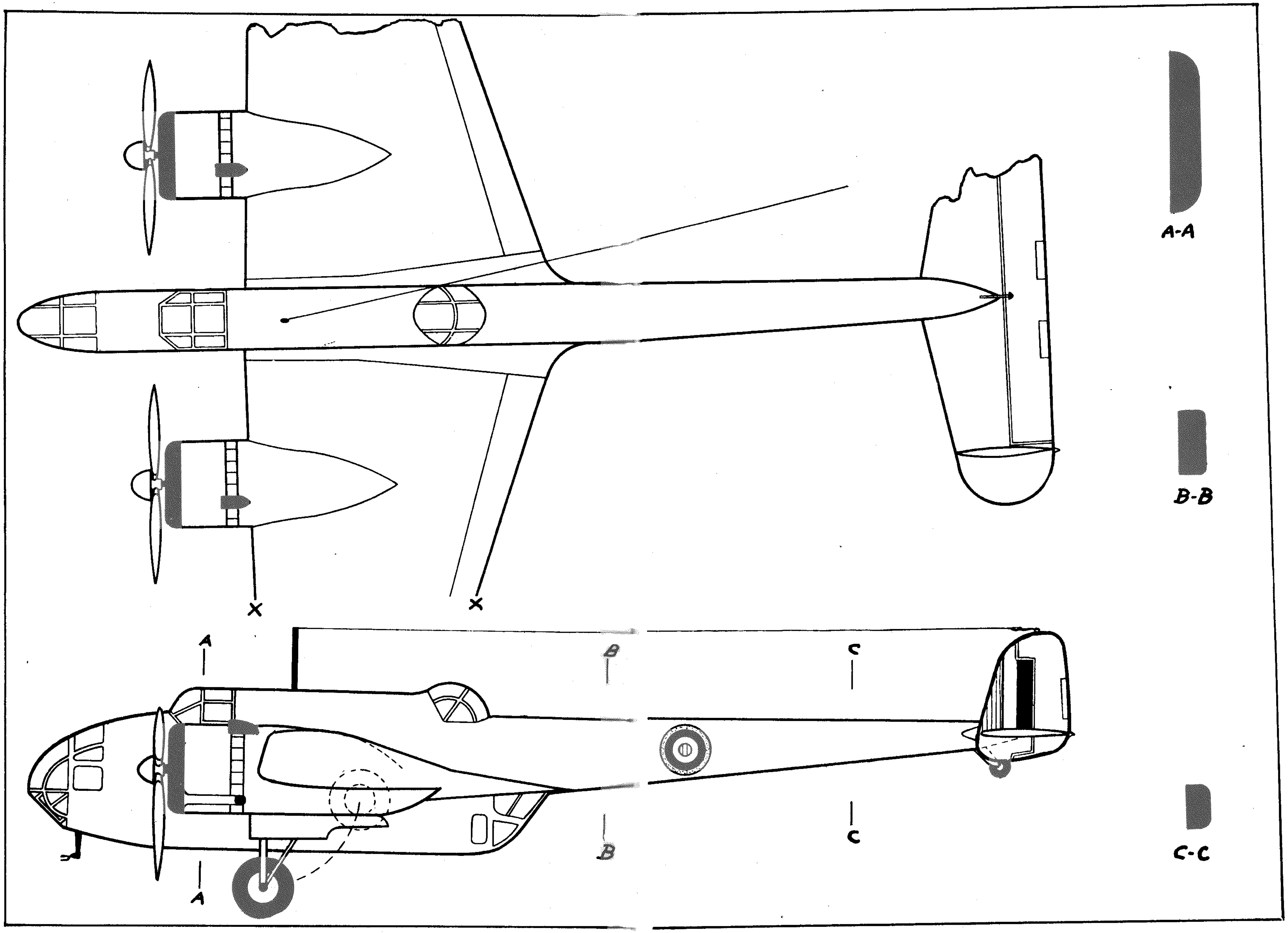
machine guns: one in the nose and two in each of the machine-gun turrets; the pilot has one fixed gun at his control.

Fuselage

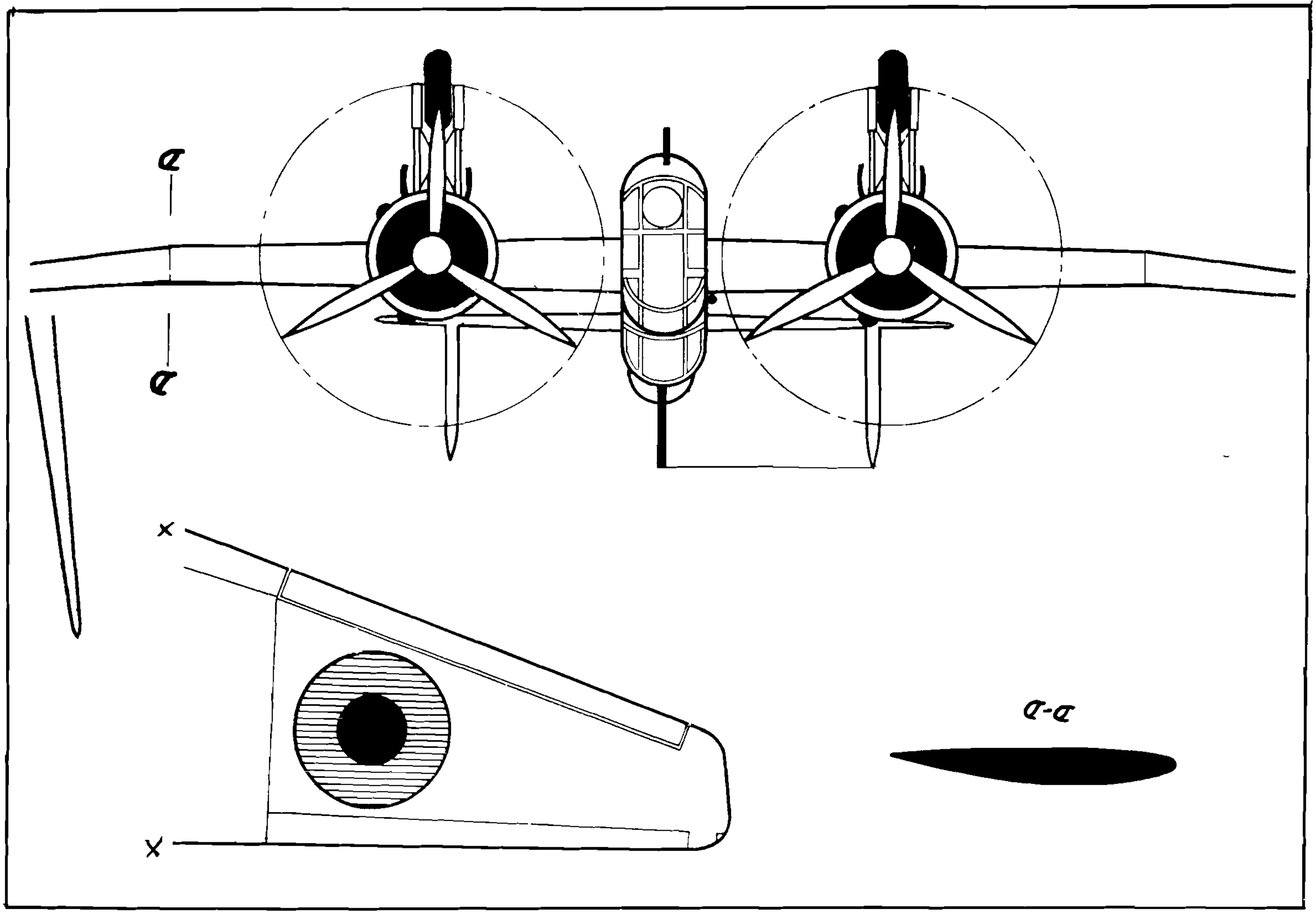
Despite the unorthodox side view of the Hampden, it is a reasonably easy model for beginners to tackle; this because all lines are clean-cut and simple, and because no work is required to achieve the top-view silhouette. After cutting the side view to shape, simply round off the edges and the fuselage is all but finished. As with other models, finish off with medium sandpaper and put aside for assembly.

Wing and Tail

As with the Bristol Beaufort, it is necessary to make the Hampden's



A-A
B-B
C-C
A
A
B
B
C
C
X
X


a
a
x
x
a-a

wing in four units. Join the two wing sections at X-X (Plates 1 and 3) and trace the outline of the wing. Work to the D-D airfoil section, and then saw the wing sections in two, as shown on Plate 3. Sand the butt ends of the outer panels to an angle, and cement to the center sections with the proper dihedral.

Since the Hampden is a twin-tail job, it will be necessary to make two rudders. Sand these to a streamline section and then make the rudder in similar fashion. After finishing these units the work becomes a little more difficult, for it is necessary to slot the rudders carefully in order to insert the elevator. Take your time and measure carefully, and this will not prove too difficult. Cement the rudders to the elevator, being sure that they form right angles.

Nacelles

Follow the same construction procedure as listed for the Bristol Beaufort.

Details

Oleo struts for the landing gear are made from scrap sheet, as are the air intakes on the nacelles, the pitot tube, and the antenna mast. The propeller blades may be made from either paper or sheet wood, carved to the outline size shown on Plate 3. The spinners are tips of dowels, rounded off.

Assembly and Painting

Cement the wing to the fuselage, taking care to have the panels line up properly. When dry, notch the extreme tail of the fuselage and cement the rear control surfaces in place. Add the landing gear, antenna mast, and other units, and paint British colors. A length of black thread may be used for the aerial, stretching from the antenna to the right rudder.

Paint the front of the nacelles, and use decalcomania for British markings.

CHAPTER XIII

THREE-VIEW SALON

IN THE LAST FEW years solid scale exact-replica models have come to hold a larger place than ever in model building. Once it was considered juvenile to build solid models, because the test of the modeler had been proved in the flying. Now that conception has changed. While it is admitted that flying models are the backbone of aircraft modeling, in the exact-replica field there have been many models built that are works of finest craftsmanship. Composed of hundreds or thousands of individual pieces, these models often have built-up engines, retractable landing gears, full lighting systems, movable controls, scale seats, controls and instruments, and even propellers that can be made to turn by electricity.

While no solid scale model could ever be as complete as some of the built-up replicas, it is nevertheless a means of expression quite apart from the art of flying models. In order to turn out a completely finished job, the solid builder must be meticulous in his every move, must work with an eye constantly cocked for detail, and must apply all-important finishes with care and precision. Only then can he be called an expert at the craft, and only then will he be able to turn out models worthy of blue-ribbon consideration.

For the novice builder, a few words of construction procedure are in order, so that he may be able to follow the accepted method of solid scale building.

First—after having the plans scaled up or enlarged to working size by photostating—cut templates from the plans and mount them on light cardboard. Scribe the center line on the fuselage block and rough-cut one side at a time, using the templates frequently to check cross-section stations. When the templates almost fit, use medium sandpaper to work the fuselage down to the exact shape.

The wing is constructed in like manner. Using the top-view plan, cut the wing panels to their outline shape, and then add the airfoil section by carving and sanding.

You will note that plans usually call for some ingenuity in executing landing-gear details. Remember, though, that the use of paper and light cardboard for many of these parts will save hours of labor. The various diameter struts needed can be imitated successfully by wrapping thin strips of paper around wire or dowels.

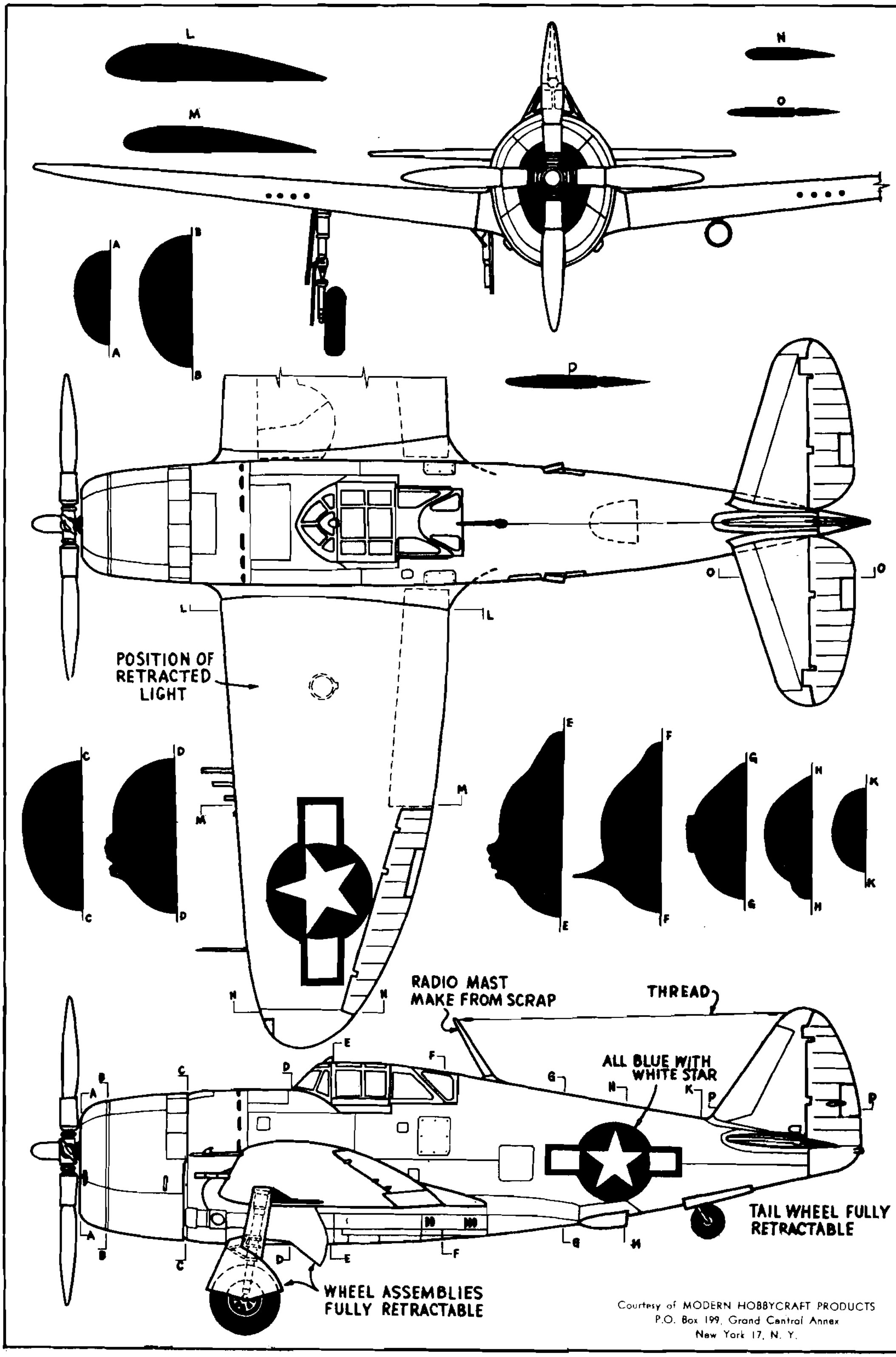
After the various sections have been carved and sanded to shape and assembled, the use of fillet material and filler will make a solid model much better than could otherwise be expected. And the paint job and scribing of various details will mean the difference between only a half-finished model and a beautiful display piece.

In general, the best instructions that can be given are these: Always work with extreme care, and constantly keep alert for ideas which will make your model just a little bit better. In the long run, the little extra work spent on detail will pay great dividends.

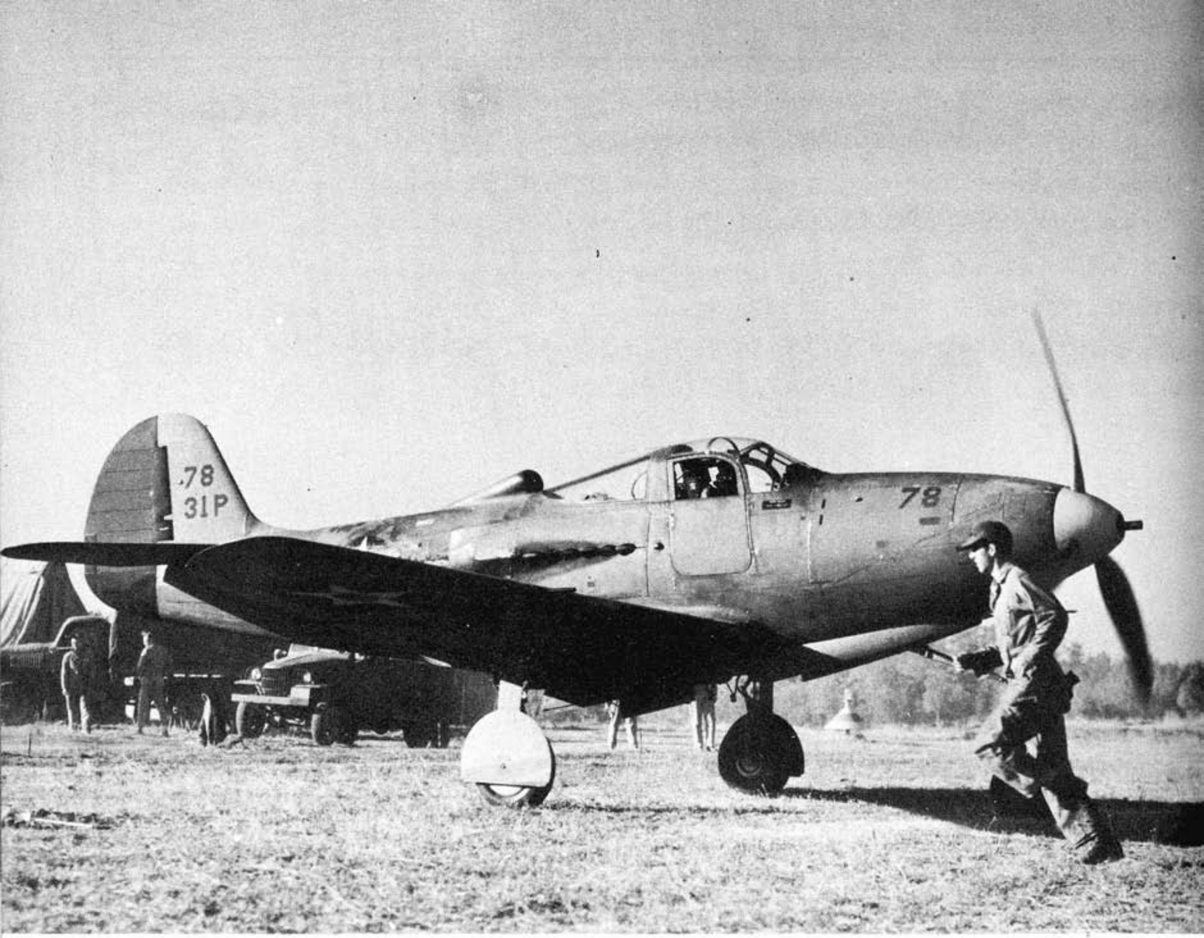
The models presented on the following pages are representative of the most popular among builders. Many of the plans are reproduced through the courtesy of Maircraft: Famous Planes in Miniature, and were executed by James R. Wyse.

REPUBLIC P-47 THUNDERBOLT

One of the most powerful single-seat fighters in the world, the Republic P-47 Thunderbolt has more than proved its prowess in combat with Axis aircraft. Weighing 13,500 pounds—making it the heaviest single-seat, single-engine fighter in the world—the Thunderbolt mounts eight .50-caliber machine guns and throws no less than 870 pounds of lead per minute; this gives an impact force equal to that exerted by a five-ton truck hitting a stone wall at 60 m.p.h. Power is supplied by a Pratt & Whitney engine of more than 2,000 h.p.

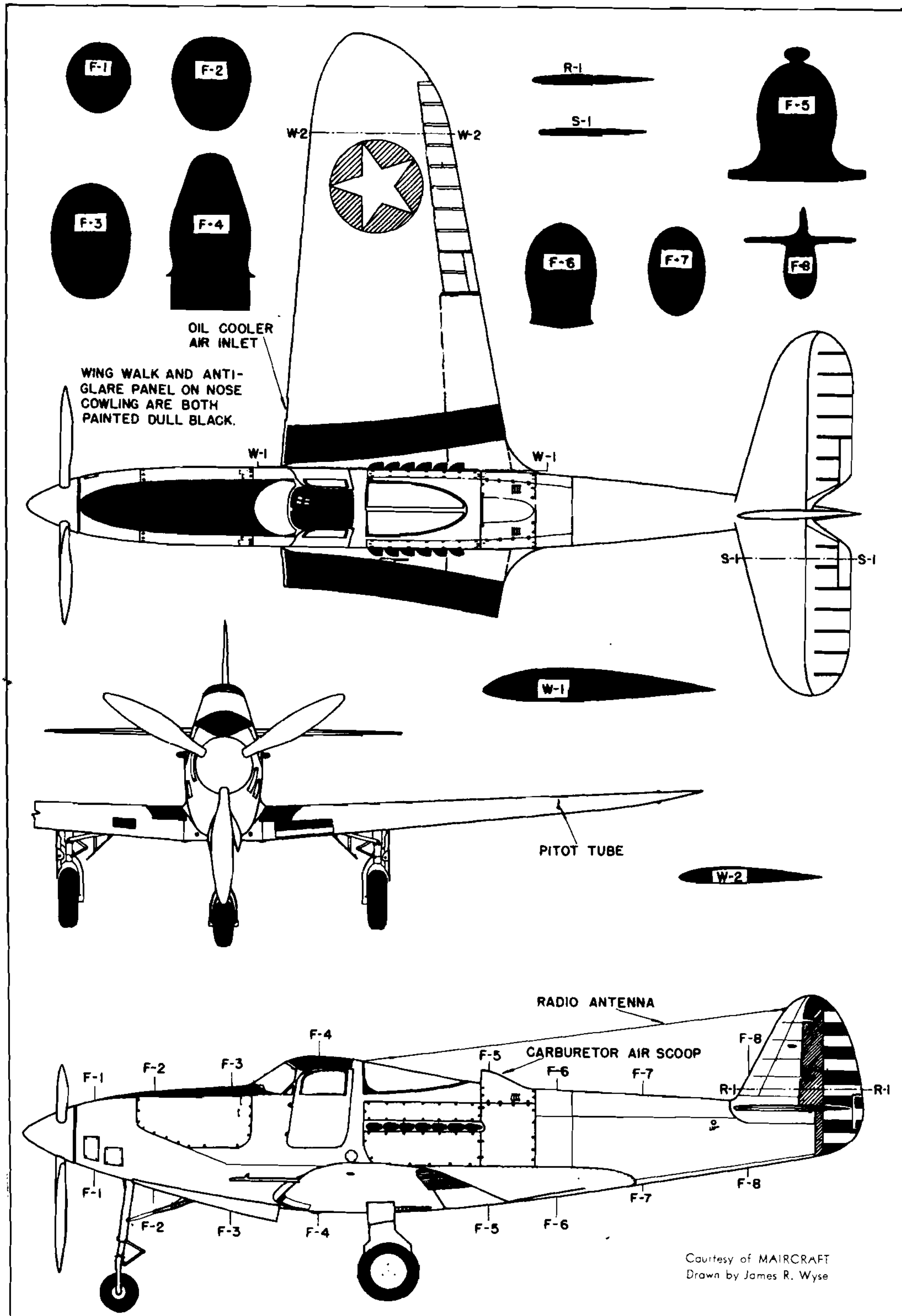


Courtesy of MODERN HOBBYCRAFT PRODUCTS
P.O. Box 199, Grand Central Annex
New York 17, N. Y.



BELL P-39 AIRACOBRA

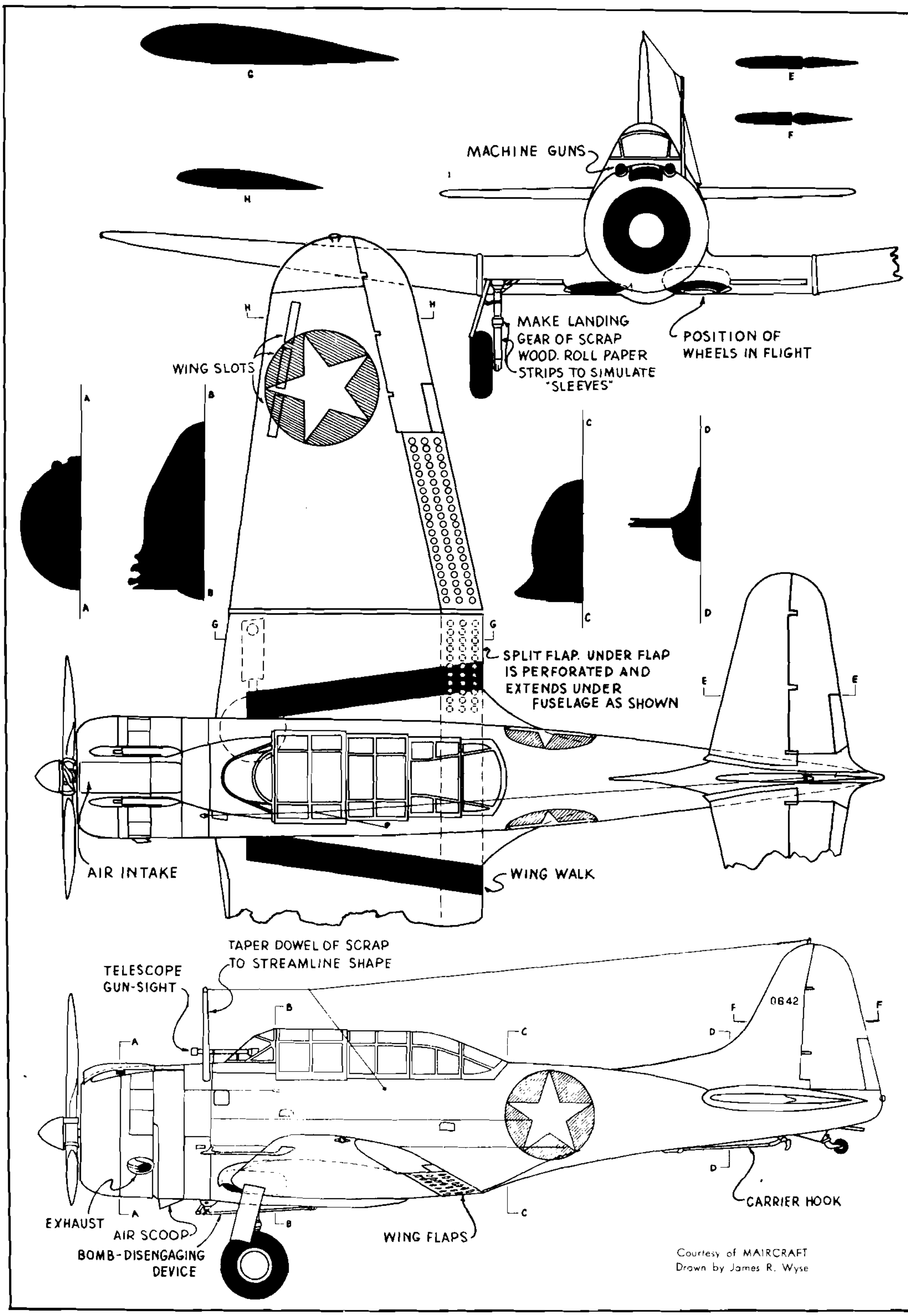
In service as a stock AAF single-seat fighter since the beginning of the war, the medium-altitude Bell P-39 Airacobra has been in action in every war theater; it has also been sold to both England and Russia. The Airacobra is especially famous because of the central mounting of its engine and its hub-mounted 37mm. cannon, which was until recently the largest ordnance used on any aircraft. Another point in favor of the ship is its tricycle undercarriage, which makes possible safe landings on small, muddy fields.



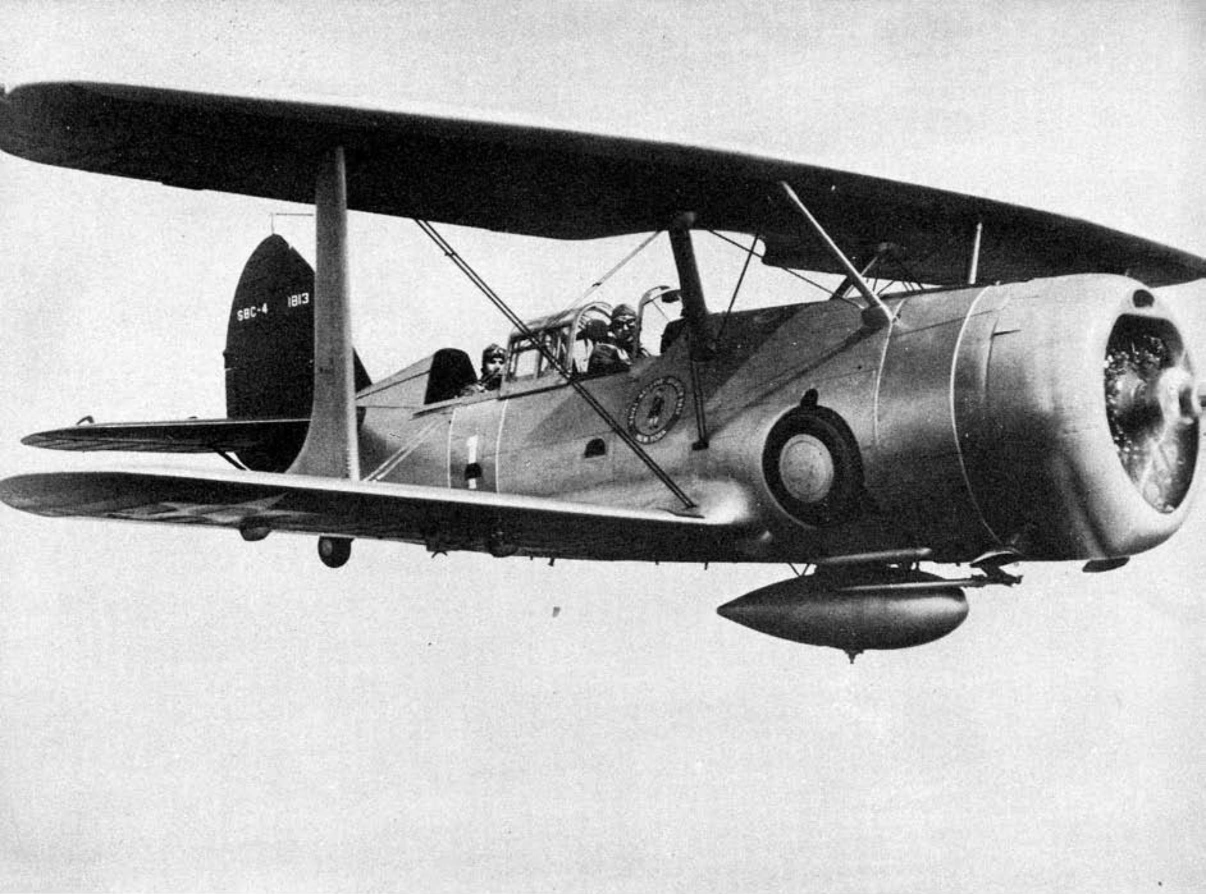
Courtesy of MAIRCRAFT
Drawn by James R. Wyse

DOUGLAS SBD DAUNTLESS

Though not as fast as other dive-bombers, the Douglas SBD Dauntless has been acclaimed as one of the best machines of its type. In service with both the Navy and Army (AAF designation is A-24 Banshee), the ship is powered by an air-cooled radial Wright Cyclone engine of 950 h.p. and has a top speed of 275 m.p.h. at 7,500 feet. Its loaded weight of only 8,157 pounds makes the Dauntless able to fly and maneuver much like a fighter, with the additional protection of a rear machine gun. Heavy bombs are slung below the fuselage on an ejector-type rack.

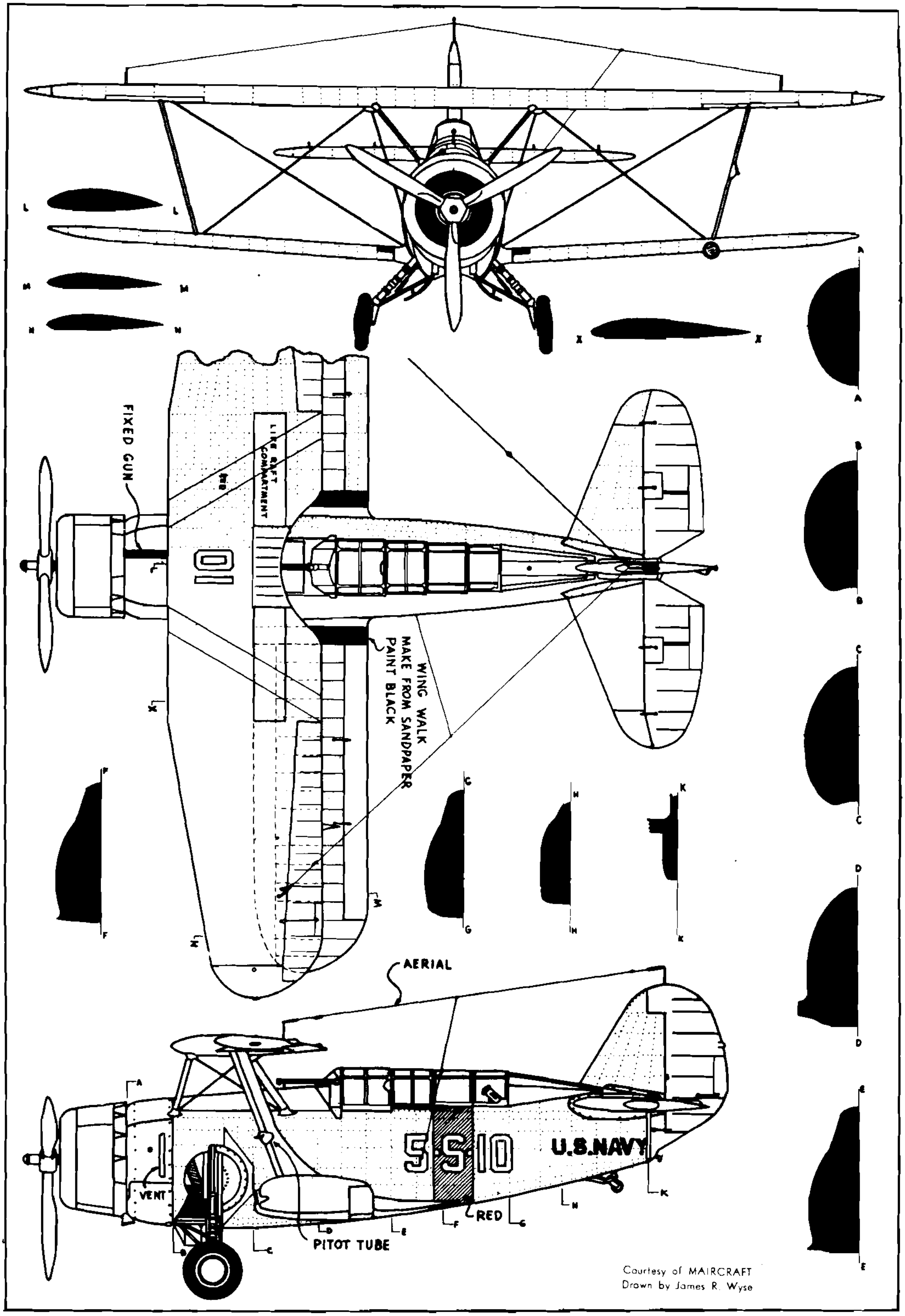


Courtesy of MAIRCRAFT
Drawn by James R. Wyse



CURTISS SBC-4 CLEVELAND

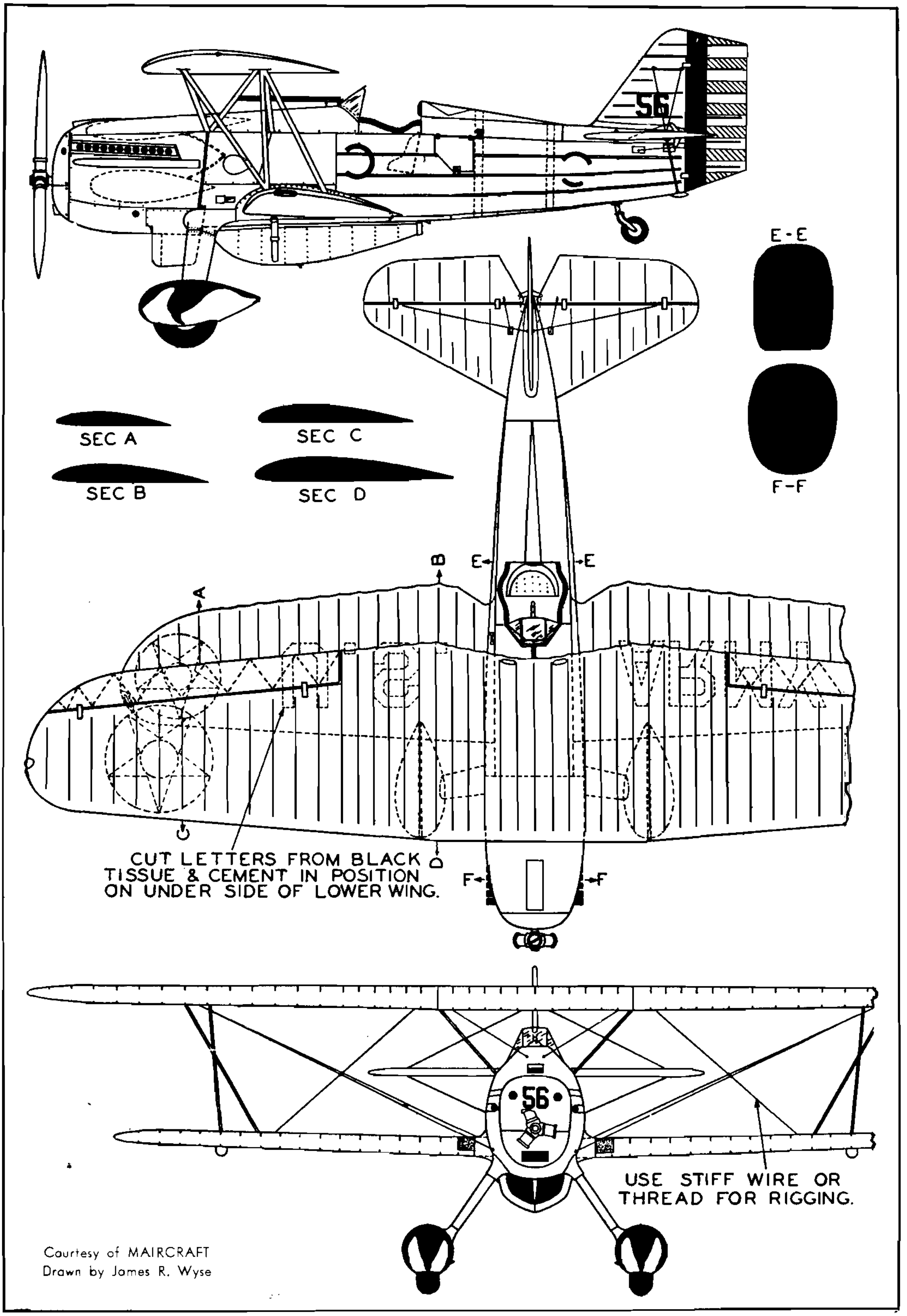
Last biplane scout-bomber accepted by the Naval Air Service was the Curtiss SBC-4 Cleveland. A crew of two is accommodated and the cockpits are covered by a long transparent canopy. Provisions are made for carrying a 500- or 1,100-pound bomb under the fuselage and smaller bombs on wing racks. Under Lend-Lease, the SBC-4 was shipped to both France and England. Powered by a Wright Cyclone engine of 850 h.p., it has a top speed of 235 m.p.h. and a cruising speed of 197½ m.p.h.



Courtesy of MAIRCRAFT
Drawn by James R. Wyse

CURTISS P-6E HAWK

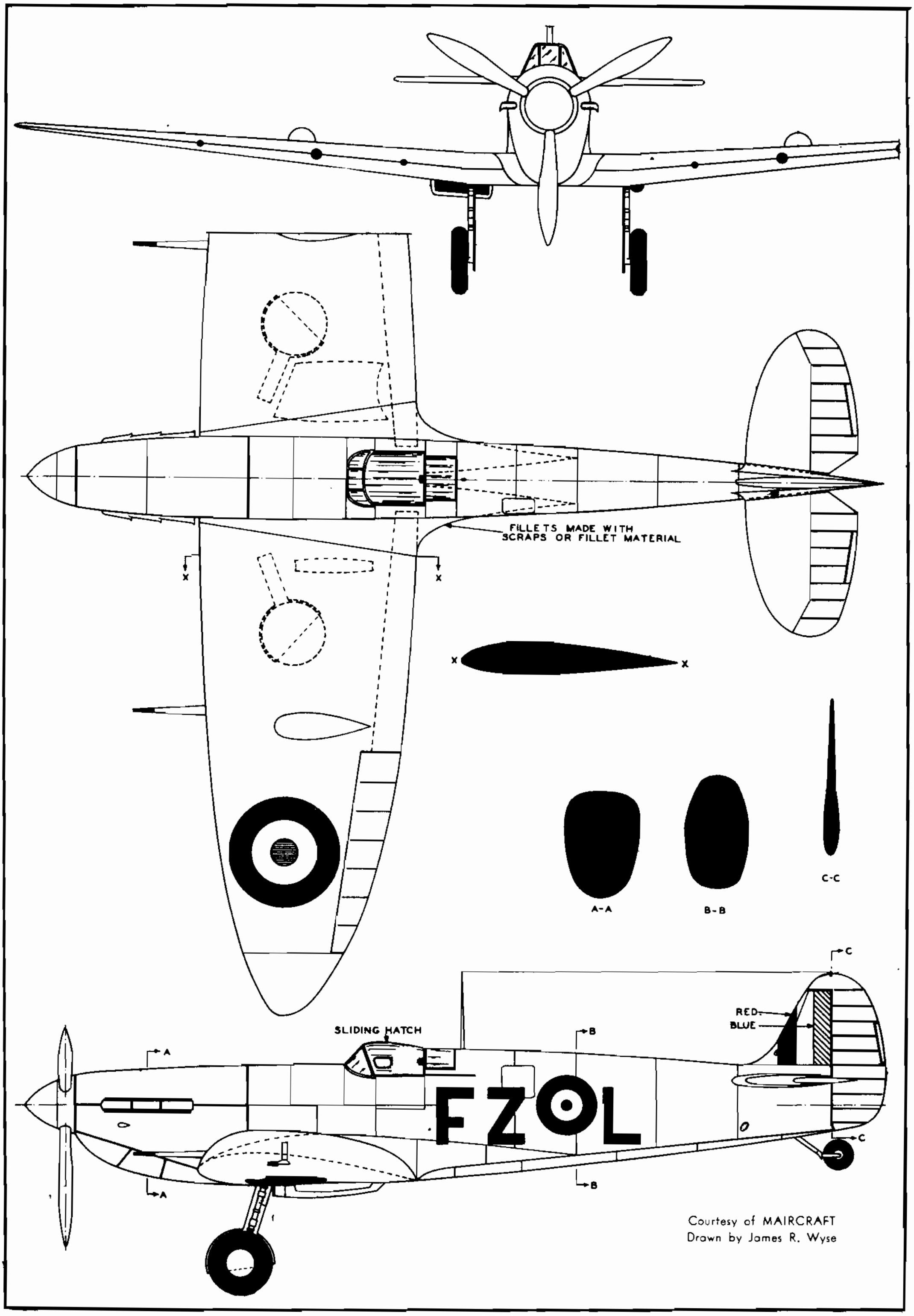
One of the most popular and colorful fighters ever to see service with the Army was the Curtiss P-6E. Though slow as compared with present-day fighters, it was highly maneuverable and was the most speedy single-seater in the Air Corps in its heyday. A later model of the ship, the P-6H, was fitted with six machine guns—more than carried by any similar American warplane up to 1939. The P-6E itself was fitted with only two .30-caliber machine guns, and these were synchronized to fire through the propeller arc. Though obsolete, the ship is still a favorite with modelers.



Courtesy of MAIRCRAFT
Drawn by James R. Wyse

SUPERMARINE SPITFIRE

Commonly called the savior of Britain, the Supermarine Spitfire was developed from the old Schneider Cup Race winners. The lines are exceptionally graceful and it is claimed that the technique utilized in construction, which is of the stressed-skin variety, gives extra stiffness to the wing and fuselage for a structure never before attained in this class of craft. And although the Spitfire is now quite old as warplanes go, it is still in mass production and is Britain's stock first-line fighter. The ship has been built with various armament arrangements, from eight machine guns to four 20mm. cannon.


FILLETS MADE WITH
SCRAPS OR FILLET MATERIAL
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X
A-A
B-B
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C
RED
BLUE
SLIDING HATCH
A
A
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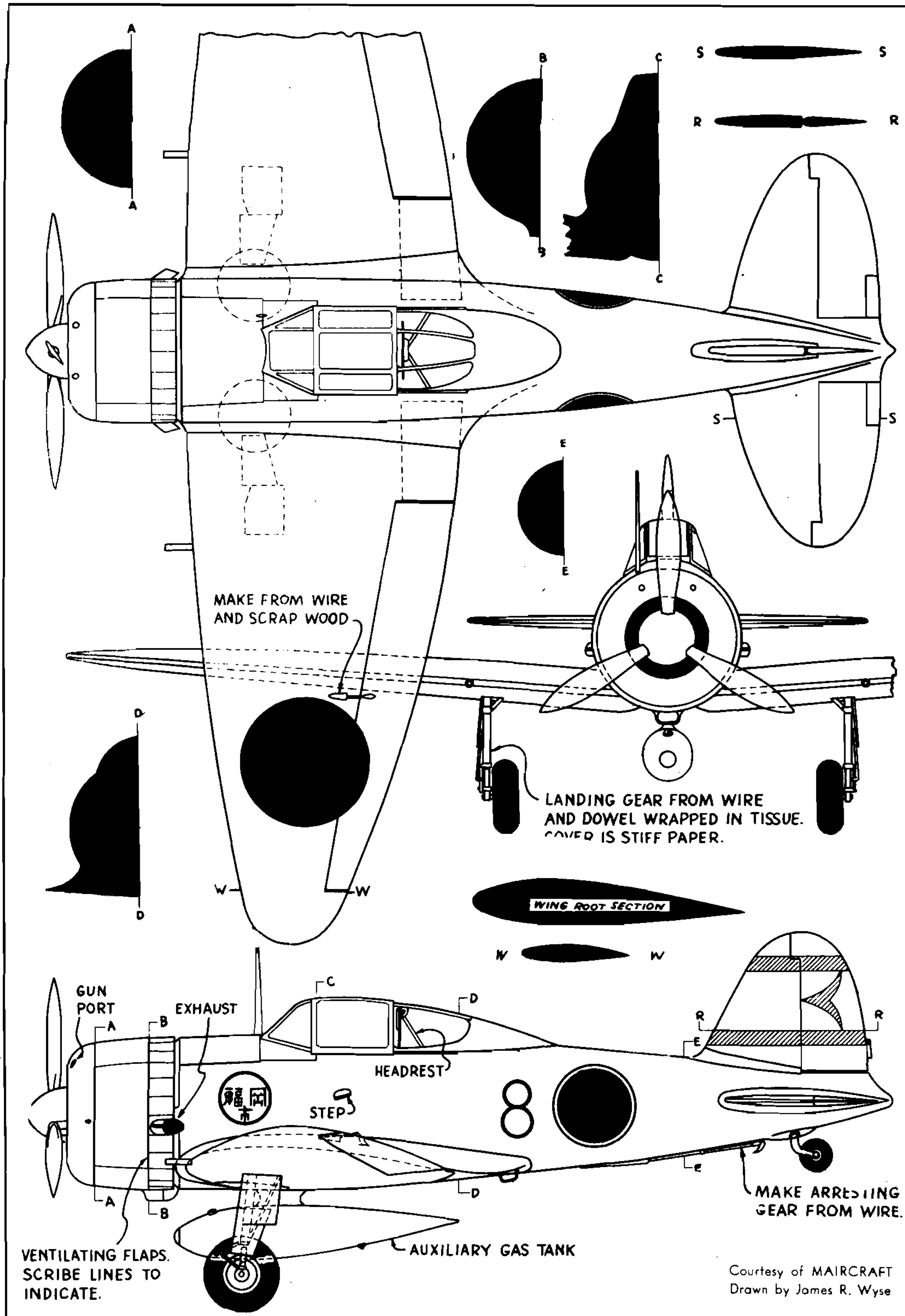
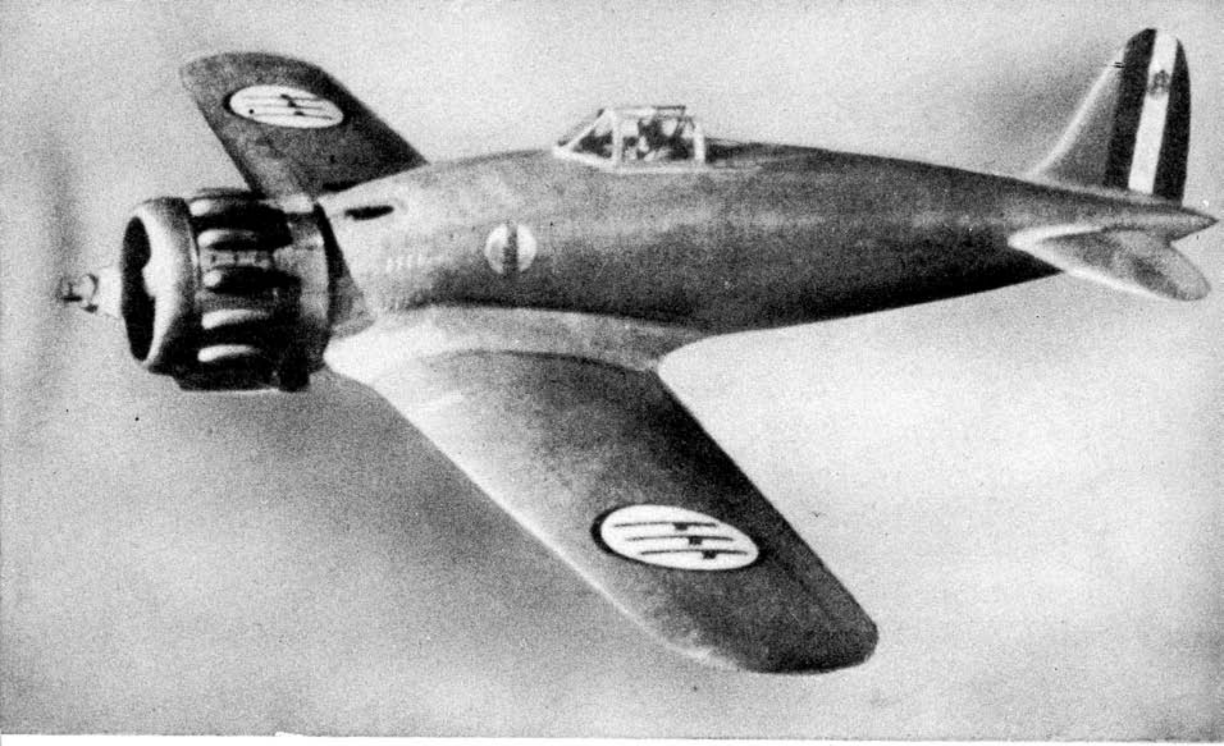
B
FZ L
Courtesy of MAIRCRAFT
Drawn by James R. Wyse

JAPANESE ZERO

Even though the Japanese Zero is far outclassed by modern Army and Navy aircraft, the ship, in the words of American Navy air experts, is "built like a fine watch." And Lieut.-Comdr. W. R. Sanders, who test-flew a captured Zero in this country, found it a "stable, easy-to-fly plane, well constructed but lacking self-sealing tanks and armor protection for the pilot." The Zero can by no means be ignored, for with its two 20mm. cannon and two 7.7mm. machine guns it packs a good punch, and more recent versions have had the earlier faults corrected. With an auxiliary tank of 215 gallons, the Zero has a cruising range of 1,200 miles.

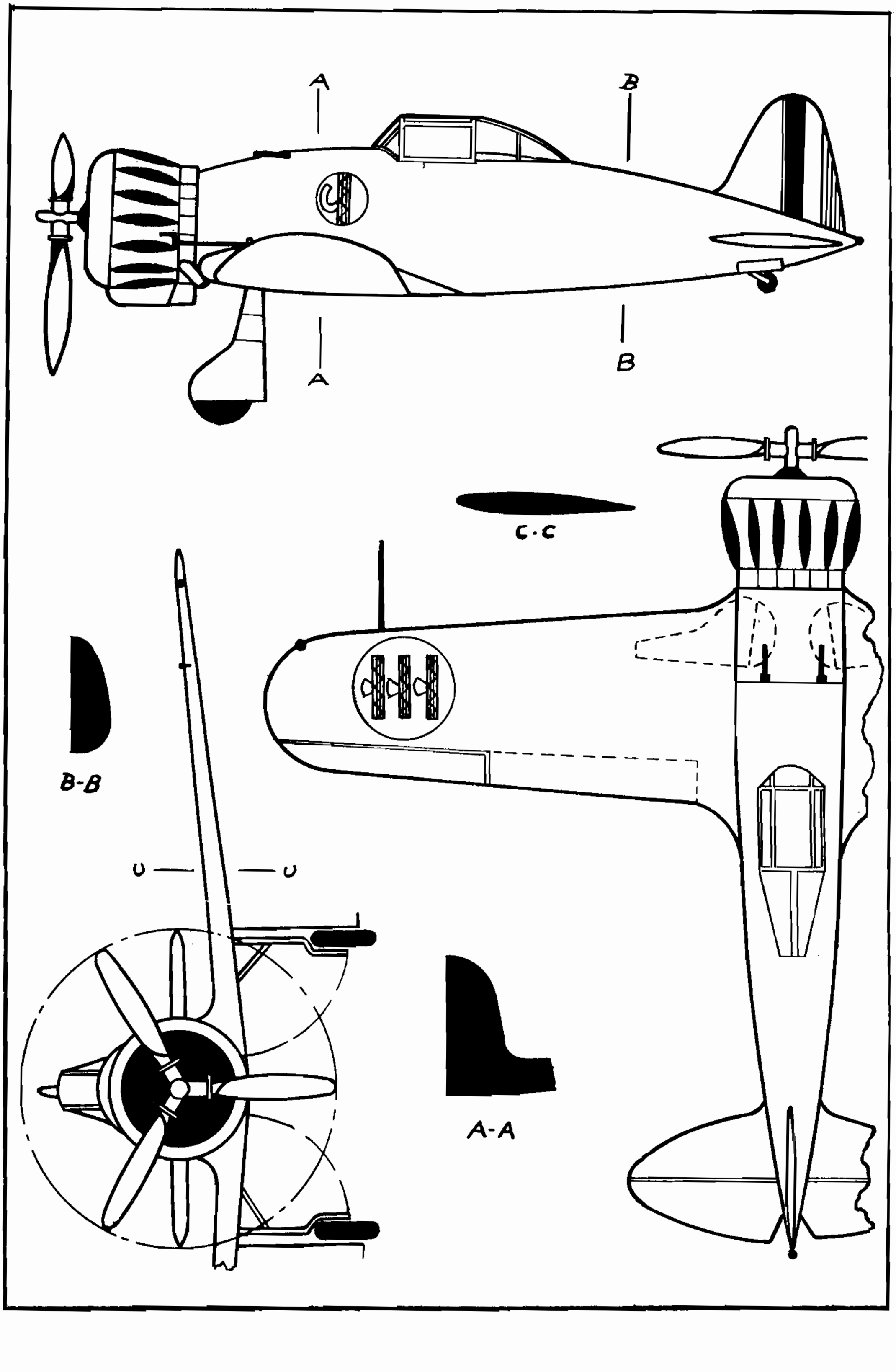


Courtesy of MAIRCRAFT
Drawn by James R. Wyse



MACCHI C. 200

One of Italy's standard fighters was the Macchi C. 200, which was later fitted with an in-line Daimler-Benz engine and called C. 202. And though Italy is out of the war, many C. 200's are still seeing service against the Allies; this because the Germans controlled all air bases from which the Italians flew and captured all the Italian planes at the time of the surrender. The C. 200 is reported to be tricky on the controls, but it is a fine machine when flown by a competent pilot and has very good handling characteristics. With its twin-row Fiat engine of 840 h.p., the top speed is 314 m.p.h. at 15,745 feet.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B-B
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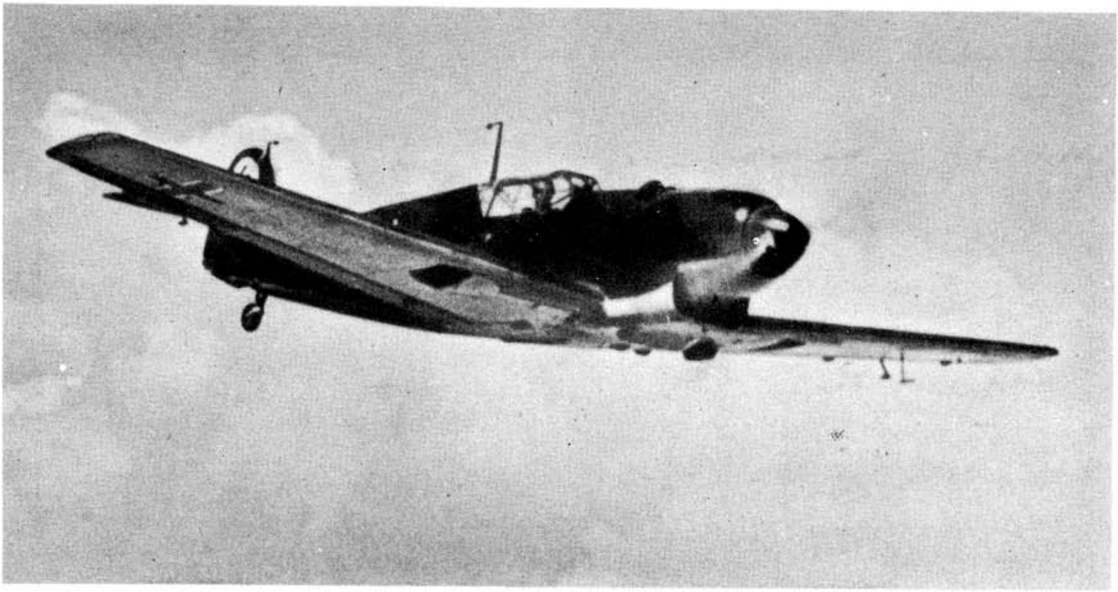
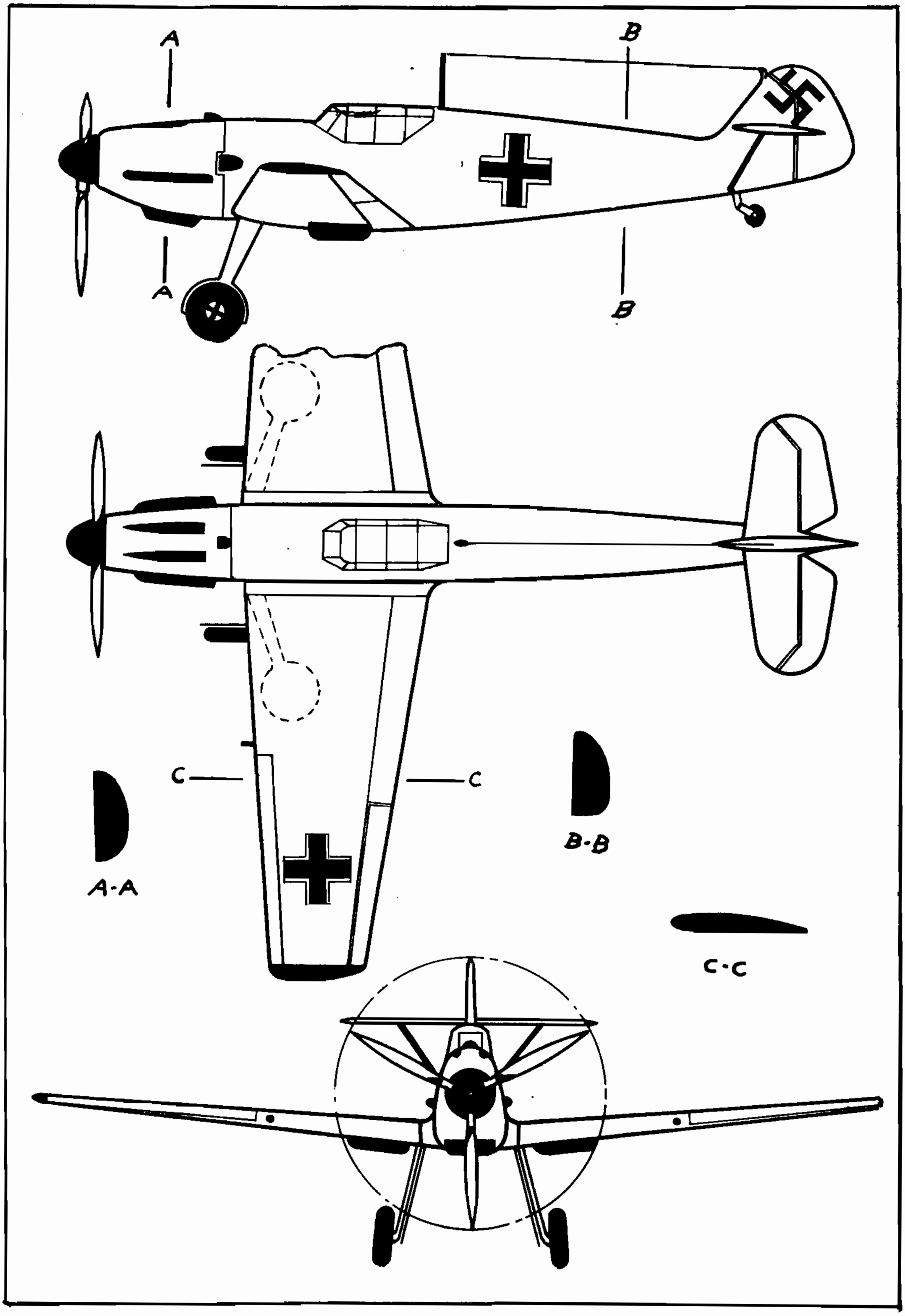


MESSERSCHMITT ME. 109

Probably the most famous of all German single-seat fighters, the Messerschmitt Me. 109 in its various models is used by the Nazis in large numbers. Regardless of early reports to the contrary, the Me. 109 is not a slipshod job. It is well built and carries as many instruments as similar American or British fighting craft. The monocoque fuselage is of all-metal construction; covering is flush-riveted metal sheet. In a special souped-up version, the Me. 109R, Fritz Wendel on April 26, 1939, did 468.225 m.p.h., and the next day he flew 481.4 m.p.h.; this latter is still the highest official world's speed record.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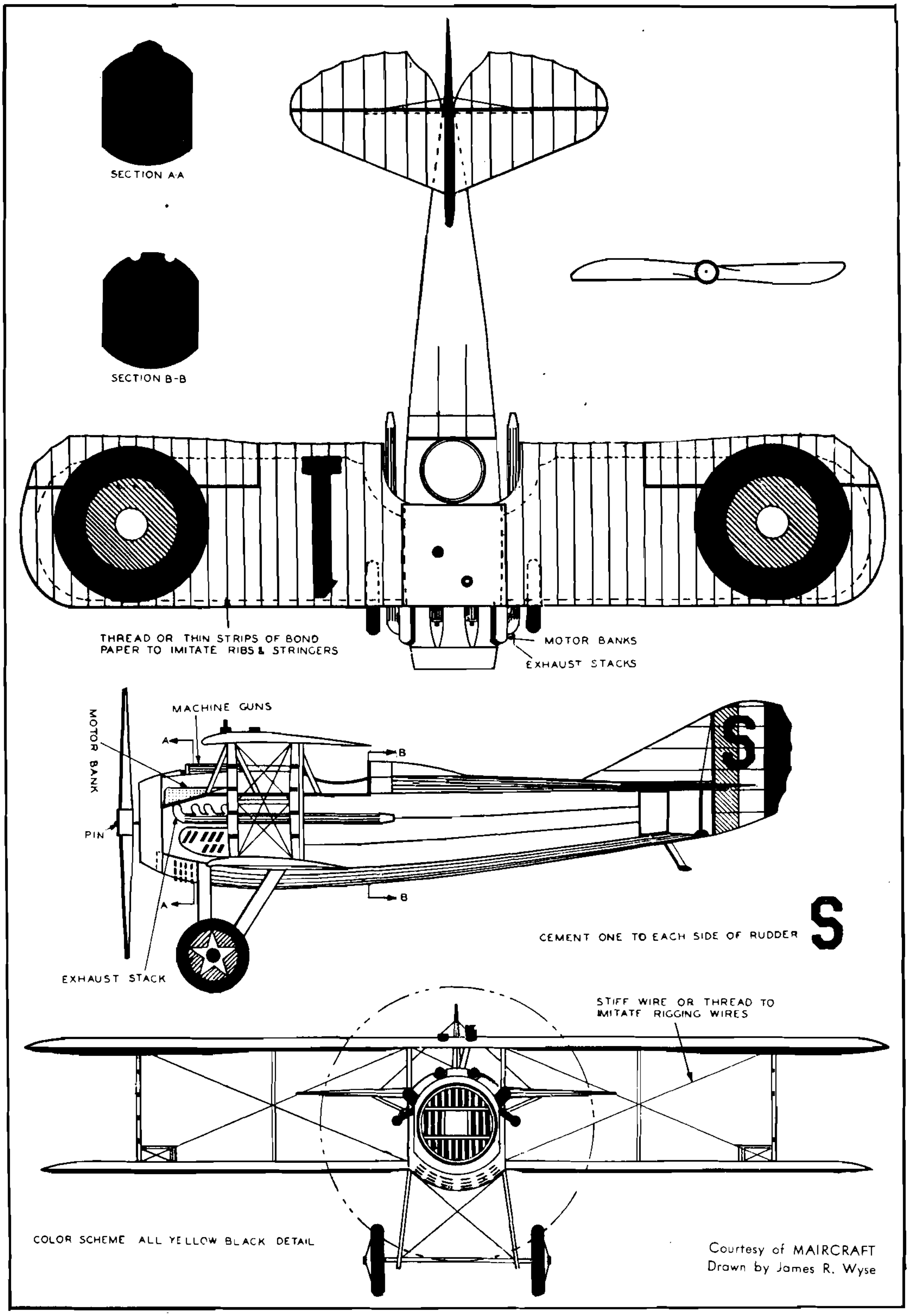
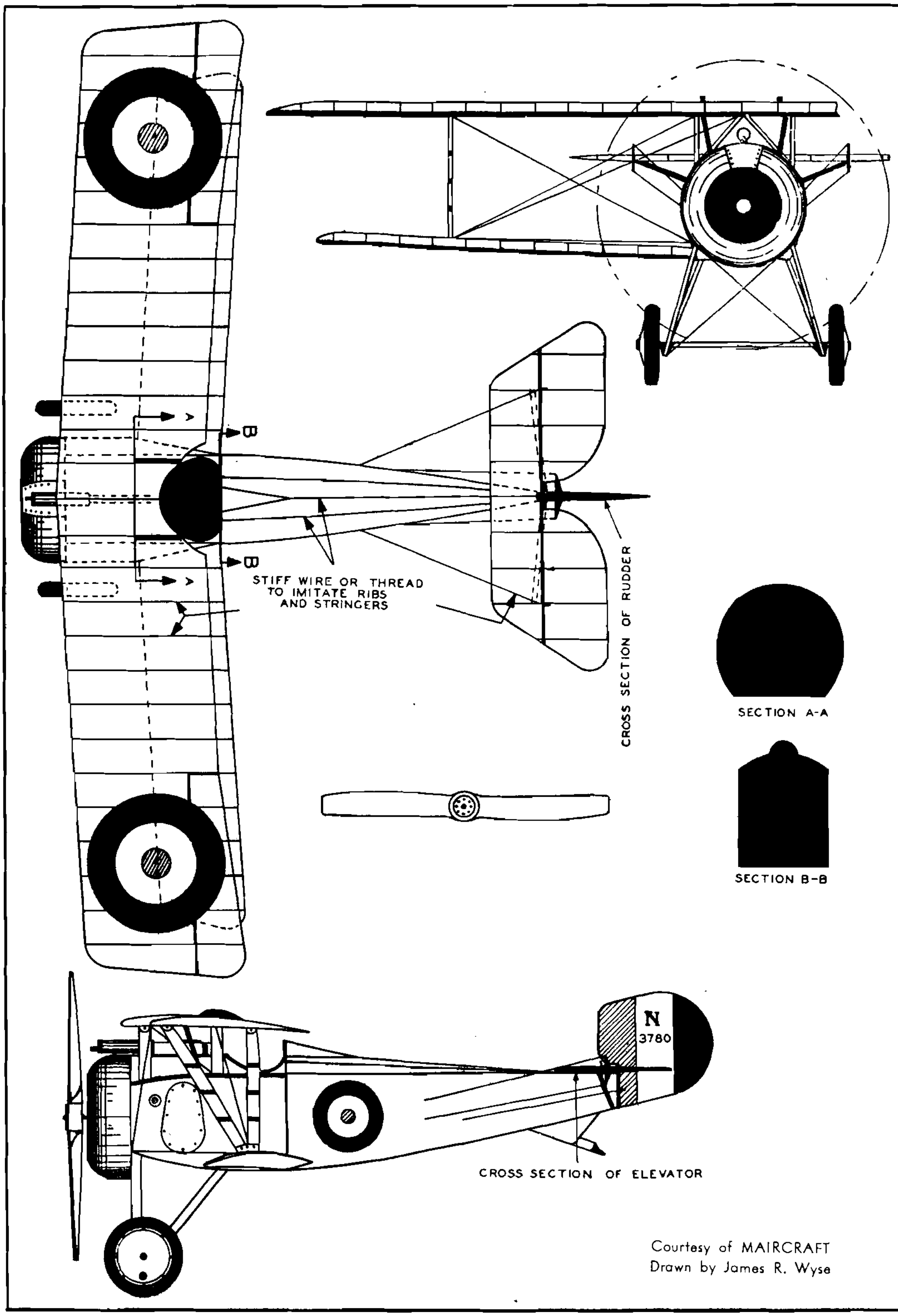
SPAD 13C1

One of the best first World War fighting planes was the Spad 13C1. Of all-wood construction, the ship was covered with fabric. It was powered by a Hispano-Suiza engine and had a top speed of about 125 m.p.h. The Spad was also turned out as a two-seat fighter, and one version had a cannon firing through the propeller shaft; normal armament was two .30-caliber synchronized machine guns mounted on the engine cowl. Captain Eddie Rickenbacker used the Spad, in combat, as did Frank Luke and many other American Aces.


SECTION A-A
SECTION B-B
THREAD OR THIN STRIPS OF BOND PAPER TO IMITATE RIBS & STRINGERS
MOTOR BANKS
EXHAUST STACKS
MACHINE GUNS
MOTOR BANK
PIN
A
B
S
CEMENT ONE TO EACH SIDE OF RUDDER
S
EXHAUST STACK
STIFF WIRE OR THREAD TO IMITATE RIGGING WIRES
COLOR SCHEME ALL YELLOW BLACK DETAIL
Courtesy of MAIRCRAFT
Drawn by James R. Wyse

NIEUPORT 17

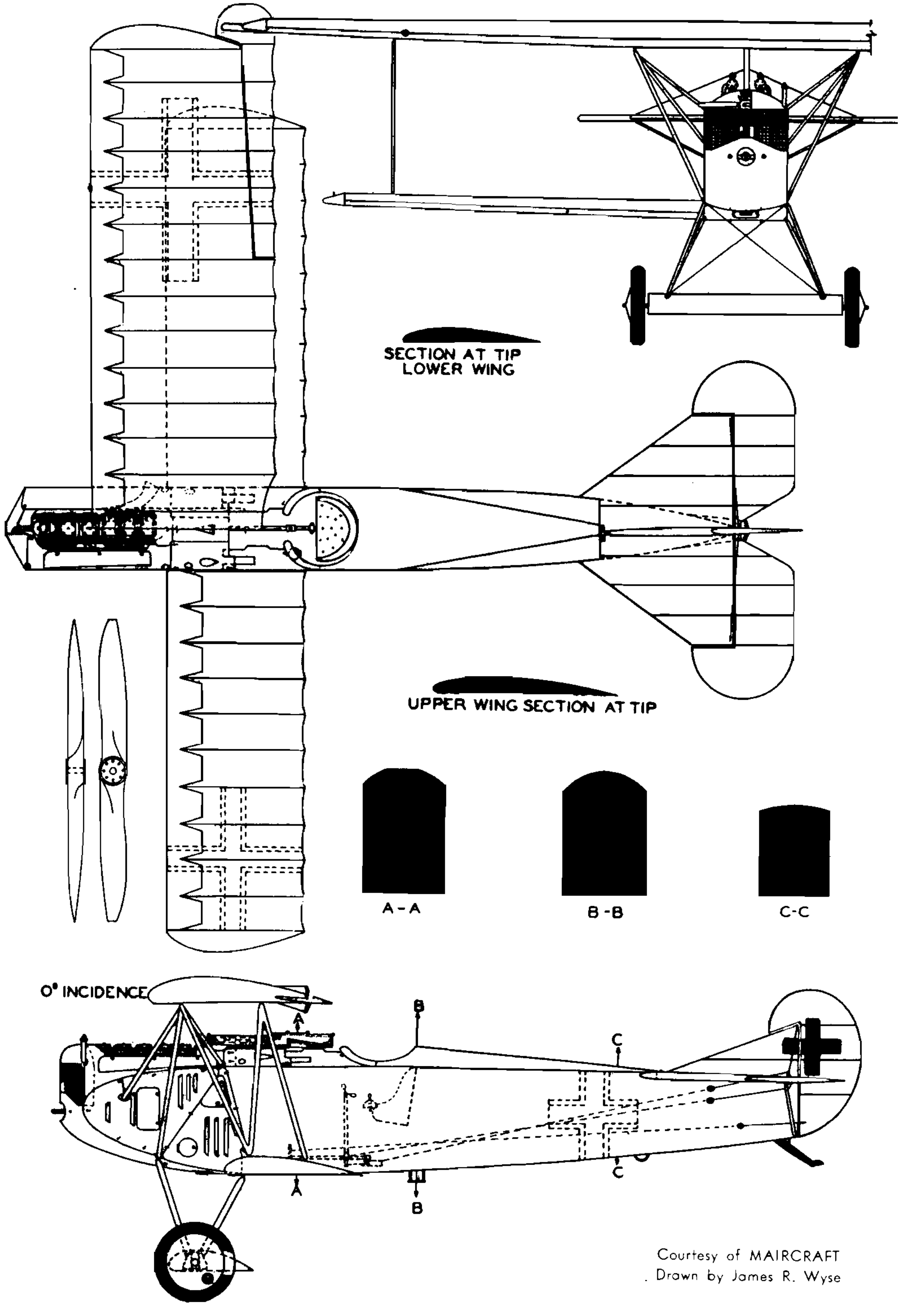
Notorious for shedding fabric from its upper wing in steep power dives, the Nieuport 17 was nonetheless popular with combat pilots in the first world conflict. Its 80-h.p. Le Rhone rotary engine caused trouble, too, because torque made tight right turns risky; it was very easy to fall into a spin from too tight turns. This picture was taken at a Royal Naval Air Service station, to which new ships were flown before delivery to the front. This was one of the smallest and lightest planes in the war, and one of the most famous in service with the Allies.



Courtesy of MAIRCRAFT
Drawn by James R. Wyse

FOKKER D-7

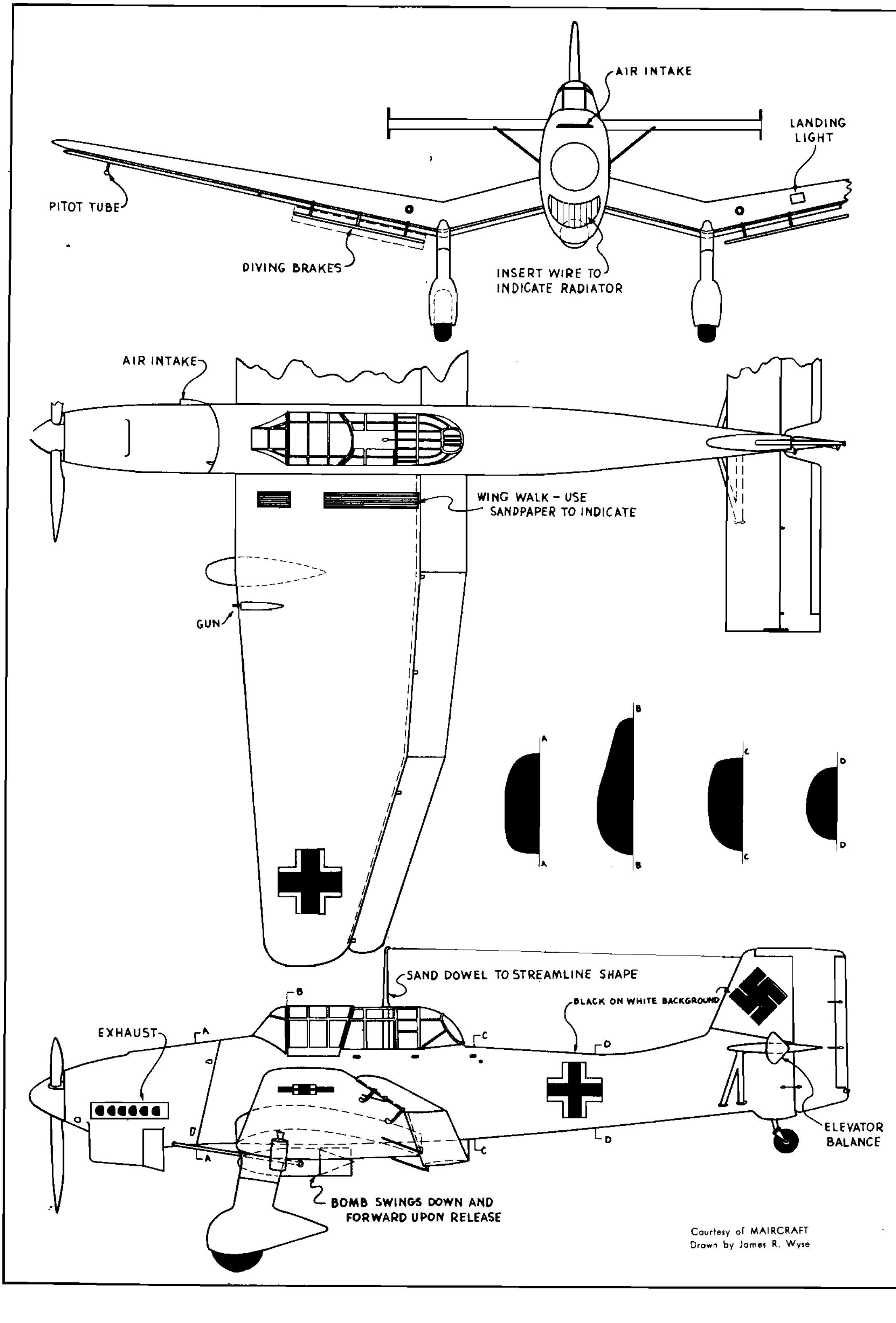
Generally acknowledged to be one of the best single-seat fighters in German service during the first World War, Tony Fokker's coffin-nosed D-7 accounted for many Allied planes and pilots. It was not what can be called a "good-looking" plane, but it had more than enough of what it takes in air combat. The design was so good, as a matter of fact, that after the war Fokker continued to build the machine, in this country, as a two-seater. The D-7 used a Mercedes engine of 160 h.p. and mounted two machine guns. This particular picture, incidentally, is a collector's item, because of the four-bladed prop mounted.



Courtesy of MAIRCRAFT
. Drawn by James R. Wyse

JUNKERS JU. 87B

Obsolete but still in service in large numbers, the Junkers Ju. 87B dive-bomber is the plane which struck such terror into defenders of Poland, Belgium, Holland, and France. Actual battle, however, proved that the machine was certainly no match for first-line Allied aircraft and that seasoned infantry troops were not troubled by the screaming bombs dropped by Stukas. Hitler placed much faith in the Ju. 87B, and this was justified up to the Battle of Britain. Then the Stuka was proved to be just a lot of sound and fury, with little actual war value other than terror. After that had been discovered, the war worth of the ship was killed once and for all. Powered by a liquid-cooled in-line Junkers Jumo engine of 1,000 h.p., it has a top speed of 242 m.p.h.



Courtesy of MAIRCRAFT
Drawn by James R. Wyse

CHAPTER XIV

OFFICIAL AMA RULES

IN VIEW OF WARTIME conditions, the Contest Board of the Academy of Model Aeronautics will, in effect, remain "in session" during the year and will consider suggested revisions each quarter—that is, in March, June, September, and December—as submitted by the modelers. It is felt that in this manner the rules will be more or less constantly kept up to date, at least until peace is declared and it is possible to hold the traditional meetings in conjunction with the Nationals each year.

Under authority of the National Aeronautic Association, American representatives of the Fédération Aeronautique Internationale, world-wide governing body for all sporting aviation, the following model aircraft classifications and regulations are prescribed for the year 1944 by the Academy of Model Aeronautics.

I. DEFINITIONS

(A) MODEL AIRCRAFT. All aircraft of reduced size which are not capable of supporting a human being. Such aircraft are classified as indoor or outdoor models. No restrictions are placed on design of the models except that they shall meet the specifications listed in these regulations. The models must be so designed, however, that they drop no parts in flight or during take-off. Projected area of the horizontal stabilizing surface(s) in excess of 50 percent of the projected area of the supporting surface(s) (wing area) shall be considered as supporting surface for purposes of classification and wing loading requirements.

(B) Indoor Model Aircraft. A model of the indoor type is designed to fly indoors. Indoor models are classified as powered models or non-powered models. There are no weight specifications for such aircraft other than for flying scale models.

(C) Outdoor Model Aircraft. A model of the outdoor type is designed primarily to fly outdoors. Outdoor models are classified as powered models or non-powered models. There are weight specifications for all outdoor aircraft. If ballast is used to bring an outdoor model up to the required weight, such ballast shall be permanently affixed to the model.

(D) Stick Model. A model of the stick type has a body composed of stick(s), tube(s), or open framework, rather than a fuselage. Models using tubes or framework to enclose the motor(s) shall have a total maximum cross-section area of the tubes or sticks not greater than $L^2/150$, where "L" equals the overall length of the model, excluding the propeller(s). A model powered by other than an internal combustion engine of the "flying wing" category shall be included for purposes of competition in the stick model classification. A "flying wing" has no fuselage, nor has it stabilizing surfaces other than those fastened directly to the single supporting surface.

(E) Cabin Model, Powered by Other Than Internal Combustion Engine(s). A model of the cabin type powered by other than internal combustion engine(s) has built-up enclosed fuselage. The total maximum cross-section area of the fuselage(s) must not be less than $L^2/100$, where "L" equals the over-all length of the model, excluding the propeller(s). In the case of multiple fuselages, the sum of their cross-sections shall be considered. The fuselage(s) shall have not less than 90 percent of its (their) surface area covered. Outriggers and booms may be used. The rubber used for motive power shall be contained entirely within the built-up fuselage.

(F) Model Aircraft Powered by Internal Combustion En-

GINE(S), FREE-FLIGHT. Model aircraft powered by internal combustion engine(s) shall have a built-up fuselage of the cabin type. The maximum cross-section area of the fuselage(s) must not be less than $L^2/100$, where "L" equals the over-all length of the model, excluding the propeller(s). The fuselage(s) shall have not less than 90 percent of its (their) surface area covered. There shall be no fuselage cross-section requirements for model aircraft of the "flying wing" category. A "flying wing" has no fuselage, nor has it any stabilizing surfaces other than those fastened directly to the single supporting surface.

(G) CABIN MODEL, NON-POWERED. A non-powered model of the cabin type (towline glider) must have a total maximum cross-section area of the fuselage(s) of not less than $L^2/100$, where "L" equals the over-all length of the model. The fuselage(s) shall be of streamline form and have not less than 90 percent of its surface area covered. Outriggers and booms may be used. There shall be no fuselage or stick cross-section requirement for towline gliders of the "flying wing" category.

(H) HAND-LAUNCHED. A model airplane is hand-launched when it is released into flight directly from the hands of the launcher. The model shall be launched from an elevation of not more than 6 feet above the ground or floor.

(I) RISE-OFF-GROUND. A model airplane of the rise-off-ground (R.O.G.) type has a take-off gear that permits it to take off from the ground, floor, or runway under its own power. R.O.G. models may be guided, but not pushed nor mechanically assisted, by the contestant. In guiding a model at the start of its take-off run, the contestant shall not take a forward step. Mechanical take-off assistance is not permitted. The take-off gear must be strong enough to support the model in a normal attitude while at rest and permit it to take off without damage, nosing over, or striking a wing tip. When one wheel is used, skids or similar devices shall be required to keep the model upright in a normal attitude and to prevent any part other than the take-off gear from touching the ground, floor or runway. Wheel(s) shall turn freely and be of such strength and size as to permit the model to taxi freely. The minimum diameter of the wheel(s) for all models powered by other than internal combustion engine(s) is as follows:

One-half inch, where the projected area of the supporting surface(s) does not exceed 30 square inches; three-quarters inch, where the projected area of the supporting surface(s) exceeds 30 but is not more than 100 square inches; one inch, where the projected area of the supporting surface(s) exceeds 100 but is not more than 150 square inches; one and one-half inches, where the projected area of the supporting surface(s) exceeds 150 but is not more than 300 square inches; and two inches, where the projected area of the supporting surface(s) exceeds 300 square inches.

(J) LAUNCHING. A model powered by internal combustion engine(s) or powered by other than internal combustion engine(s) must R.O.G., except in the case of R.O.W. models and except in the event of extremely adverse weather conditions when, at the discretion of the Contest Director, models may be hand-launched. No records shall be recognized if made by hand-launched models.

(K) TOWLINE-LAUNCHED. A model airplane is towline-launched when it is pulled into the air from the ground by an inextensible line. The towline shall be no longer than 100 feet, and shall be released from the model by the launcher at the end of the tow. Launching mechanism designed to assist the take-off may be used provided it is dropped from the glider at the same time the towline is released. To assist in determining the time of release, a fabric or paper streamer shall be affixed to the towline not more than 12 inches from the end which is attached to the model.

(L) RISE-OFF-WATER. A model airplane of the rise-off-water (R.O.W.) type can take off from and alight on water and shall float unassisted. All surfaces and parts other than floats or pontoons shall be above the surface of the water. The model shall take off from the water starting from a stand-still under its own power, but is not required to land on the water at the end of the flight. Indoor rise-off-water models shall demonstrate their seaworthiness by floating unassisted five seconds. Outdoor rise-off-water models shall demonstrate their seaworthiness by floating unassisted thirty seconds.

(M) MODELS POWERED BY INTERNAL COMBUSTION ENGINE(S). NOT FREE-FLIGHT. A model airplane of the control type is designed to fly under control of the operator by means of cord(s), string(s), or wire(s) attached to the model in such a way as to provide means for controlling the flight of the model. Control models shall have take-off gear which permits them to take off and land in a normal fashion, as described under Rule I (I) except that device(s) for retracting and lowering the landing gear may be used.

(N) AUTOGIRO. An autogiro model is supported in flight by the action of the air on vanes which rotate freely on an approximately vertical axis, supplemented by the thrust of propeller(s) on an approximately horizontal axis. If a fixed wing is employed, the projected area of the vanes shall not be less than that of the fixed wing(s), and the sums of these projected areas shall be considered the main supporting surface(s).

(O) ORNITHOPTER. An ornithopter model derives its propulsion solely from the flapping of its wing(s). The projected area of the wing(s) shall be taken midway between the upward and downward positions of the wing(s).

(P) HELICOPTER. A helicopter model rises without assistance and is supported in flight solely by the lift of power-driven propeller(s) and/or vane(s). The projected area of the propeller(s) and vane(s) shall be considered the supporting surface(s).

(Q) GLIDER. A glider is similar to a model airplane but differs in that it has no power plant.

II. CLASSIFICATION

(A) MODEL AIRCRAFT POWERED BY INTERNAL COMBUSTION ENGINE(S). Both free-flight and controlled-flight models powered by internal combustion engine(s) are classified by engine(s) displacement as follows:

Class A, where the displacement of the engine(s) does not exceed .20 cubic inches; Class B, where the displacement of the engine(s) exceeds .20 but is not more than .30 cubic inches; and Class C, where the displacement of the engine(s) exceeds .30 but is not more than 1.25 cubic inches. Free-flight models powered by internal combustion engine(s) shall employ a device to limit the length of the engine run and may utilize a device to limit the length of the flight time.

(B) Models Powered by Rubber, Spring, or Hand-Launched. All models other than those powered by internal combustion engine(s) are classified by projected area of the supporting surface(s) as follows:

Class A, where the projected area of the supporting surface(s) does not exceed 30 square inches; Class B, where the projected area of the supporting surface(s) exceeds 30 but is not more than 100 square inches; Class C, where the projected area of the supporting surface(s) exceeds 100 but is not more than 150 square inches; Class D, where the projected area of the supporting surface(s) exceeds 150 but is not more than 300 square inches; and Class E, where the projected area of the supporting surface(s) exceeds 300 square inches.

(C) Models Powered by Other Than Rubber or Internal Combustion Engine(s). (Experimental). These models with experimental miniature engines (excluding rockets) shall follow the same categories as internal combustion powered models in respect to classes and piston displacement. Complete specifications shall be submitted to the Academy of Model Aeronautics with each record claim in this category.

III. WING LOADING REQUIREMENTS

(A) Indoor. There are no wing loading (weight) requirements for indoor model aircraft.

(B) Outdoor Model Aircraft Powered by Internal Combustion Engine(s). All free-flight model aircraft powered by internal combustion engine(s) shall be limited to a total flying weight of not more than 7 pounds, shall weigh not less than 80 ounces for each cubic inch of engine(s) displacement, and shall weigh not less than 7 ounces for each 100 square inches of projected supporting surface(s).

(C) Models Powered by Internal Combustion Engine(s). Not Free-Flight. Model aircraft of the control category in which the operator controls the flight of the model by means of cord(s), string(s), wire(s), attached to the model, shall weigh not more than 3 pounds for each square foot of projected lifting surface(s) area and not less than 80 ounces for each cubic inch of motor displacement. Control models shall meet the following minimum wing area requirements:

Class A—Not less than 75 square inches; Class B—Not less than 125 square inches; and Class C—Not less than 200 square inches.

(D) Models Powered by Other Than Rubber or Internal Combustion Engine(s). (Experimental). Model aircraft of this category shall follow the wing-loading and piston-displacement classifications outlined for free-flight model aircraft powered by internal combustion engine(s).

(E) Outdoor Model Aircraft Powered by Other Than Internal Combustion Engine(s). All outdoor model aircraft powered by other than internal combustion engine(s) shall weigh, complete and ready to fly, not less than 3 ounces avoirdupois for each 100 square inches of projected supporting surface(s), except autogiros, ornithopters, and helicopters.

(F) Outdoor Autogiros, Ornithopters, and Helicopters Powered by Other Than Internal Combustion Engine(s)—shall weigh, complete and ready to fly, not less than one ounce avoirdupois.

(G) Outdoor Model Aircraft, Non-Powered. Outdoor hand-launched gliders shall weigh, complete and ready to fly, not less than 2 ounces avoirdupois for each 100 square inches of projected supporting surface(s). Outdoor towline-launched gliders shall weigh, complete and ready to fly, not less than 3 ounces avoirdupois for each 100 square inches of projected supporting surface(s). Launching aids or stabilizing devices used in launching, and which are designed to be dropped at release, shall not be considered as an integral part of the model when checking for wing-loading requirements.

IV. CATEGORIES

The Academy of Model Aeronautics has established the following model aircraft categories:

(A) Indoor Model Aircraft, Powered—

Stick Models, Hand-Launched	Class B, C
Stick Models, Rise-Off-Ground	Class A, B
Stick Models, Rise-Off-Water	Class A, B
Cabin Models, Rise-Off-Ground	Class B, C

Cabin Models, Rise-Off-Water	**Class B, C**
Autogiro, Launching Optional	No classes for size
Ornithopter, Launching Optional . . .	No classes for size
Helicopter, Launching Optional . . .	No classes for size

(B) INDOOR MODEL AIRCRAFT, NON-POWERED—

Glider, Hand-Launched	Class A, B

(C) OUTDOOR MODEL AIRCRAFT, POWERED BY INTERNAL COMBUSTION ENGINE(S)—

Cabin Model, Rise-Off-Ground	Class A, B, C
Cabin Model, Rise-Off-Water	Class A, B, C
Control Model, Rise-Off-Ground .	Class A, B, C (Speed only)
Control Model, Rise-Off-Water .	Class A, B, C (Speed only)
Experimental Model	Class A, B, C

(D) OUTDOOR MODEL AIRCRAFT, POWERED BY OTHER THAN INTERNAL COMBUSTION ENGINE(S)—

Stick Model, Hand-Launched	Class C, D
Stick Model, Rise-Off-Water	Class C, D
Cabin Model, Rise-Off-Ground	Class C, D, E
Cabin Model, Rise-Off-Water	Class C, D
Ornithopter, Launching Optional . . .	No classes for size
Helicopter, Launching Optional . . .	No classes for size

(E) OUTDOOR MODEL AIRCRAFT, NON-POWERED—

Glider, Hand-Launched	Class B, C, D
Cabin Glider, Towline-Launched	Class C, D, E

V. OFFICIAL AND DELAYED FLIGHTS

(A) INDOOR MODEL AIRCRAFT, POWERED. An indoor powered model makes an official flight when it remains in the air for 60 seconds or more. An indoor powered model makes a delayed flight when it remains in the air for less than 60 seconds; hits an obstruction which prevents further flight; or hits an obstruction or another model which throws the model out of adjustment, changing its angle of flight so that it descends at an accelerated rate striking the ground or floor. Should a model hit an obstruction the timing device (stop watch) shall be permitted to run for an additional 10 seconds, and if the model does not fall free independently within the 10-second period, the timing device shall be stopped, the 10 seconds deducted from the total flight time and the entire performance recorded as a delayed flight. 3 successive delayed flights displace 1 official flight; the duration of all delayed flights shall be recorded. If there is no official flight which surpasses the duration of a delayed flight, the contestant shall be entitled to a reinstatement of the delayed flight as his best official flight. An indoor model makes a voided delayed flight, and is not credited with any duration time when it drops any part in flight or during take-off. Flights which are aided in any way, including the artificial upward displacement of air, shall be declared voided delayed flights. Pushing or touching a model during the take-off or flight constitutes a voided delayed flight.

(B) Indoor Model Aircraft, Non-Powered. All flights made by indoor gliders are official flights, regardless of duration. Delayed flights for indoor gliders are not recognized.

(C) Outdoor Model Aircraft, Powered by Internal Combustion Engine(s). An outdoor model powered by internal combustion engine(s) makes an official flight when it remains in the air for 40 seconds or more, providing that the engine run does not exceed 20 seconds. An outdoor model powered by internal combustion engine(s) makes a delayed flight when it remains in the air for less than 40 seconds, providing the engine run does not exceed 20 seconds. At option of the contestant, an outdoor model powered by an internal combustion engine makes a delayed flight when the motor run is less than 10 seconds. Three successive delayed flights displace one official flight: the duration of all delayed flights shall be recorded. Should an outdoor model powered by internal combustion engine(s) collide in the air with another model, the contestant may declare the flight either delayed or official flight. If three successive flights are recorded as delayed flights, the contestant shall be entitled to the reinstatement of the longest of these three successive delayed flights as an official flight. If one or more delayed flight(s) is/are followed by an official flight, the contestant shall not be entitled to reinstatement of the delayed flight(s) in place of an official flight. An outdoor model powered by internal combustion engine(s) makes a voided delayed flight, and is not credited with any duration time when it drops any part during take-off or flight. Flights which are aided in any way, including the artificial upward displacement of air or by mechanical take-off assistance, shall be declared voided delayed flights. An outdoor model powered by internal combustion engine(s) makes a voided delayed flight when its engine run exceeds 20 seconds from the time the model is released for take-off by the contestant. Timing shall start from the moment the plane is released for take-off by the contestant, and total flight time shall include the length of the motor run. If a flight time limiting device is used on any outdoor model and such a device accidentally operates within one minute of take-off while the ship is still in the air the flight may be called a delayed flight. Flights are to be limited to not more than 10 minutes. If a flight exceeds that time, it is to be ruled as a delayed flight with no time credited. This limit may be lowered at option of Contest Director. In unrestricted areas where conditions warrant, flight limitations may be removed at the discretion of the Contest Director.

(D) Outdoor Model Aircraft, Powered by Other Than Internal Combustion Engine(s). An outdoor model powered by other than internal combustion engine(s) makes an official flight when it remains in the air for 40 seconds or more. An outdoor model powered by other than internal combustion engine(s) makes a delayed flight when it remains in the air for less than 40 seconds. Three successive delayed flights displace an official flight; the duration of all delayed flights shall be recorded. Should an outdoor model powered by other than internal combustion engine(s) collide in the air with another model, the contestant may declare the flight a delayed or official flight. If 3 successive flights are recorded as delayed flights, the contestant shall be entitled to the reinstatement of the longest of these 3 successive delayed flights as an official flight. If one or more delayed flight(s) is/are followed by an official flight, the contestant shall not be entitled to reinstatement of the delayed flight(s) in place of the official flight. An outdoor model powered by other than internal combustion engine(s) makes a voided delayed flight, and is not credited with any duration time when it drops any part in flight or during take-off. Flights which are aided in any way including the artificial upward displacement of air, shall be declared voided delayed flights. Touching a model during flight constitutes a voided flight.

(E) Outdoor Model Aircraft, Non-Powered, Hand-Launched. All flights made by outdoor hand-launched gliders are official flights, regardless of duration. Delayed flights for outdoor hand-launched gliders are not recognized.

(F) Outdoor Model Aircraft, Non-Powered, Towline-Launched. An outdoor towline-launched glider makes an official flight when it remains in the air for 40 seconds or more after the towline is released from the model. Launching mechanism designed to assist the take-off, which is dropped from the glider at the termination of the tow, may be used. An outdoor towline-launched glider makes a delayed flight when it remains in the air for less than 40 seconds after the towline is released from the model. Three successive delayed flights displace one official flight; the duration of all delayed flights shall be recorded. Should an outdoor towline glider collide in the air with another model, the contestant may declare the flight either a delayed or official flight. If three successive flights are recorded as delayed flights, the contestant shall be entitled to the reinstatement of the longest of these three successive delayed flights as an official flight. If one or more delayed flight(s) is/are followed by an official flight, the contestant shall not be entitled to reinstatement of the delayed flight(s) as in place of the official flight. An outdoor towline glider makes a voided delayed flight, and is not credited with any duration time when it drops any part during take-off or in flight (except launching mechanism described above). Flights which are aided in any way, including the artificial displacement of air, shall be declared voided delayed flights.

(G) Model Aircraft Powered by Internal Combustion Engine(s)—Not Free-Flight. Model aircraft which are controlled from the ground shall be flown on cord(s), string(s), or wire(s), of the following lengths: Classes A and B, 52 feet, 6 inches; Class C 70 feet. All measurements of control line(s) shall be taken from the grip or pylon to the point where the line(s) enter the model. In the case of a combination whip and line control, measurement shall include the length of the whip. Time shall be taken for one-half mile runs (8 laps for Class A and B, 6 laps for Class C). Contestants shall signal timers for time-in by raising the hand or some similar prearranged signal. Models must be kept below the height of 20 feet during an official run. If a model during an official run exceeds the height of 20 feet, the preceding portion of the run shall be nullified and the contestant must again signal for time-in without stopping the flight. The maximum height must be clearly marked before the beginning of the event. Models forced down at any time before the completion of the run shall be charged with a delayed flight. Two successive delayed flights shall constitute an official flight and the best speed of either flight shall be recorded as the official flight time for the event. The speed attained on all delayed flights shall be recorded.

VI. NUMBER OF FLIGHTS

(A) Indoor Model Aircraft, Powered. Each contestant shall be allowed a total of 3 official flights, with 3 successive delayed flights displacing one official flight.

(B) Indoor Model Aircraft, Non-Powered. Each contestant shall be allowed a total of 9 official flights.

(C) Outdoor Model Aircraft, Powered. Each contestant shall be allowed a total of 3 official flights in all outdoor powered model events, with 3 successive delayed flights displacing one official flight.

(D) Control Models. Each contestant shall be allowed 3 flights, the fastest time (miles per hour) recorded on any official flight shall be the final standing of the contestant in the event. All official flights shall be of the prescribed distance or greater.

(E) Outdoor Model Aircraft, Non-Powered, Hand-Launched. Each contestant shall be allowed a total of 9 official flights in outdoor hand-launched glider events.

(F) Outdoor Model Aircraft, Non-Powered, Towline-Launched. Each contestant shall be allowed a total of 3 official flights in outdoor towline-launched glider events, with 3 successive delayed flights displacing one official flight.

(G) RECORD TRIALS. Unlimited number of flights are permitted in record trials provided sufficient timing equipment is available; the scoring of such flights, however, shall be according to the standard established for sanctioned competitions.

VII. TIMING OF FLIGHTS

(A) INDOOR. Time of flight starts the instant a model is launched by hand or released for take-off and ends when the model touches the ground or floor after being launched, or meets an obstruction that prevents further flight.

(B) OUTDOOR, FREE FLIGHT. Time of flight starts the instant a model is launched by hand or released for take-off and ends when the model touches the terrain after being launched, or meets an obstruction that prevents further flight. Time also ends when a model passes from the sight of the timer; should a model pass from sight of the timer behind a cloud or obstruction, the timing device (stop watch) shall be permitted to run for an additional 10 seconds and if the model reappears within these 10 seconds, the timing shall continue uninterrupted. If the model fails to reappear within these 10 seconds, the timing device shall be stopped and the 10 seconds deducted from the total official flight time. The timer shall make every effort to keep a model in sight until it lands. Timers at an outdoor contest shall remain on the field within a prescribed circle not to exceed 200 feet in radius, and timers shall keep models in sight only by use of normal vision (colored glasses and sun shades are permitted, and glasses may be used by timers who ordinarily wear them).

(C) OUTDOOR, NOT FREE FLIGHT. Time of flight starts when contestant signals the timer for time-in and continues for prescribed number of laps. Time is taken at a pre-determined starting and finishing point on the circumference of the flight circle.

VIII. SCORING OF FLIGHTS

(A) ACCURACY. Flight duration shall be scored to the nearest fifth of a second.

(B) INDOOR. Scoring time for indoor models shall be the longest of 3 official flights for powered models; the longest of 9 official flights for non-powered models.

(C) OUTDOOR MODEL AIRCRAFT, POWERED BY INTERNAL COMBUSTION ENGINE(S)—FREE FLIGHT. Scoring time for outdoor model aircraft powered by internal combustion engine(s) shall be the average elapsed time of three official flights.

(D) MODEL AIRCRAFT POWERED BY INTERNAL COMBUSTION ENGINE(S)—NOT FREE FLIGHT. Scoring time for model aircraft controlled from the ground by cord(s), string(s), or wire(s) shall be in miles per hour computed to the nearest one-tenth of a mile per hour. Highest speed recorded in any one of 3 official flights shall decide the contestant's standing in the event.

(E) OUTDOOR MODEL AIRCRAFT POWERED BY OTHER THAN INTERNAL COMBUSTION ENGINE(S). Scoring time for outdoor model aircraft powered by other than internal combustion engine(s) shall be the average of 3 official flights.

(F) OUTDOOR MODEL AIRCRAFT, NON-POWERED. Scoring time for outdoor model aircraft, non-powered, hand-launched (gliders), shall be the longest of 9 official flights. Scoring time for outdoor model aircraft, non-powered, towline-launched (gliders) shall be the longest of 3 official flights.

(G) VISIBLE RECORDS. It is recommended that whenever possible all flights be recorded on a large chart visible to all contestants.

IX. SANCTIONED COMPETITION

(A) SANCTIONED COMPETITION. The Academy of Model Aeronautics will sanction model aircraft competition which is conducted by recognized contest directors according to these official regulations.

(B) CLASSIFICATION OF SANCTIONED COMPETITION. The Academy of Model Aeronautics classifies sanctioned contests and record trials as follows:

Class A—"Closed Competition," a contest open only to members of a single model airplane club, or affiliated model airplane organizations; Class AA—"Invitation" contest open to licensed model flyers with awards available to all who enter; Class AAA, state or regional championship contest which is large in size, draws 100 or more contestants, and offers important awards; Class AAAA, national and international Championship Contest, which offers traditional trophies of the Academy of Model Aeronautics; and Record Trials, a contest conducted for the sole purpose of providing an opportunity and facilities for attempts to establish or surpass official model aircraft duration records, with no special awards offered to the winners.

(C) Officials. All sanctioned contests and record trials shall be conducted by a contest director who has been appointed by the Academy of Model Aeronautics. To receive appointment, a contest director must be a leader member of the Academy of Model Aeronautics. The contest director may name as many assistants as are necessary to insure a well-run competition. As many of these assistants as possible shall be leader members of the Academy of Model Aeronautics.

(D) Competition of Directors. The contest director shall not enter any contest he or she directs unless another contest director is present to time him and record his times. At no time shall any official of a sanctioned competition engage in any activities which interfere with the proper execution of his or her duties.

(E) Application for Sanction. Application for sanction of a model aircraft contest or record trials shall be made at least 30 days in advance of the competition by a contest director of the Academy of Model Aeronautics.

(F) Equipment. Timing devices (stop watches) with graduations of not less than one-fifth of a second shall be used in sanctioned competition. Such scoring and recording aids as are necessary to insure a well-run competition shall be provided by the contest director or his assistants.

(G) Take-Off Facilities. In rise-off-ground events, horizontal raised runways shall be not more than 6 inches off the ground or floor. For rise-off-water events the depth of the water shall be not less than one-inch indoors and not less than 6 inches outdoors; the surface area of the water shall be large enough to permit free take-off.

(H) Terrain. The terrain for outdoor competition shall not vary as to difference of level and location more than standard practice for landing areas of airports.

(I) Report of Competition. A complete report of each sanctioned contest or record trials shall be filed with the Contest Board of the Academy of Model Aeronautics by the contest director within 7 days following the competition. The report shall include: The names, ages, and addresses of all entrants and their individual flights in each category and class; the type of ship and engine(s) used shall be shown for all model aircraft powered by internal combustion engine(s). Report(s) of record performance(s) shall be filed with the Contest Board of the Academy of Model Aeronautics within 7 days following the competition. Failure to fulfill these requirements shall constitute sufficient cause for the revocation of contest director's appointment.

(J) Who May Compete. Only those who hold membership in a model airplane club affiliated with the Academy of Model Aeronautics shall be permitted to enter the events of a Class A competition. Only those possessing the gas model flyers sporting license issued by the Academy of Model Aeronautics, or the special "Letter of Authority to Gas Model Flyers Under 14," shall be permitted to enter events for models powered by internal combustion engine(s) in Record Trials and Class AA, AAA, and AAAA contests. Only those possessing a model flyers sporting license issued by the Academy of Model Aeronautics shall be permitted to enter events for non-powered models and models powered by other than internal combustion engine(s) in Record Trials and Class AA, AAA, and AAAA contests. The contest director of each sanctioned competition or his representative shall examine the sporting license of each contestant to determine its validity and the contestant's eligibility to compete.

(K) Builder of Model. Each contestant shall assemble and cover all lifting surfaces and fuselages. The design may be obtained from any source. Only the builder may fly the model for record or in sanctioned competition. Models built from kits are acceptable. For all models other than those powered by internal combustion (or other) engines, the builder must build, carve, or complete the propeller(s).

(L) Team Entry. In the case of a team entry of a model aircraft in a sanctioned contest, it shall be required that each member of the team shall have taken an active part in the construction of the model. One member of the team shall be designated to fly the model. Entry in a sanctioned contest shall be made in the name of the team (including the names of all members) and any records established or prizes won shall be recorded or awarded in the name of the team. No team shall enter more than one model in each class.

(M) Number of Models, Indoors. Each contestant will be allowed a maximum of 3 models in each indoor event, and he may use any or all to complete his flights. The 3 models used may be of different design; and if an event is announced as a general category without specific size classes, the 3 models used may be of different size classes.

(N) Number of Models, Outdoors. Each contestant will be allowed only one model for each outdoor event. A contestant is allowed to enter each event only once. He cannot enter one ship more than one time in any one event nor can he enter more than one ship in any one event.

(O) Identification of Model. Each model powered by internal combustion engine(s) shall have the sporting license number assigned to the builder and flyer by the Academy of Model Aeronautics permanently affixed to the upper side of the right-hand lifting surface. Each outdoor model shall have a registration certificate bearing the name and address of the builder and pertinent information concerning its size characteristics permanently affixed to the model.

(P) Cross-Section Drawing of Cabin. In cases of doubt, contestants shall present a full-size drawing of the maximum cross-section of the cabin model; drawing shall be ruled into half-inch squares.

(Q) Age Classification of Contestants. Contestants under 16 years are classed as juniors; contestants 16 or more but under 21 years are classed as seniors; and contestants 21 years or more are classed as open flyers. Records are segregated as junior, senior, or open, according to the age of the contestant when the record was established.

(R) Disqualification. Any contestant who breaks any rule of a contest, or conducts himself or herself contrary to the ordinary requirements of common courtesy, may be disqualified upon recommendation of the officials. Models broken in landing are not disqualified.

(S) Exclusion. A sentence of exclusion may be pronounced by the local contest committee against any entrant from any event or from all events in a contest or Record Trials, if the contestant is ineligible to take part in the events, or guilty of misbehavior or unfair practice. The local contest committee may order the removal of any entrant from the flying field or building who refuses to obey the order of a responsible official.

(T) Loss of Award. Any competitor who may be excluded or suspended in any event shall thereby forfeit all right to award in that event.

(U) Protests. Protest will be considered only when presented in writing to the contest director within one hour after the close of the contest or record trials. The protestant must report in full the action or decision, the names of entrants and officials involved, and complete details.

(V) Appeal. Appeal may be made to the Contest Board of the Academy of Model Aeronautics on action taken on protest. Such appeals must be made in writing within a three-day period following the action of the local contest committee on the original protest.

X. RECORDS

(A) National Records. Perpetual American model aircraft duration records are homologated by the Contest Board of the Academy of Model Aeronautics. Perpetual records may be established at any time and shall continue until exceeded or affected by changes in the official regulations.

(B) Acceptance of Records. No record is official until it has been homologated by the Contest Board of the Academy of Model Aeronautics. Only duration records for flying model aircraft are officially recognized. All records to be eligible for recognition must be made in sanctioned competition under the regulations of the Academy of Model Aeronautics.

XI. GENERAL

(A) Projected Area. The projected area of a supporting or stabilizing surface is the area seen when looking directly down on the surface. Supporting surface area enclosed in a fuselage or stick shall not be considered as wing area.

(B) Tube. A tube which is formed from sheet material shall not be considered as being built-up.

(C) Changing Stick and Fuselage Model. No parts shall be added to, or taken from, a stick model to qualify it as a fuselage model; no parts shall be added to, or taken from, a fuselage model to qualify it as a stick model.

(D) Pusher-Tractor. The Academy of Model Aeronautics does not differentiate between pusher or tractor models for purposes of classification or record. However, such types are defined as follows: Pusher—a model airplane of the pusher type has its propeller(s) behind the supporting surface(s); Tractor—a model airplane of the tractor type has its propeller(s) forward of the supporting surface(s); and tractor-pusher—a model airplane of the tractor-pusher type has its propeller(s) forward of, and propeller(s) behind the supporting surface(s).

(E) Vacuplane, Rotorplanes. Vacuplanes and rotorplanes are not classified by the Academy of Model Aeronautics.

(F) Lighter-Than-Air Model Aircraft. Lighter-than-air model aircraft are not classified by the Academy of Model Aeronautics.

(G) Exhibition Scale, Flying Scale, and Radio-Controlled Models. Exhibition scale, flying scale and radio-controlled models are not classified for purposes of record by the Academy of Model Aeronautics. Such models are encouraged and regulations for flying scale and radio-controlled models are available from the Academy of Model Aeronautics.

(H) Interpretation of Regulations. The Contest Board of the Academy of Model Aeronautics shall be the final authority in the interpretation and execution of these model aircraft classifications and regulations.

CHAPTER XV

GLOSSARY OF AERONAUTICAL TERMS

IT IS NOT THE author's purpose to list all of the aviation words and terms in this chapter, for such a project would take much more space than we are able to devote to it here. However, model builders should have a guide to the most used words and terms, and the majority of these are listed in this chapter. Probably some words are missing, and others are included which have little to do with model matters, but the attempt has been to make this fit the model field as far as possible, except in cases where certain words or terms obviously had to be included.

ABSOLUTE CEILING. The greatest altitude at which an aircraft can maintain horizontal flight. This is determined by not only the engine but also by the airfoil section.

ACETONE. An inflammable liquid prepared by special fermentation of grain, forming butyl alcohol and acetone. A general solvent used as an ingredient for the thinning of dope and lacquer.

AERODYNAMIC CENTER. A point located on or near the mean line approximately one-quarter of the chord length, aft of the leading edge, and about which the moment of coefficient is practically constant.

AERODYNAMICS. The branch of dynamics that treats of the motion of air and other gaseous or aeriform liquids and of the forces acting on solids in motion relative to such gases or liquids.

AILERON. A hinged or movable portion of a wing, the primary function of which is to impress a rolling motion on the aircraft. It is usually located on the wing trailing edge, near or at the wing tips.

AIR SPEED. The speed of an aircraft relative to the air through which it is passing.

AIRFOIL. Any surface, such as an airplane wing, aileron, rudder, or elevator, designed to obtain a useful reaction from the air through which it moves.

ALTITUDE. The position of an aircraft as determined by the inclination of its axis to some frame of reference, usually fixed to the earth.

AMPHIBIAN. An aircraft designed to arise from, or alight on, either water or land.

ANGLE OF ATTACK. The acute angle between the reference line in a body and the line of relative wind direction.

ANGLE OF INCIDENCE. The acute angle between the plane of the wing chord and the longitudinal axis of an aircraft. The angle is positive when the leading edge is higher than the trailing edge.

BALSA WOOD. An exceptionally light wood used to a great extent in model building and full-scale aviation, as well as in other modern fields. It is only about 25 per cent the weight of spruce, or about eight pounds per cubic foot. It is a product of the West Indies and Central America.

BEARING. Any mechanism designed for the purpose of reducing friction between moving parts.

CAMBER. The rise of the curve of an airfoil section, usually expressed in the ratio of the departure of the curve from the straight line, joining the extremities of the curve to the length of this straight line. Camber is positive when this departure is upward and negative when it is downward. Simply stated, camber is the curve of a wing surface from the leading edge to the trailing edge.

CANTILEVER. A cantilever monoplane is one in which the main plane has no external support from struts or wires back to the fuselage.

CENTER OF GRAVITY. The point of the intersection of the resultant aerodynamic force and the chord line of an airfoil, i.e., the point about which the body would balance in any position.

Center of Lift. The mean of all the centers of pressure on an airfoil.

Center Section. The central panel of a wing or main plane. Where there is no definite center section, this is determined arbitrarily.

Chandelle. An abrupt climbing turn that is used to obtain a higher rate of climb.

Chine. The extreme side member of the hull of a flying boat running approximately parallel to the keel in side elevation.

Chord. The length of that part of the chord line which is intercepted by the airfoil.

Chord Line. A straight line through the center of curvature at the leading and trailing edges of an airfoil.

Chord, Mean. The quotient obtained by dividing the wing area by the span.

Compression Ratio. The ratio of the volume of gas in an engine cylinder at the beginning of the compression stroke to its volume at the end of the stroke.

Control Stick. The vertical lever by means of which longitudinal and lateral control of an airplane can be operated. The elevators are operated by the fore-and-aft movement of the stick, while the ailerons are operated by the side-to-side movement.

Control Surface. A movable airfoil designed to be rotated or otherwise moved in order to change the attitude of the aircraft.

Cowling. A removable covering which extends around the engine or other parts of an aircraft.

Crack Up. A term which means that the aircraft has been damaged by accident or by other circumstances beyond control.

Cross-Braces. Side-to-side members of the framework. The term also often refers to those braces which extend between longerons or stringers of a fuselage.

Cross-Section. A drawing made of an object as it would look if it were cut in two on an axis inferred or designated on the drawing.

Cruising Speed. A speed not greater than 90 per cent of the design level speed.

Datum Line. A base line or reference line from which calculations or measurements are taken.

Dead-Stick Landing. A landing made with engine not running and the propeller stopped.

Detail Drawing. A drawing which shows a small portion or part of a machine in minute detail.

Dihedral. A wing design in which the wing tips are raised above the center section of a wing.

Dope. A liquid material applied to framework covering to increase strength and produce toughness by shrinking.

Drift. The lateral velocity of an aircraft due to side winds.

Elevator. An auxiliary airfoil whose purpose is to make an aircraft rise or descend.

End Hook. The hook used in the rear of a rubber-powered model as an anchor for the rubber strands.

Endurance Model. A model built primarily for the purpose of making long flights. Endurance models rarely are scale versions.

Engine. A means of power—rubber, gasoline, or compressed air—by which a plane is given forward motion.

Exhibition Model. A scale model which is built primarily for display purposes. It may be either flying or non-flying.

Fairing. An auxiliary member or structure whose primary function is to reduce head resistance or drag of the part to which it is fitted.

False Rib. Short, light ribs which are used as auxiliaries to main ribs. They extend only from the leading edge to the front spar.

Fillet. Fill-in at angular joints, the purpose of which is to make for smoother air flow over the unit.

Fin. A fixed or adjustable airfoil employed to provide directional stability.

Fishtail. A colloquial term, describing the motion made when the tail of an aircraft is swung from side to side to reduce the landing speed.

Flap. A hinged or pivoted section forming the rear portion of an airfoil, used to vary the effective camber or increase drag.

Float. A watertight structure attached to an aircraft in order to give it buoyancy and stability when in contact with water.

Fuselage. The body of approximately streamline form to which the wings and tail units of an aircraft are attached.

Gap. The distance between the planes of the chords of any two adjacent wings.

Glide. To descend at a normal angle of attack with little or no thrust.

Gross Weight. The total weight of an aircraft fully loaded.

Ground Loop. An uncontrollable violent turn of an aircraft in taxiing or during the landing run or take-off.

Ground Speed. The horizontal speed of an aircraft relative to the earth. Ground speed and air speed are rarely the same.

Gusset. Although a gusset may be any shape, it is usually a small rectangular brace used to strengthen corners in a structure.

Head Wind. A wind which blows approximately parallel to the flight path of an aircraft and which retards ground speed.

H.L. Abbreviation for hand launched. All models which are launched from the hand are in this classification.

Horn. A short lever attached to a control surface, and to which the operating wire or rod is attached.

Hover. To be stationary or suspended in one spot above the earth.

Hull. The main structural and flotation body of a flying boat or boat amphibian.

I-Beam. A structural member which has a cross-sectional shape of the capital letter "I."

Intercostal. Between ribs.

Jig. Any rigid structure which holds parts while they are being fabricated or which holds the component parts of a structure while it is being assembled or disassembled.

Keel. A closing-in plate or shaped piece on the bottom center line of the hull, to which the frames and sides are anchored.

Laminated Wood. A product formed by gluing or otherwise fastening together a number of laminations of wood with the grain substantially parallel.

Leading Edge. The foremost edge of an airfoil or propeller blade.

Longeron. A principal longitudinal member of the framework of a fuselage or nacelle.

Loop. A maneuver executed in such a manner that the aircraft follows a closed curve in the vertical plane.

Main Planes. The main supporting surfaces of an aircraft, including the ailerons.

Maximum Range. The greatest distance an aircraft can fly under given conditions and at the most economical cruising speed.

Medium Gliding Turn. An elementary maneuver which consists of a medium turn during a normal glide.

Mock-Up. A full-sized model of a proposed type of aircraft, made to provide a means of setting forth the arrangement of the interior and exterior parts.

Monoplane. An aircraft which has but one main supporting surface.

Multiplane. An aircraft which has two or more main supporting surfaces placed one above another.

Nacelle. An enclosure which accommodates the crew or power plants of an aircraft.

Nose-Over. A colloquial expression referring to the accidental turning over of an aircraft on its nose when landing.

N-Strut. A type of bracing which utilizes three struts so placed as to resemble the capital letter "N." It is frequently used to brace the wings of a biplane.

Overhang. One half the difference in span of any two main supporting surfaces of an aircraft. The overhang is positive when the upper of the two supporting surfaces has the larger span. The term is also used to mean the distance from the outer strut attachment to the tip of the wings.

Overshoot. To fly beyond a designated spot or area while attempting to land.

Pancake Landing. A landing in which an aircraft is leveled off several feet above the ground and then drops. This is a result of the aircraft stalling, or losing air speed.

Panel. A portion of an aircraft wing constructed separately from the rest of the wing to which it is attached. Also, a removable section.

Pants. Streamlined enclosures used to cover wheels in order to decrease drag.

Parasol Monoplane. A monoplane in which the wing is above the fuselage.

Pitch. An angular displacement about an axis parallel to the lateral axis of an aircraft.

Pitot Tube. A cylindrical tube with an opening pointed in the direction of flight, the purpose of which is to measure impact pressure.

Plywood. Layers of wood glued or otherwise fastened together with alternate plies, with the grain at right angles.

Power Spin. A normal spin with the engine running at any speed above idling.

Profile. The outline of an object as viewed from a side.

Pull-Out. The maneuver of transition from a dive to horizontal flight.

Pusher. An aircraft with the propeller or propellers mounted to the rear of the main supporting surfaces.

Pylon. A structure usually pyramidic in shape, used as a marker for closed-course races. Also the structure used to support the rotors of an autogiro.

Rib. A member that gives the desired shape to the covering material of planes or control surfaces.

R.O.G. Abbreviation for "rise off ground." The term is used for a model airplane equipped with a landing gear enabling it to rise from the ground under its own power.

R.O.W. Abbreviation for "rise off water." The term is used for a model airplane equipped with flotation gear enabling it to rise from water under its own power.

Rudder. A hinged or movable auxiliary airfoil, the function of which is to impress a yawing movement to an aircraft.

Rudder Post. The main vertical member of the rudder to which the rudder hinges are attached.

Runway. A strip of open ground used by aircraft for the purpose of landing and taking off.

Scale Model. A model airplane built to the exact scale of a real aircraft. Models in this category may or may not be capable of flight.

Sinking Speed. The downward speed of an aircraft while in a glide with power off.

Soar. To fly without engine power and without loss of altitude.

Span. The maximum distance, measured parallel to the lateral axis, from tip to tip of an airfoil.

Spin. A maneuver in which an aircraft descends along a spiral path of large pitch and small radius.

SPIRAL. A maneuver in which an aircraft descends along a spiral path of small pitch and large radius.

SPONSON. A float projecting from the hull of a flying boat, the purpose of which is to give lateral stability while at rest on the water.

STABILIZER. Any airfoil whose primary function is to increase the stability of an aircraft. It usually refers to the fixed horizontal tail surface.

STALL. The condition of an airfoil or aircraft in which it is operating at an angle of attack greater than the angle of attack at maximum lift. It results in a loss of flying speed and usually in a temporary loss of lift.

STEP. A break in the undersurface of a float or hull designed to facilitate take-off.

STRINGER. A light auxiliary member parallel to the main spars or longitudinals which assists in preserving the external form of the object.

STRUT. A compression member of a truss frame.

SWEEPBACK. A wing design in which the wing tips slope backward from the center section.

TAB. An auxiliary airfoil attached to a control surface for the purpose of trimming the aircraft to straight flight.

TAIL. The rear section of an aircraft, usually consisting of a group of stabilizing planes or fins to which are attached the rudder and elevator.

TAPER. A gradual change in the chord length of an aircraft wing along the span from the root to the tips.

THERMAL. An up-current of air.

TOWLINE GLIDER. A glider which is pulled into flight by means of a long line. This towline is usually detachable, so that the aircraft may fly without further assistance.

TRAILING EDGE. The rear edge of an airfoil.

WARP. To change the form of a wing or airfoil by twisting.

WING. A unit of lifting surface of an aircraft.

WING TIP. The outer end of an aircraft wing.

ZOOM. To climb for a short time at an angle greater than the normal climbing angle of the aircraft. This is usually accomplished after a dive.