Introduction to AIRPLANES

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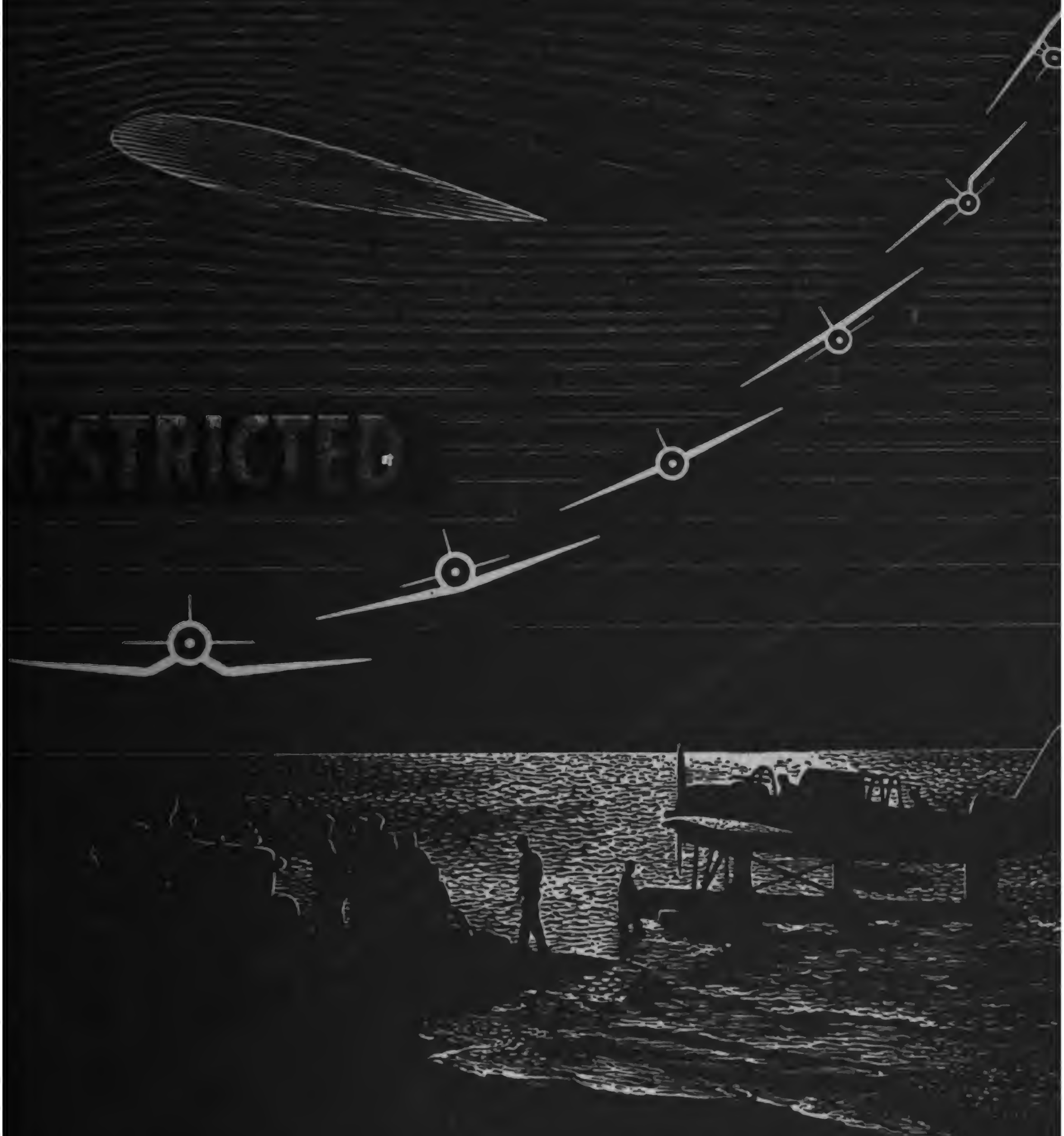

NAVY TRAINING COURSES

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INTRODUCTION
TO
AIRPLANES

PREPARED BY

STANDARDS AND CURRICULUM DIVISION
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PREFACE

This book was written for the enlisted men of Naval Aviation. It is one of a series of books designed to give them the background information necessary to perform their aviation duties.

All rates and specialists can well start their careers by studying INTRODUCTION TO AIRPLANES. In brief fashion it discusses aviation history, aerodynamics, nomenclature of airplane structures and power plants. It gives the enlisted man a quick look at some of the airplanes which today are making history. It takes up such matters as airplane handling, anchoring and mooring, aviation seamanship, cleaning and inspecting, fueling and starting, and concludes with a short discussion of aircraft armament and emergency equipment. Most of the subjects taken up here are treated more extensively elsewhere in this series. The purpose of INTRODUCTION TO AIRPLANES is to build an informational foundation—not so much in detail as in principles.

As one of the NAVY TRAINING COURSES, this book represents the joint endeavor of the Naval Air Technical Training Command and the Training Division of the Bureau of Naval Personnel.

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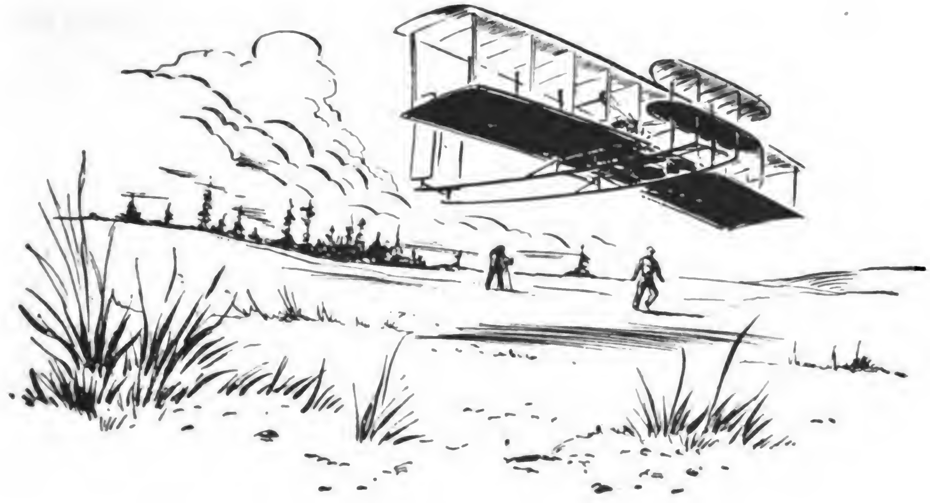


CHAPTER 1

FLIGHT

ROUTINE STUFF

You're going for a ride. Zip up your flight jacket and fasten the chin strap on your leather helmet. It quite likely will be cold up yonder. And don't forget a parachute. That's a "MUST." Before the hop is finished you'll be flying over water, too, so grab a "Mae West" out of the locker before you leave.

The ground crew rolls a trim little trainer onto the apron. That's your baby. The plane captain—Mr. Big of the ground crew—checks the inspection sheet, takes a look at the oil level in the tank, hops into the cockpit, sets the parking brakes, unlocks the surface controls, and makes doubly sure the ignition switch is off. Is there plenty of fuel? There must be, for he's getting ready to warm her up.

A member of the ground crew steps up at the plane captain's signal and turns the propeller by hand a couple of times. Then he climbs to the wing walkway and cranks the starter flywheel to set it spinning. Mr. Big, still in the cockpit, sets the engine controls. When all's clear, he engages the starter. The engine starts to purr. After a few moments he waves in your direction that everything's ready.

You scramble into the back seat of the airplane. The plane captain steps out of the cockpit and the pilot steps in. Before you know it you're taxiing off the apron and onto the runway. The pilot revs his engine from a purr to a roar. You're moving—skimming the ground—pulling up into a smooth take-off. You circle the field and soar into the blue highway of the air.

Routine stuff, did you say? Maybe so. But nobody in the history of the WORLD had ever done it before 1903, which wasn't very long ago as history runs.

DREAM OF THE AGES

Man first started dreaming about flying ages ago. Back in Greek mythology there was a sculptor named Daedalus who supposedly made wings of wax with which he and his son flew out of the concentration camp where an unfriendly king had imprisoned them. You aren't required to believe this legend. It just goes to show you that folks were THINKING OF AVIATION long before your great-granddad's day.

As far as the basic principles of flying were concerned, some of the so-called dreamers of the past were pretty much on the beam with their thinking. Leonardo da Vinci, who is known best as a great artist of the Fifteenth Century, was really quite some shakes as a scientist and inventor. Among other things, he constructed a set of working plans for an airplane which would have flown with the right sort of engine. Many others made early efforts to fly with wings flapped by manpower, but they didn't work. The big hitch was the inability to propel such flying machines.

It was a big laugh to most people—the flying-machine notion. So it took a lot of gumption for any serious inventor to stick to his guns and refuse to give up in the face of endless ridicule. Even some of the most famous scientists said, "It is physically impossible to build such a contraption." And they "proved" their profound pronouncements with formulas and figures.

For centuries the facts seemed to back up the scoffers. The dreamers, who believed that man would some day fly, were forced to be content with their dreams. In 1783, however, two Frenchmen named Montgolfier made a public demonstration of a flying balloon. It got its lifting power from hot air. The balloon, without ballast, rose to about 6,000 feet and drifted a mile and a half before descending. Later that same year another French pair made the first balloon flight as passengers. THE LID WAS OFF. Man had discovered one way of getting off the ground.

A few people played around with balloons for the next 60 years, experimenting with hydrogen and with gas from city gas mains, as well as with hot air, as a means of getting lift. All this, of course, came under the heading of lighter-than-air aviation. Very little was being done toward the development of heavier-than-air craft.

It wasn't until around 1846 that two English inventors, Henson and Stringfellow, built a successful miniature steam-driven airplane. This revolutionary machine, which weighed 6¼ pounds fully loaded with water and fuel, flew approximately 40 yards on its first test. It thus became the first power-driven airplane to fly.

However, it really was little more than a gadget, and couldn't have carried a pilot bigger than Mickey Mouse.

For reasons unknown, nobody was very excited about this 1846 model, and another 50 years went by before the next noteworthy step was taken. In 1896 Professor Samuel P. Langley, an American, brought forth a steam-driven affair having a 13-foot wing span and weighing 30 pounds. Langley had something in this package that previous flying machines had lacked—AN ENGINE WITH OOMPH. His model showed splendid stability and made a number of interesting flights.

You'd have thought that Langley's success with his model airplane would have squelched the skeptics. But most people were still far from being convinced that anybody would ever build a contraption that would carry a man during flight. Congress apparently believed it was possible, however, and appropriated $50,000 to enable the Professor to build a man-carrying airplane. Langley built a machine, but it didn't fly successfully. Before further trials could be made, Langley died.

Meanwhile, quite a number of people in various parts of the world were experimenting with gliders. Otto Lillienthal, in Germany, was one of the outstanding glider pioneers. In fact, one of the contrivances he built was so well thought out that a little two-horsepower engine would have kept it up in the air—ONLY he didn't have such an engine. Then there were the Wright brothers—Orville and Wilbur—of Dayton, Ohio. They hit the JACK POT.

They went to Kitty Hawk, N. C., in 1900 to experiment with some gliders they had built. WHY did they pick Kitty Hawk? There was a fine slope called Kill Devil Hill at this North

Carolina town—just right for gliding. Moreover, the prevailing wind there was unusually steady, and generally in the right direction for good glider flights.

For three seasons the Wrights studied the behavior of their gliders, made improvements, and perfected their skill in piloting. Finally they had collected enough dope on gliding to try the pay-off stunt that was in the back of their minds all the time. In 1903 they constructed an airplane with a 16-horsepower engine driving 2 propellers. It was a rickety, odd-looking device by modern standards—resembling an overgrown kite. But it flew! With Orville Wright inside its maze of wires and braces, the airplane LEFT THE GROUND, STAYED ALOFT 12 SECONDS, AND FLEW A DISTANCE OF 120 FEET. MAN HAD CONQUERED THE AIR!

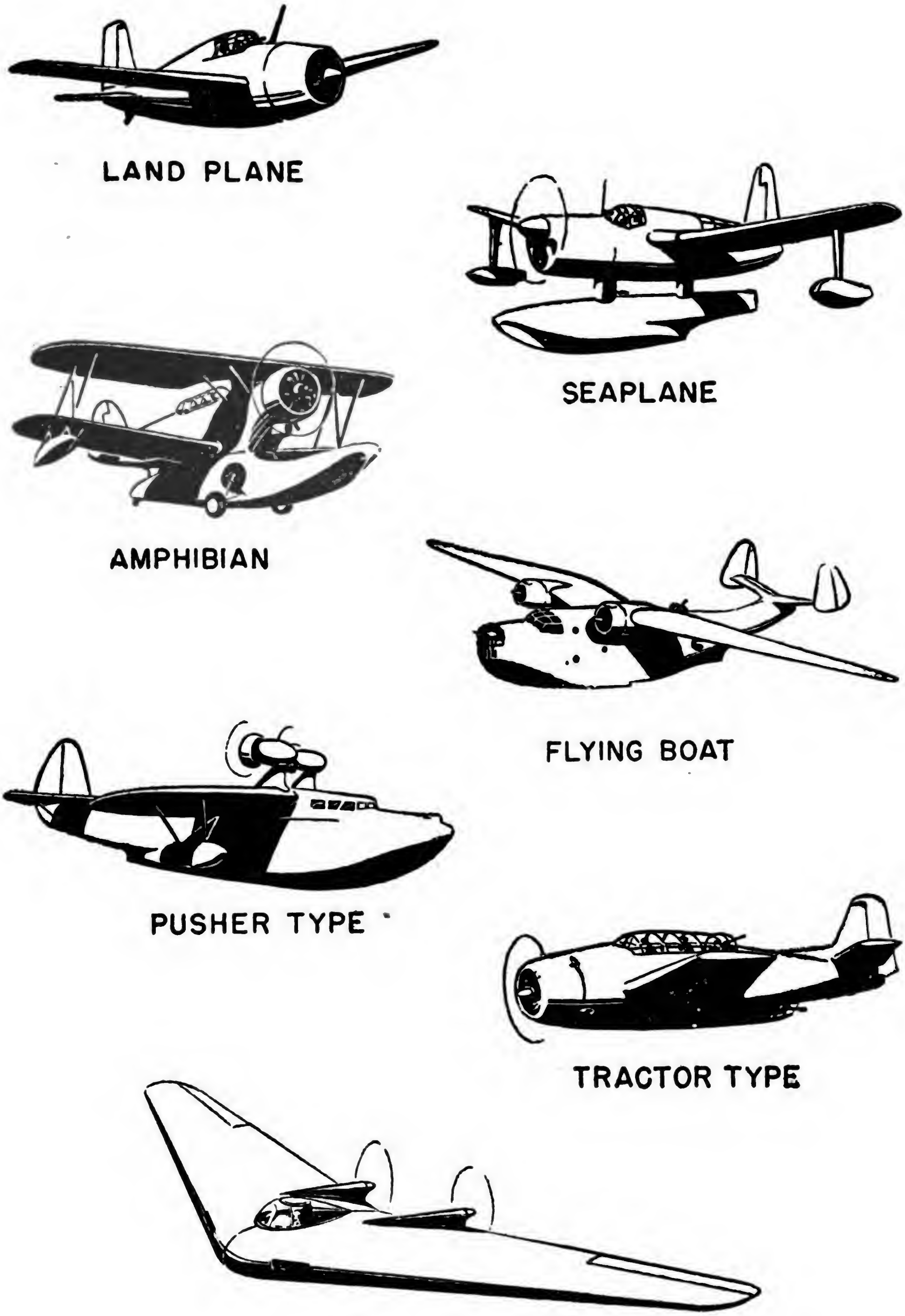
The famous Kitty Hawk incident might have taken place, quite comfortably and with space to spare, on the deck of a modern carrier. It was a short flight. But the same principles which lifted the first awkward airplane into the air enable today's giants to span the seven seas.

TYPES OF AIRPLANES

Aviation has come a long way since the Wright brothers proved to the world that man could fly. Present-day types of airplanes can be counted in the hundreds. You see some of them in figure 1.

One way of classifying airplanes is by the number of wings. The MONOPLANE has one wing. The BIPLANE has two—one above the other.

Monoplanes are further described by the location of the wing. On a PARASOL MONOPLANE the wing is entirely above the rest of the airplane, and is supported by means of struts. If the wing is attached to the top surface of the fuselage, the airplane is called a HIGH-WING MONOPLANE. The



LAND PLANE

SEAPLANE

AMPHIBIAN

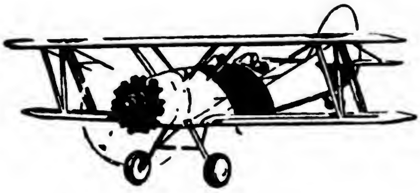
FLYING BOAT

PUSHER TYPE

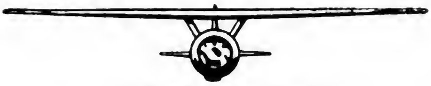
TRACTOR TYPE

FLYING WING

Figure 1.—Types of airplanes.

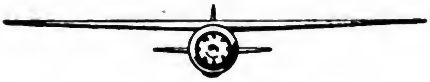


BIPLANE



PARASOL WING

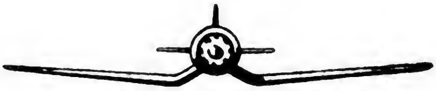
GULL WING



HIGH-WING

MID-WING

LOW-WING



INVERTED GULL WING

MONOPLANES

HELICOPTER

AUTOGIRO

Figure 1a.—More airplane types.

MID-WING MONOPLANE has the wing attached near the center of the fuselage. The LOW-WING MONOPLANE carries the wing at or near the bottom of the fuselage.

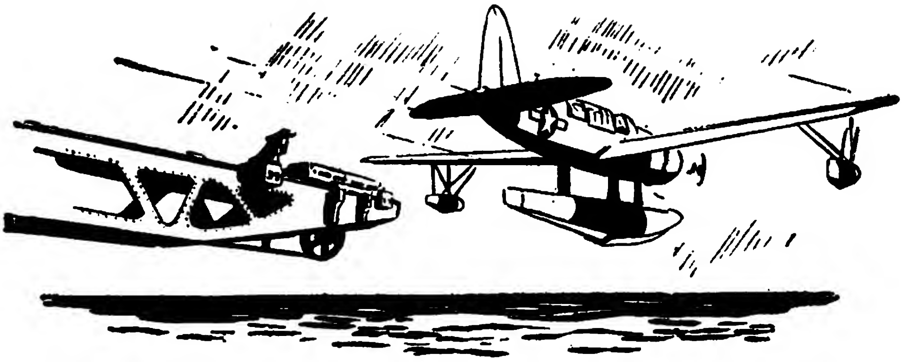
Another way to classify airplanes is by the number of engines and where they are placed. Thus you have SINGLE-ENGINE, TWIN-ENGINE, and MULTI-ENGINE airplanes. Few airplanes made today, except those for experimental purposes, have more than four engines.

Airplanes with propellers located in front of the engines are called TRACTORS. If the propellers are behind the engines, the airplanes are called PUSHERS. The majority of airplanes in use now are the tractor type.

Landing gear gives you still another way of classifying airplanes. LANDPLANES are equipped with wheels, either fixed or retractable, for taking off and landing on airports or carriers. SEAPLANES and FLYING BOATS take off and land on the water, and are equipped with flotation gear. The flying boat alights on its hull, which is simply the bottom of its fuselage. The seaplane has one or more floats attached below it. On some airplanes the floats can be interchanged with landing wheels. AMPHIBIANS have both wheels and hulls (or floats) for alighting on either land or water.

In the Navy, airplanes are classified according to their purpose. There are TRAINERS and TRANSPORTS, OBSERVATION SCOUTS, SCOUT BOMBERS, FIGHTERS, TORPEDO BOMBERS, and PATROL BOMBERS. A system of designation symbols is used to distinguish Navy airplanes. When you know this system you can tell the manufacturer, the model, and the purpose of the airplane from its symbol.

AUTOGIROS and HELICOPTERS are in a class by themselves. The autogiro obtains its support from wings which rotate above the rest of the airplane. This rotation is produced by the forward motion of the autogiro through the air. The helicopter also gets its lift from rotating wings above the fuselage, but its wings are engine-driven. The helicopter can rise and descend vertically, go backward or forward, or hover over one point as long as your please. The FLYING WING is still in the experimental stage.



CHAPTER 2

WHY AIRPLANES FLY

AERODYNAMICS

WHAT makes it possible for man to fly? How can a contraption of wood and metal and fabric transform earthworms into creatures that can outwing the birds of the air? The answer is locked up in the science of AERODYNAMICS.

Actually, aerodynamics is just two Greek words spliced together. "Aer" means air. "Dyne" means force, or power. Teamed together they mean "the force or power of the air."

As a kid, you probably flew a kite. If so, you learned one of the basic lessons in aerodynamics. A kite is really quite a scientific toy. When a breeze is blowing the kite stays up by itself. But if the air is still you have to run with the kite to keep it flying. In both cases there is ONE important similarity. Either the air moves with respect to the stationary kite, or the kite moves with respect to the still air.

Aerodynamics has to do with the forces produced by the relative motion between air and any other object. An airplane, which is fundamentally a glorified kite, is supported in flight by the forces of the air in motion across its wing surfaces.

It's easy to understand how the forces of the air in motion operate if you remember a few basic facts about AIR. First of all, air is a substance—like cheese, or gravel, or water—and therefore has weight. It is a fluid, hence it will flow when moderate pressure is applied. It is a gas and can be compressed into a smaller space by pressure.

The deeper you go below the surface of the ocean the greater the pressure becomes, because of the weight of the water overhead. Well, there is a "sea" of air—about 500 miles deep—surrounding the earth. The greater the depth from the outer surface of the "air sea," the greater the pressure of the air. Thus, at ocean level on the surface of the earth, the air pressure is 14.7 pounds per square inch under average conditions. At this level, the air is more dense than the air above it because the weight of the "air sea" presses down on it. Figure 2 will help you to picture this quickly.

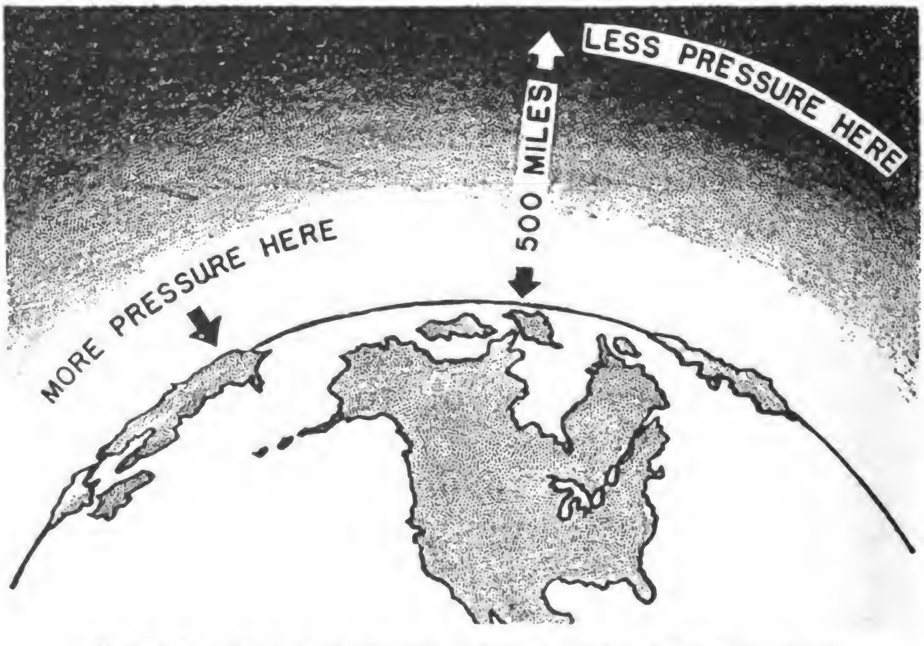


Figure 2.—High and low air pressure zones of the "air sea."

Since air pressure is equal in all directions, you can't feel it when you are standing still. But stick your hand out the window of a moving automobile. You feel the force of the air immediately, even though there is no wind blowing. You and the automobile, however, are moving in relation to the still air, and a pressure is built up in front of your hand, tending to push it back. That push is called IMPACT PRESSURE.

Other forces are also at work. Your motion through the air creates a partial vacuum behind your hand, REDUCING the pressure on that side. The result is similar to what would happen if you leaned against a wall and it were to collapse suddenly. The pushing force (YOU) would still be there, but the resisting force (THE WALL) would be removed. As a result, you'd tend to fall toward where the wall was before it collapsed.

Now, take a look at an airplane wing. Its surfaces furnish the support for the airplane in flight. A wing can't be as thin as a kite, since then it wouldn't have enough strength to hold up the weight of the airplane. If you were to cut a vertical slice out of a wing, you'd get an AIRFOIL SECTION, like one of those in figure 3. Notice that it's curved on top, and maybe on the bottom.

The curvature of airfoil surfaces is called the CAMBER. The top camber of a wing airfoil is always POSITIVE—that is, its central part bulges outward. The bottom camber may be either positive or negative—bulging outward or inward. In many cases, there is no bottom camber at all—the bottom being flat.

The front of the airfoil section is the LEADING EDGE, and the rear is the TRAILING EDGE. The distance between the leading edge and trailing edge is called the CHORD. And the term ANGLE OF ATTACK is used to describe the angle between the wing chord and the direction of the relative wind. In a moment it will be clear why these definitions appear here.

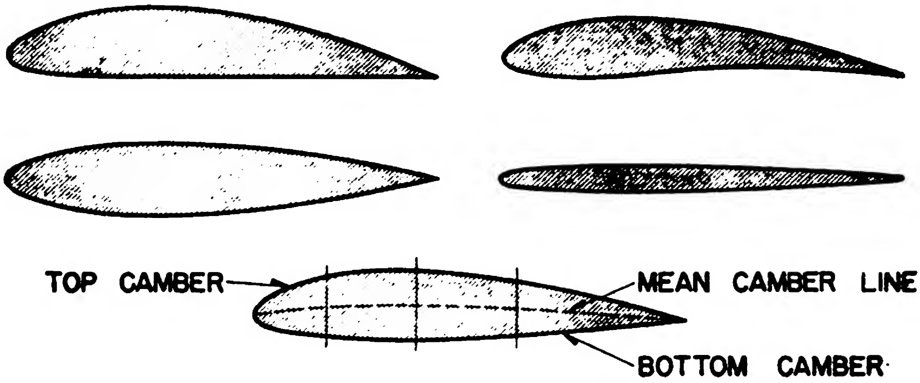


Figure 3.—Typical airfoil sections.

An airplane wing obtains its lifting power from the action of the relative wind on the airfoil surfaces. The ability of an airfoil-shaped wing to lift is determined according to a principle set down by a scientist named Bernoulli. This principle is utilized in another device known as the venturi tube, and an understanding of how a venturi tube works will help to clarify the whole idea. A venturi tube is simply a short piece of tubing which is reduced in diameter near its midpoint. When a fluid passes through such a constricted tube, THE SPEED OF THE FLUID IS GREATEST—AND THE PRESSURE IS LOWEST—AT THE NARROWEST PART, OR THROAT.

That's fine! But what does it have to do with an airplane wing? Just about everything, as far as its LIFT is concerned. A look at figure 4 (*A, B,* and *C*) will help you visualize the similarity between an airfoil section and one-half of a venturi tube. Remember, air is a fluid, and acts accordingly. In (*A*) and (*B*) you'll notice that the path of the air is straight along the center line of the

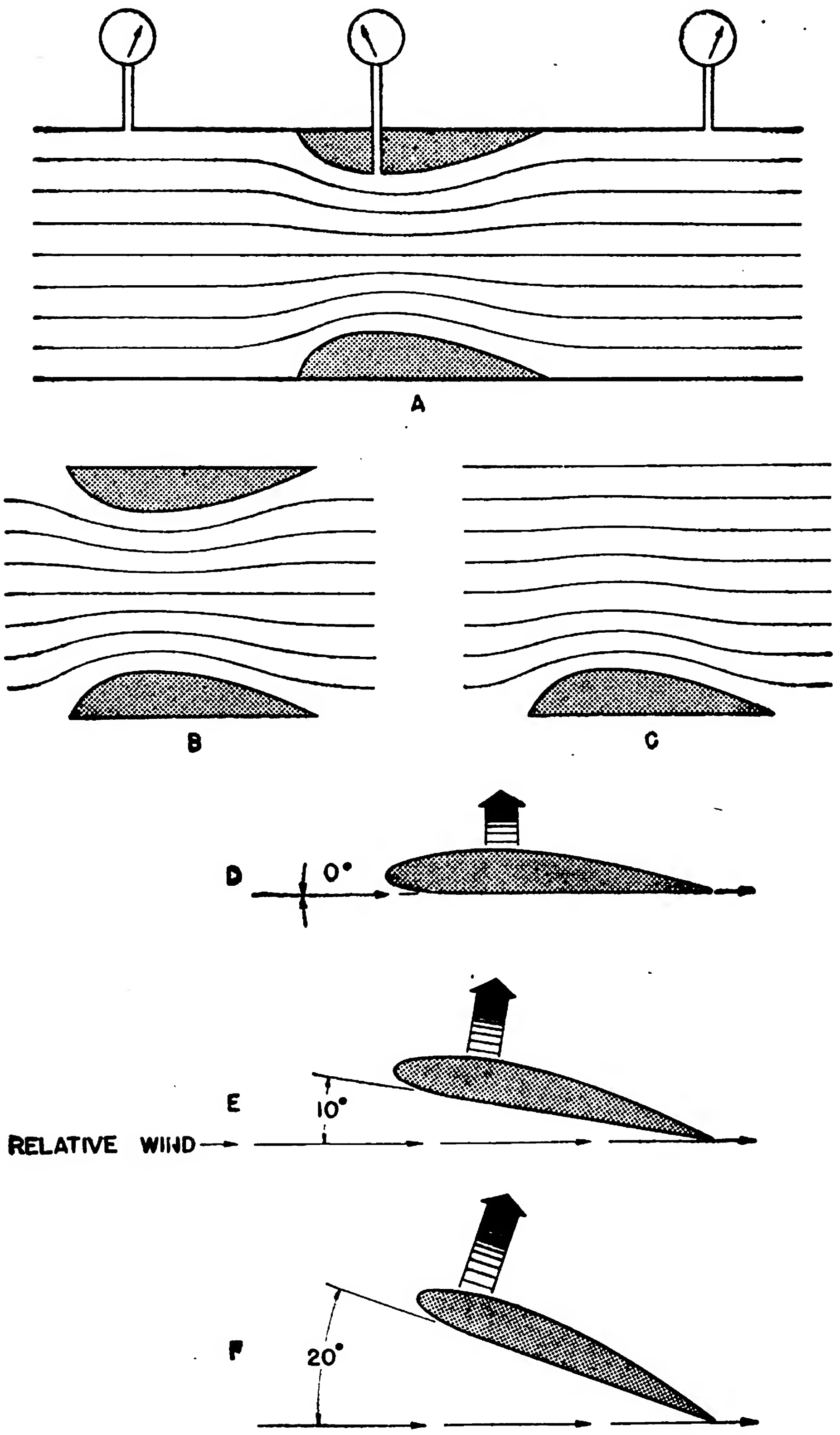


Figure 4.—(A, B and C) How the venturi-tube principle causes airfoil lift; (D, E and F) the effect of angle of attack on lift.

tube, but that the air particles next to the walls follow a curved path. In (*C*) the top half of the tube has been lifted off and taken away.

The remaining lower half of the tube resembles those cambered airfoil sections you saw in figure 3. You'll recall that the fluid passing through the throat of the venturi tube moves at its fastest rate—but exerts its smallest pressure—at the narrowest part. Well, air passing over the top of an airfoil's upper surface speeds up in the same way. And here's the **PUNCHLINE** of the story! The air pressure on the top of the airfoil, therefore, is **LESS** than the pressure on the bottom, and the wing is pushed upward.

Actually, this tendency of the wing (to be pushed upward because of reduced pressure above it) provides by far the biggest part of the lift which keeps an airplane in the air. If the wing is **TILTED** upward in the path of the relative wind, impact pressure on the bottom will also contribute something to the lift. But under many conditions of airplane operation, impact pressure is negligible.

The propeller of an airplane has one main function—to pull or push the airplane through the air so that the relative wind will maintain the craft in flight. Whenever possible, pilots also take advantage of any of nature's own wind by making their take-offs into the wind, thereby gaining additional lift.

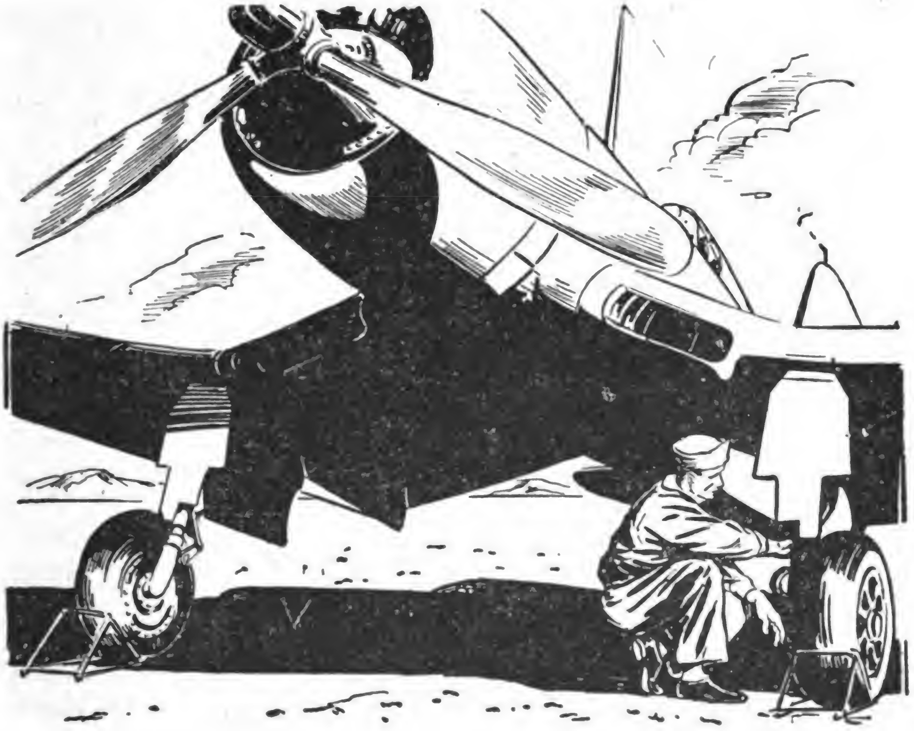
You'll recall that the angle of attack was defined as the angle between the wing chord line and the direction of the relative wind. By looking at figure 4 (*D, E,* and *F*) you'll see airfoils at three different angles of attack. As the angle of attack is increased, the lift is also increased—up to a certain point. The increase in lift with each increase in the angle of attack is due to two things.

First, the impact pressure on the bottom surface of the wing is greater. Second, the venturi-tube effect on the wing's upper surface is greater. When the angle of attack becomes too great, however, the air no longer flows smoothly over the top of the wing and the lift begins to decrease.

The angle of attack up to which lift increases and above which lift decreases is called the BURBLE POINT, or STALLING ANGLE.

The speed at which an airplane travels affects lift directly, because it effectively changes the velocity of the relative wind. With the angle of attack remaining the same, an airplane traveling 200 miles per hour has FOUR times as much lift as it would have at 100 miles per hour.

The density of the air also helps to determine the lifting power of an airplane wing. Thus, with other factors being the same, an airplane wing has more lift at sea level—where the air is most dense—than at higher altitudes where the air is more rarefied. Density of the air, however, varies considerably with temperature and humidity as well as with altitude. As air becomes warmer or more humid, its density decreases. So, in hot and humid weather considerably more speed is needed to lift an airplane into the air than is required in dry and cool weather.



CHAPTER 3

STRUCTURES

WHAT THEY ARE

For purposes of discussion, an airplane is usually divided into five parts—

FUSELAGE
WINGS
EMPENNAGE (TAIL ASSEMBLY)
LANDING GEAR
POWER PLANT

The FUSELAGE is the main body of an airplane. It is comparable to the body of an automobile.

The WINGS are the principal lifting surfaces. The wing assembly includes the following—

STRUTS—which are structure supports to carry either tension or compression loads. BRACE WIRES (OR TIE RODS)—which carry tension loads only.

AILERONS—which are control surfaces for banking an airplane. TABS. FLAPS and SLOTS.

The EMPENNAGE (TAIL ASSEMBLY) is made up of a number of control surfaces called—the FIN, the RUDDER, TABS, STABILIZERS, and ELEVATORS. The fin is a stationary vertical surface for the purpose of increasing directional stability—that is, to hold an airplane on a straight course and prevent weaving from left to right when you DON'T want to change your direction of flight. The rudder is a flexible vertical surface, hinged to the rear of the fin, for the purpose of swinging an airplane from left to right when you DO want to change your direction of flight. The stabilizer is a stationary horizontal surface, projecting from either side of the tail, for the purpose of increasing longitudinal stability—that is, to keep an airplane from bobbing up and down like a porpoise. The elevators are flexible horizontal surfaces, hinged to the rear of the stabilizers, for the purpose of controlling upward and downward direction of flight.

The LANDING GEAR supports the weight of an airplane on land or water. There are several different types of landing gear suitable for different types of airplanes. Some have WHEELS, some have FLOATS, some a combination of WHEELS-AND-FLOATS. Some have HULLS for landing gear. Landing shock, such as bounce during take-off, is eased by OLEO STRUTS—which act as shock absorbers for airplanes with wheels.

FUSELAGE

The fuselage, as you have seen, is the body of the airplane, to which all the other main parts are attached. It starts at the FIREWALL—a sheet of metal between the powerplant and the body—in most airplanes. The purpose of the firewall is to prevent gases, flames or burning fuel from enter-

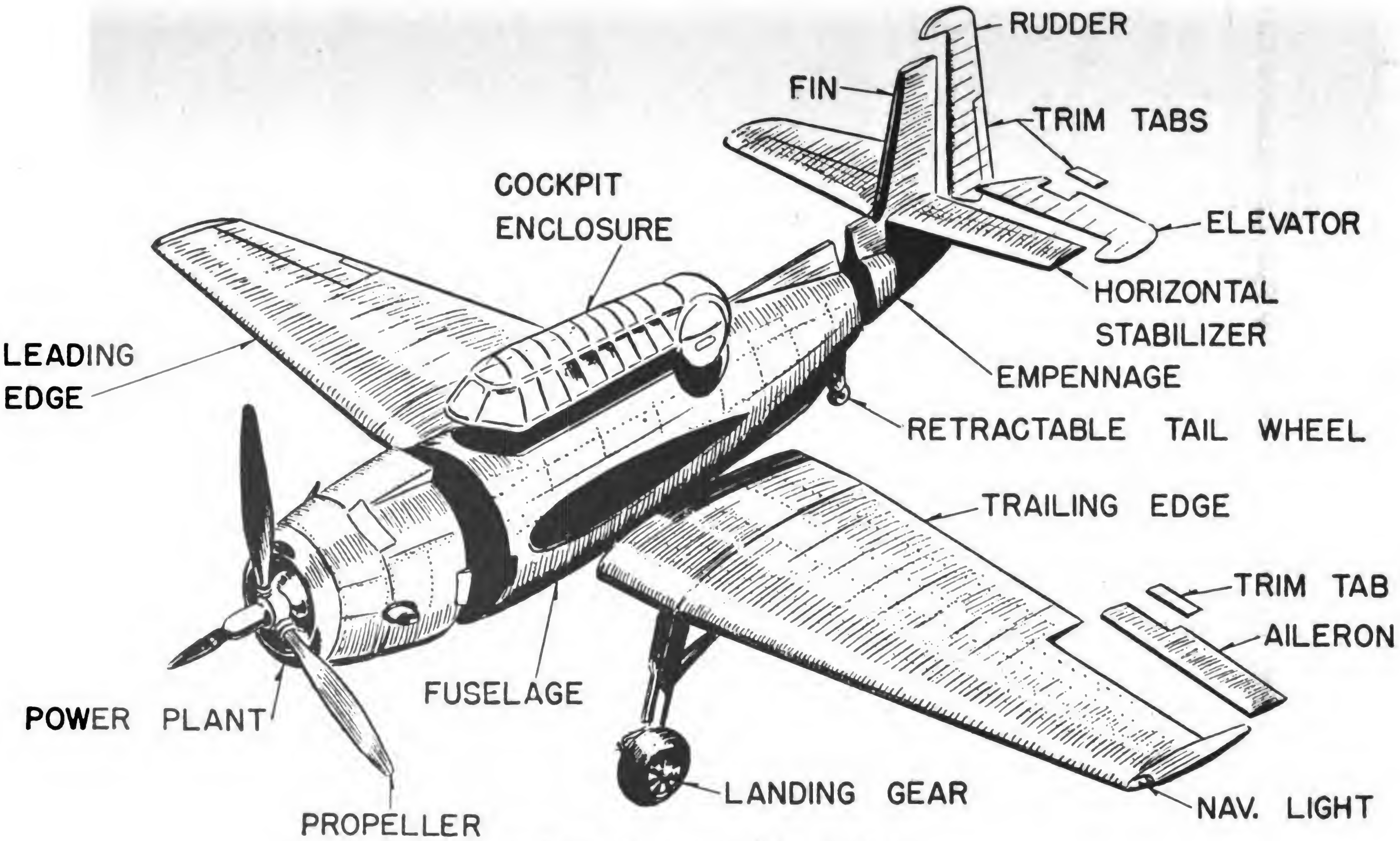


Figure 5.—Main parts of the airplane.

ing the crew compartments. The fuselage itself may contain one or more sections. The pilot's compartment is the COCKPIT.

Other compartments provide space for passengers, ammunition, bombs, and so forth. There are two types of metal fuselage structures in common use—the TRUSS type, and the MONOCOCQUE. Monococque is a French word. It means "single shell."

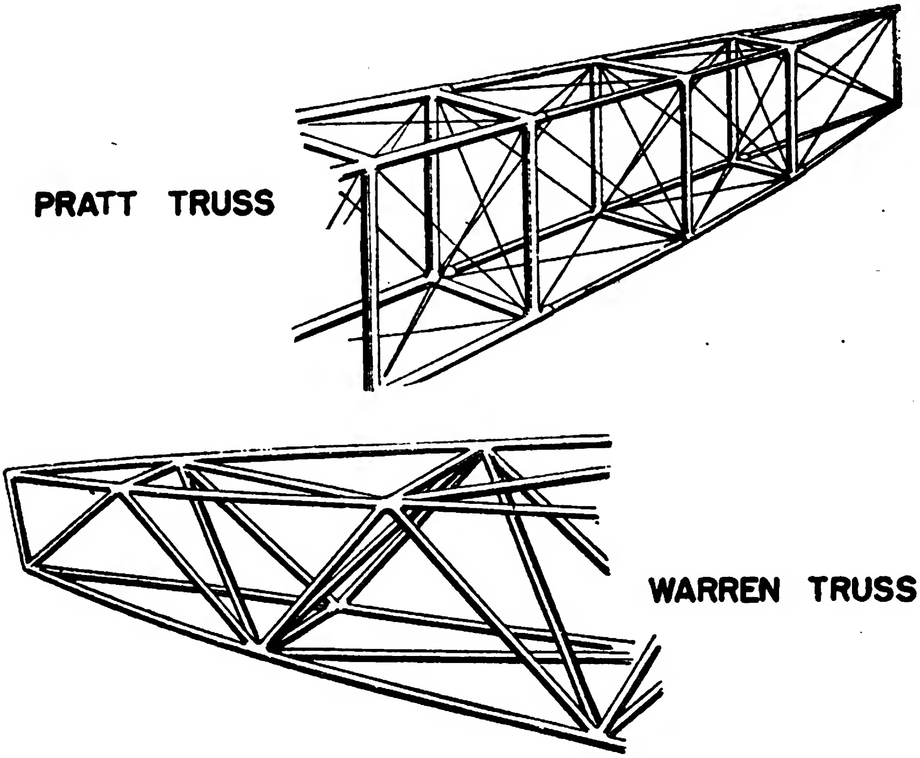


Figure 6.—Pratt truss and Warren truss fuselage construction.

The truss-type fuselage is built up of LONGERONS (longitudinal members), vertical and diagonal BRACES, and the COVERING. This type of construction relies on the strength of the truss frame to carry the loads and stresses in flight. The Pratt-type truss consists of vertical braces with diagonal, adjustable wires or rods between the longerons to permit easy realining of the frame. The Warren-type truss has an all-welded frame, which is very rigid and requires no adjustment in the course of ordinary use. Figure 6 shows both of these truss types. Some fuselage construction combines these two types of trusses. In all cases the truss frames are covered with a light-weight streamlined framework, or fairing, over which the skin is applied.

The monococque fuselage, wnich you see in figure 7, is one in which the stresses are borne by the SKIN itself. The monococque is a variety of stressed-skin construction. It has certain advantages over truss-type construction, among them being greater strength per weight, more room inside the fuselage, better streamlined form, and easier access for repairs.

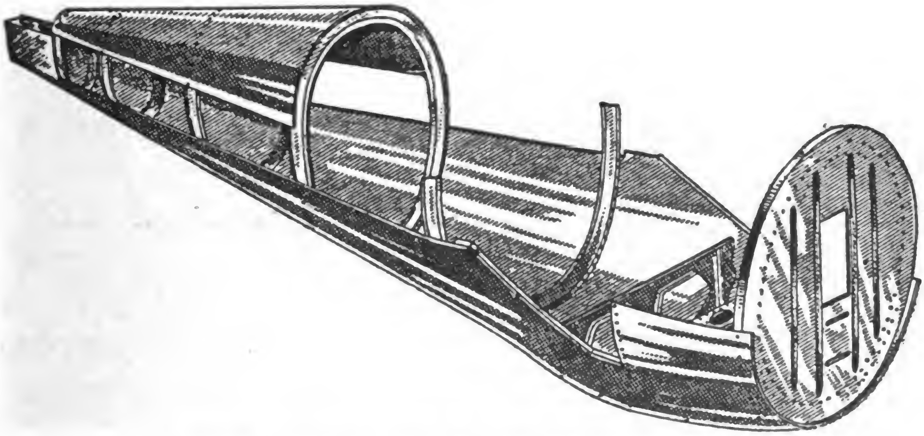


Figure 7.—Monococque fuselage construction.

Some fuselages of this type are called FULL MONOCOCQUE, because they are made by attaching thin sheets of metal to FRAMES—also called formers or bulkheads. They give the cross-sectional shape to the fuselage, which thus becomes a hollow tube made out of thin sheets of material. Full monococque structures are generally used only in light airplanes, or in those parts of an airplane where the stresses are not extreme. When more strength is needed, metal stringers are added, and the fuselage is then classified as SEMI-MONOCOCQUE.

Stringers are light-weight reinforcing members extending through the bulkheads and riveted directly to the skin. They serve as longitudinal stiffeners. Since the modern, high-speed airplane develops great stresses in flight and must be well streamlined, most of the fuselage construction is now of the semimonococque type. Some of the big airplanes are monococques of the REINFORCED SHELL type, however. That is, they have extra bracing for the skin at points of highly concentrated load.

WINGS

Remember how you build kites? If you make the diamond-shaped kind—with two crossed sticks for braces—the construction is fundamentally like that of an airplane wing.

The long stick—running from the top corner to the bottom—serves the same purpose as the RIBS in a wing. The crosspiece, running from side to side, is like a SPAR. A kite's cover material—probably an old newspaper—is stretched over the sticks and held in position by them. The airplane wing's covering is stretched over ITS structural ribs and spars and held in the proper airfoil shape in just the same way. A glance at figure 8 will show you a typical example of wing construction.

SPARS—or beams, as some people call them—provide the main strength of the wing. The lift and other forces which act upon the wing take effect first on the covering. From the covering they are transmitted to the ribs, and by the ribs to the spars. Thus, in the long run, all the load on the wing is taken by the spars.

There are quite a number of types of wing construction. Wing structures may be made of wood, and covered with fabric or plywood. Some are made of metal and covered with fabric.

Others are made of metal and covered with metal. Wings covered with fabric usually have two spars—one near the front or leading edge and one about two-thirds the distance toward the rear or trailing edge. Metal-covered wings, however, sometimes have as many as five spars.

Some spars are made of wood, others of metal. Wooden spars usually have a solid cross-section, and are either **I**-beam sections, or box-shaped sections. Most metal spars are made of aluminum alloy or of steel. Metal spars may be shaped like the letter **I** in cross section, or may be made like a truss, such as is used to hold up the roof of a building.

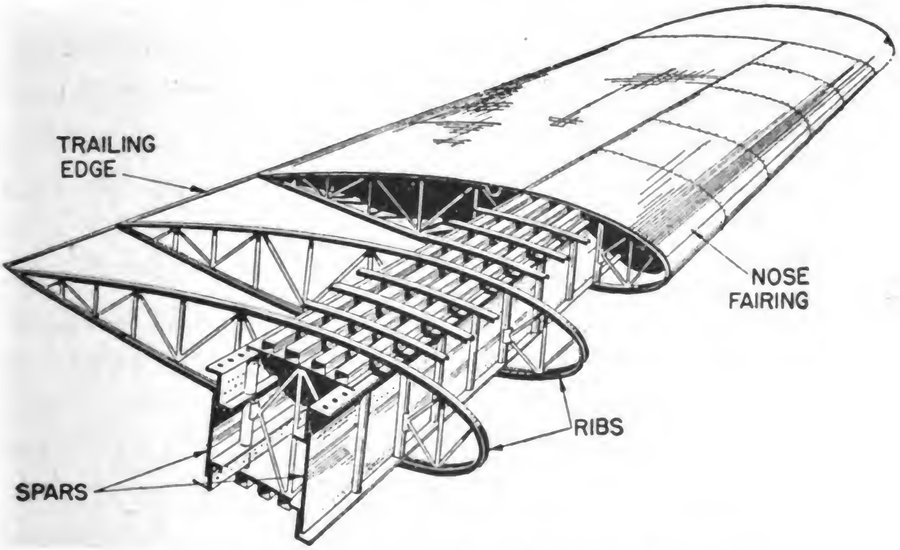


Figure 8.—Spars, ribs, and nose fairing of a wing.

You might compare the spar of an airplane wing to your own backbone. Without it you couldn't stand upright. The ribs in a wing also do much the same sort of job as your own ribs do for your body. The ribs that give the wing its shape are called FORM RIBS. Airplane wings also have other short ribs called NOSE RIBS along the leading edge, so that this front section will hold its shape in flight. There is usually a stiff layer of plywood or metal under the outside cover of an airplane wing at its nose, to help the nose ribs keep the leading edge in proper contour. Form and nose ribs are almost always made either of wood or aluminum alloy.

When an airplane goes at a high rate of speed there is generally a great deal of pressure on the wing's leading edge. In order to keep fabric- or wood-covered wings rigid in a fore-and-aft direction, it is necessary to put braces between the spars. The system of braces provided for this purpose is known as the DRAG TRUSS. The drag truss is composed of COMPRESSION RIBS, which are sturdy ribs that often do not have the contour of the wing. In wings of metal construction, compression ribs are frequently just round steel tubes. In wooden wings, compression ribs are generally made of plywood or spruce timber. The compression rib at the inner end of the wing is referred to as the ROOT or BUTT RIB.

Compression ribs are used to resist the tension of bracing wires or struts inside the structure of the wing. Wire braces for this purpose are known as DRAG and ANTIDRAG WIRES, and are more commonly used than are internal bracing struts. Metal-covered wings usually have no drag trusses. The metal covering itself keeps the wing from losing its shape or being pushed backward by the force of the air. This method of building wings is known as STRESSED-SKIN construction—a term you saw before in the discussion of the fuselage.

The wings of some airplanes have FLAPS hinged near their trailing edges. These serve as a sort of air brake. They are not in any sense control surfaces. DON'T confuse them with ailerons. Flaps reduce the airspeed of an airplane in landing, and sometimes are used to provide additional lift for take-offs. There are several different types of flaps, but they all operate on the same principle and vary only in design and efficiency.

Some wings have air passages through them in the form of SLOTS. The reason for having slots is to smooth out the flow of air over the wing when it is at a high angle of attack. In general, an airplane with slotted wings will not stall as quickly as an airplane with the same shape of wing airfoil but without slots.

Banking an airplane is accomplished by use of the AILERONS. These, you recall, are movable surfaces hinged to the trailing edges of the wings. The hinges are attached either to the rear spar or to a false spar near the trailing edge. When an aileron is moved DOWN, the LIFT on that wing is increased and the wing rises. The cables or mechanisms which control the ailerons are hooked up together so that when ONE aileron moves DOWN the other moves UP. Move the control stick to the right, and the left aileron goes down as the right aileron moves up, thus banking the airplane to the right. Reverse the motion of the control stick and the airplane banks to the left.

EMPENNAGE (TAIL ASSEMBLY)

When you drive your car down the street, you steer it merely by turning the steering wheel. Directing an airplane through the sky, however, is quite a different proposition. You have probably discovered that an airplane is fitted with a number of flight controls. Each of these controls is a separate "steering wheel" in itself. Except for the ailerons, which are attached to the wings, most of an airplane's steering surfaces are parts of the EMPENNAGE.

The empennage, or tail assembly, is made up of parts built in much the same way as wings. Fins, stabilizers, rudders, and elevators can be made of wood, steel tubing, or aluminum alloy, and covered either with fabric or metal. MOVABLE SURFACES of the empennage (meaning the elevators and rudder) are also provided with TABS in most airplanes, as in figure 9. Some tabs can be adjusted only when the airplane is on the ground. Others may be controlled from the cockpit while the airplane is in flight.

Movable control surfaces are BALANCED, as in figure 10, to keep them from fluttering during flight. There are two ways of balancing such control surfaces. A STATIC balance is a weight located at some position forward of the hinge to which the control is fastened. This weight is often a small streamlined shape attached to the end of an arm projecting from the forward end of the control surface. Large airplanes generally have AERODYNAMICALLY balanced control surfaces. This type of balancing is made possible by locating the hinge somewhat BACK from the control surface's

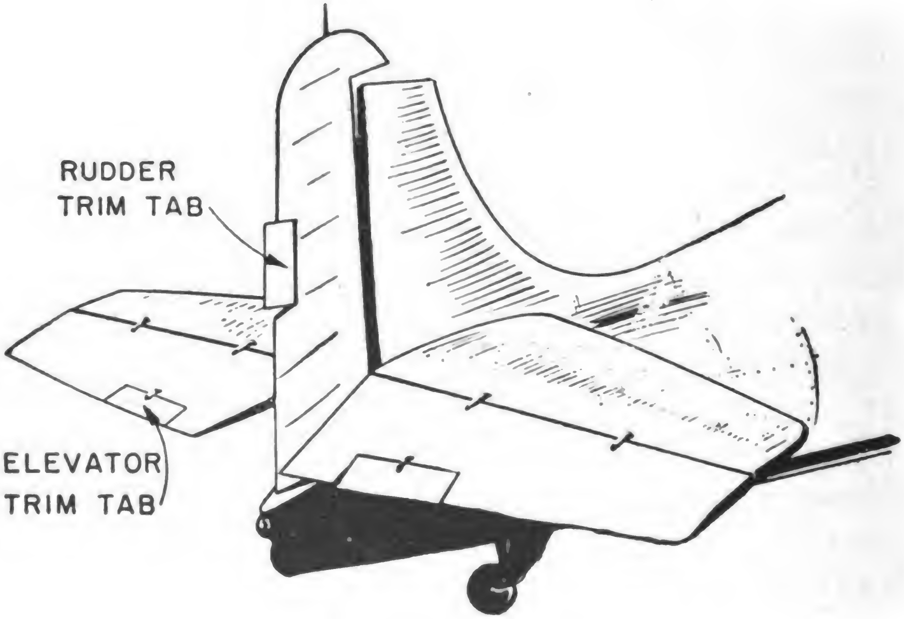


Figure 9.—Trim tabs.

leading edge. Thus, the air striking the portion forward of the hinge tends to assist in moving the surface in the direction you wish.

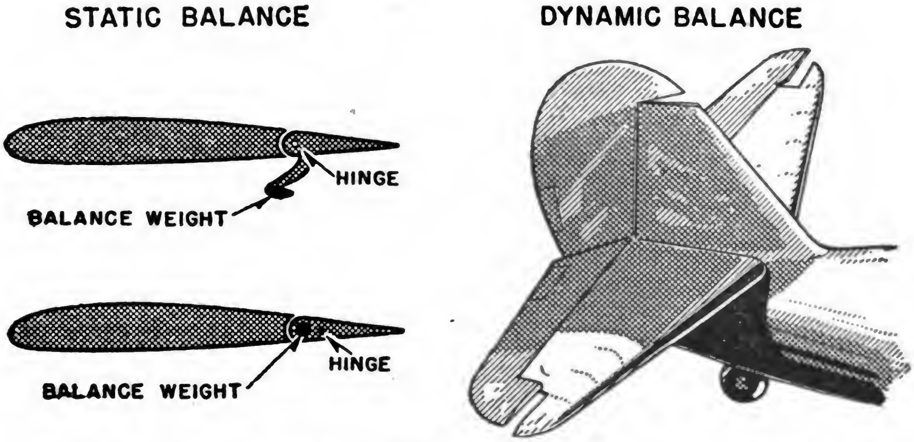


Figure 10.—Static and aerodynamic balancing of control surfaces.

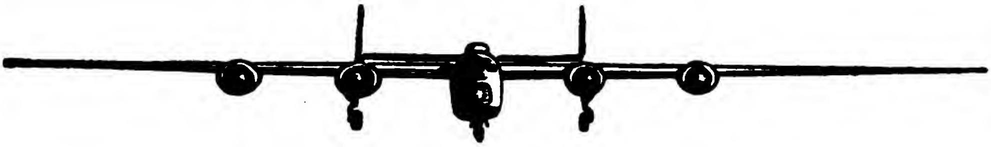
LANDING GEAR

The landing gear of an airplane can be a complete pain in the neck a great part of the time. It adds weight to an airplane in flight, cuts down the flying speed, and presents you with just one more thing to get out of kilter. But, if that little old landing gear wasn't there WHEN YOU NEEDED IT, you wouldn't have to worry about keeping that date with the blonde on your next liberty. Thereafter you'd just be a vital statistic.

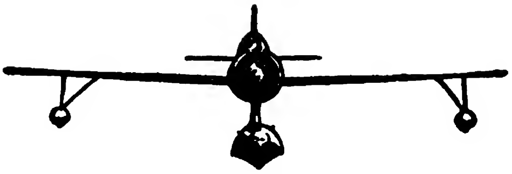
Even the birds have trouble with their landing gear. You'll notice that almost all birds tuck their feet up flat against their bodies to keep them out of the way during flight. Wheels and floats, like birds' feet, are useful only during take-off and landing, or when moving about on land or water. The main types of airplane landing gear are pictured in figure 11.

Landplanes, as you know, are equipped with wheel-type landing gear. The gear includes the chassis, shock absorber unit, wheels and brakes, tires, metal fairings, tail wheel or tail skid assem-

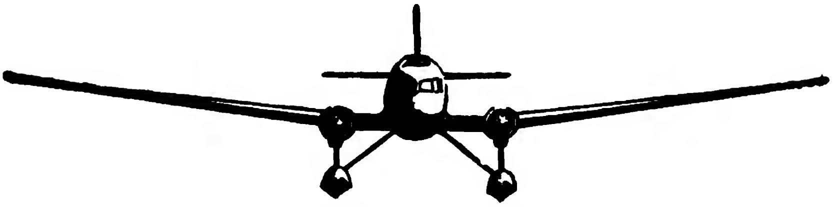
FIXED LANDING GEAR



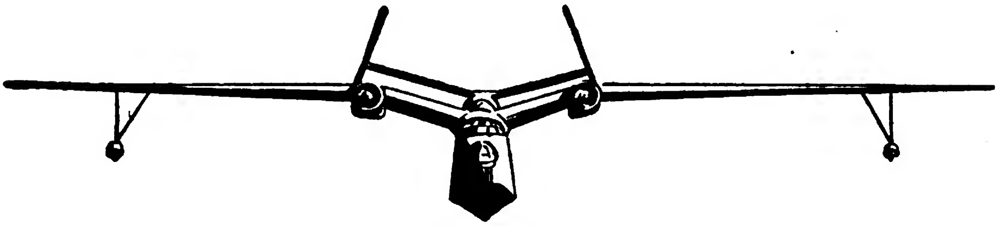
RETRACTABLE LANDING GEAR



SINGLE FLOAT



DOUBLE FLOAT



BOAT HULL

Figure 11.—Various types of airplane landing gear.

bly, and all of the necessary fittings to attach the gear to the airplane. Many modern types of airplanes have retractable landing gear which folds up into the wings or fuselage after the take-off.

Landing gear which makes it possible for some types of airplanes to alight on either land or water is called AMPHIBIAN gear. Such gear is a combination of retractable wheels and a hull or floats. Amphibian-equipped airplanes are very flexible as far as landing and take-off adaptability is concerned. But, as you'd imagine, the gear itself is somewhat cumbersome. This fact restricts the use of amphibian airplanes to special situations.

As a general rule, aviation people call float-equipped craft SEAPLANES. Strictly speaking, ALL airplanes designed to alight on the water are seaplanes, but water-based planes that use their hulls as landing gear are usually referred to as FLYING BOATS. The differentiation between flying boats and seaplanes is merely a matter of usage among aviators.

An airplane equipped with ONE main float is called a SINGLE FLOAT seaplane. Such airplanes also have small floats at each wing tip to prevent them from capsizing. These wing-tip floats do not contribute materially to the support, or buoyancy, of the airplane. If the plane is equipped with TWO large floats, which share equally in supporting it, the craft is a TWIN FLOAT seaplane and wing-tip floats are unnecessary. In a twin float seaplane the horizontal distance between the keels of the floats is called the TREAD. Frequently these floats are braced by a bar running from one to the other. Such a brace is called a SPREADER BAR.

The covering, or skin, of most seaplane floats is made of aluminum alloy sheet. The rear portion of the float is called the STERN, the front portion is called the BOW, and the vertical member at the front of the bow is known as the STEM—just as in a ship. Most floats have soft bumpers on their noses to prevent damage when striking a dock or other solid object. The top of the float is known as the DECK. The stringer, or longitudinal member that attaches the deck to the sides is called a DECK CLAMP. Inside and outside views of a float are shown in figure 12.

You will usually find one or more MOORING CLEATS attached through the deck to internal structural members of the float. These cleats, which are often in the shape of rings, are used for mooring or tying the plane to a fixed object, and also for the attachment of lines for towing. The deck is also provided with removable portions called HANDHOLES. These are used for inspection, pumping out water, and for access to the interior when making minor repairs.

A seaplane float has watertight interior bulkheads, which divide the float into several compartments. Thus, if there should be a leak, water will enter only one small section of the float, and the seaplane won't sink. Most floats are also equipped with a rudder, attached to the stern post and used for steering the seaplane while it's on the water.

There's a step about halfway between the bow and stern on the bottom of a float. That step helps more to break the float away from the grasp of the water when the water is smooth than when it's choppy, as smooth water hangs on to a float for dear life.

The part of the float in front of the step is called the FOREBODY, and the part behind the step is the AFTERBODY. That section of the bottom which is back of the step is known as the AFTER BOTTOM; the portion in front is known as the

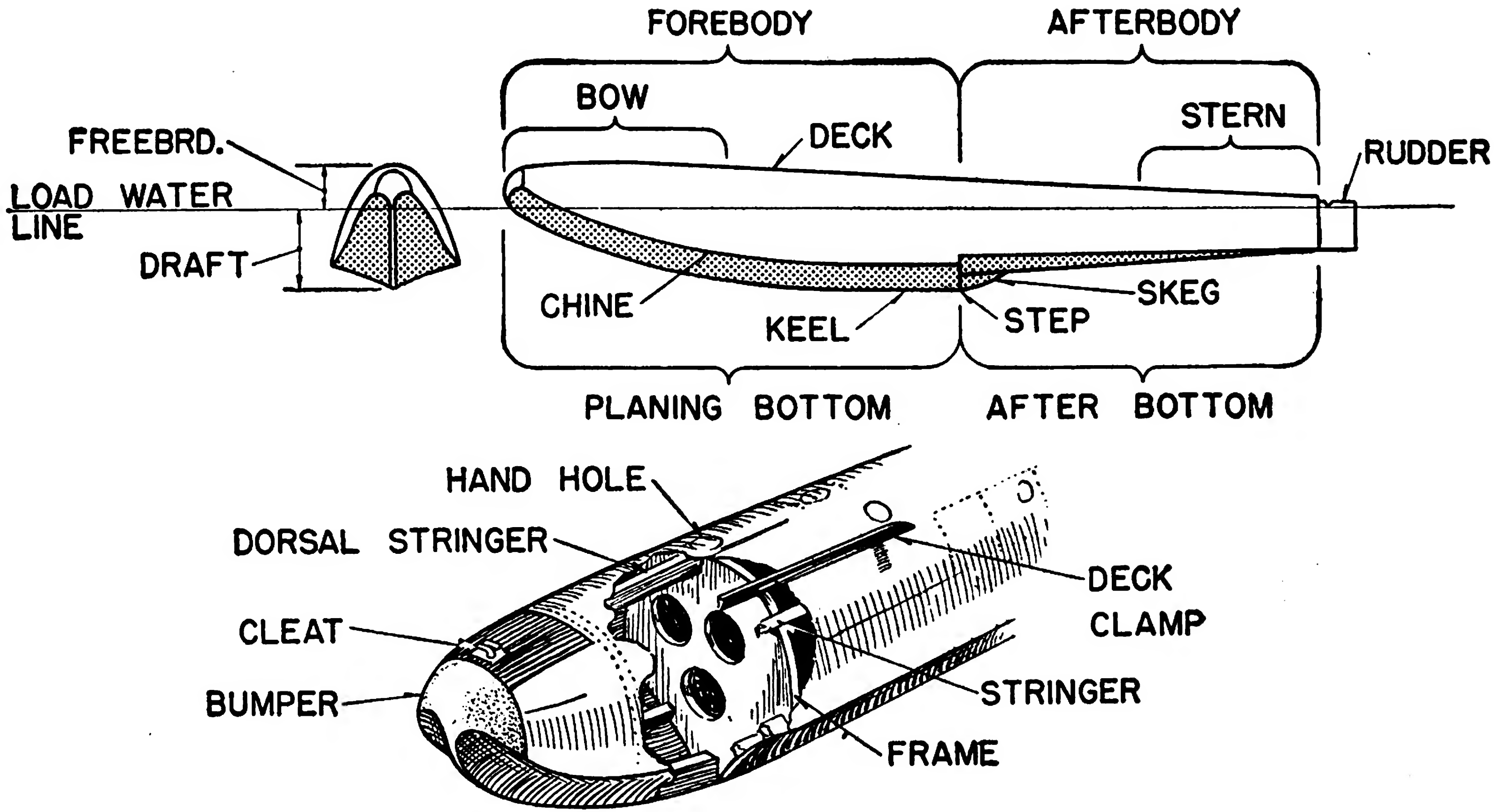


Figure 12.—Exterior and interior views of a seaplane float.

PLANING BOTTOM. Some extra-large floats have two steps—a main step near the bow, and an after step near the stern. On these big floats the section between the two steps is referred to as the MIDDLE BODY. The ridge, or corner, where the bottom meets the side is known as the CHINE.

The long strength member at the bottom of the float, running from stem to stern, is the KEEL. It's usually an angle of strong metal to which the two halves of the bottom are riveted. Pretty generally, there'll be an extra strip of metal fastened over the outside of the keel. It's known as the RUBBING STRIP, and saves the keel from wear and tear. This protective strip can be replaced with a new one, if and when it gets worn out.

When a seaplane is on the water, carrying its normal load, a part of the float, or floats, will be under water. The amount of this normal submersion is marked by the LOAD WATER LINE (often abbreviated L. W. L.). The distance from the load water line to the deck is known as the FREEBOARD, and the distance from the L. W. L. to the lowest underwater point of the float is the DRAFT.

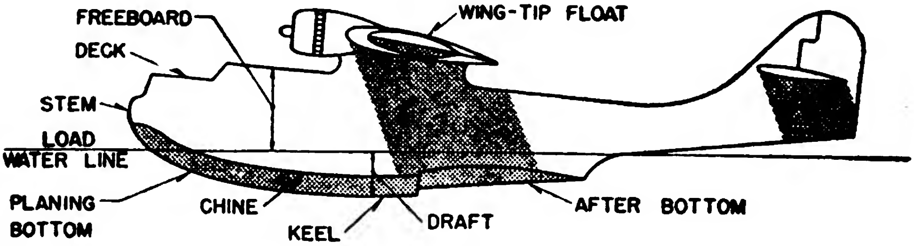


Figure 13.—The parts of a flying-boat hull.

The curved members that give the float its curved cross-sectional shape are the FRAMES. These frames are attached at right angles to the lengthwise braces. The SKIN, in turn, is fastened to the frames. Supporting the skin between the frames are fore-and-aft strips called STRINGERS, the one at the top center having its own private monicker—the DORSAL STRINGER. Other reinforcement braces, inside or outside the float, are usually referred to as STIFFENERS.

In a flying boat, that part of the fuselage which carries the crew, equipment, fuel, and the rest of the useful load also serves as the landing gear, and is called the hull, as you see in figure 13. Although built as an integral part of the flying boat's fuselage, the hull is very similar in construction to a float, and its parts carry the same names.

Some hulls have additional strip-like watertight compartments running along their sides to give them extra buoyancy in the water. Such compartments are called SPONSONS. They are seldom used on floats. Also, since the crew must be able to move back and forth through the length of the hull, there are transverse doors which can be closed if some portion of the hull is damaged.

You will notice that most flying boats have wing-tip floats, much like those on float seaplanes. But some large flying boats use SEA WINGS—sometimes called STUB WINGS—instead of wing-tip floats. Sea wings are attached to the hull at the water line near the chine, and they not only steady the plane in the water, but add to the planing surface of the hull bottom during take-off. Sea wings should NOT be confused with sponsons.

CHAPTER 4

INSTRUMENTS

A LOOK AT THE COCKPIT

To some folks, the inside of an airplane cockpit is as mysterious and complicated as the Einstein theory. The cockpit, it's true, does have a lot of equipment packed in a small space. But when you think of all the things a pilot must know and DO to fly an airplane, you realize the necessity for so many instruments and controls. They provide extra sets of "hands" and "eyes" without which flying a modern airplane would be impossible.

There are two ways of grouping airplane instruments for the purpose of learning about them. One way is according to the jobs they do. From this point of view they fall into three classes. You have FLIGHT instruments, NAVIGATION instruments, and ENGINE instruments. Another method of classifying airplane instruments is according to the principles on which they work. Some operate as the result of changes in TEMPERATURE or PRESSURE. Some are HYDRAULIC—that is, they operate by fluid pressure. Others are put in action by MAGNETISM and ELECTRICITY. Some use GYRO-

SCOPES. You'll find this second method of classifying a big help if you go on to specialize in instrument work.

FLIGHT INSTRUMENTS

Flight instruments keep you posted on the positions assumed by the airplane in flight, and make it possible for you to control them intelligently.

The main flight instruments appear in figure 14. The CONTROL STICK (or, in some airplanes, the "wheel" control) operates the ailerons and elevators. Move the stick forward and you lower the elevators, so the airplane noses down. Pull it back and the nose rises. Move the stick from side to side and you operate the ailerons, causing the airplane to bank to right or left, according to the direction in which you're leaning.

To STEER the airplane to left or right you use the RUDDER PEDALS. Most airplanes also have BRAKE PEDALS attached to the forward ends of the rudder pedals. The brakes work independently—that is, you can apply them to either landing wheel separately, or to both at the same time.

The ALTIMETER shows you how high above the point of take-off the airplane is flying. It can also be adjusted to indicate height above sea level, if that's preferable under the circumstances. The AIRSPEED INDICATOR tells how rapidly the airplane is moving in relation to the air.

The BANK AND TURN INDICATOR is another one of those combination instruments. The turn indicator part of it shows whether the airplane is flying in a straight line or turning. The bank indicator is a little ball in a curved groove. If the airplane is skidding or slipping, the ball rolls to one side like the "tilt" on a pinball machine.

The RATE OF CLIMB INDICATOR—not to be confused with the altimeter—indicates how fast you're

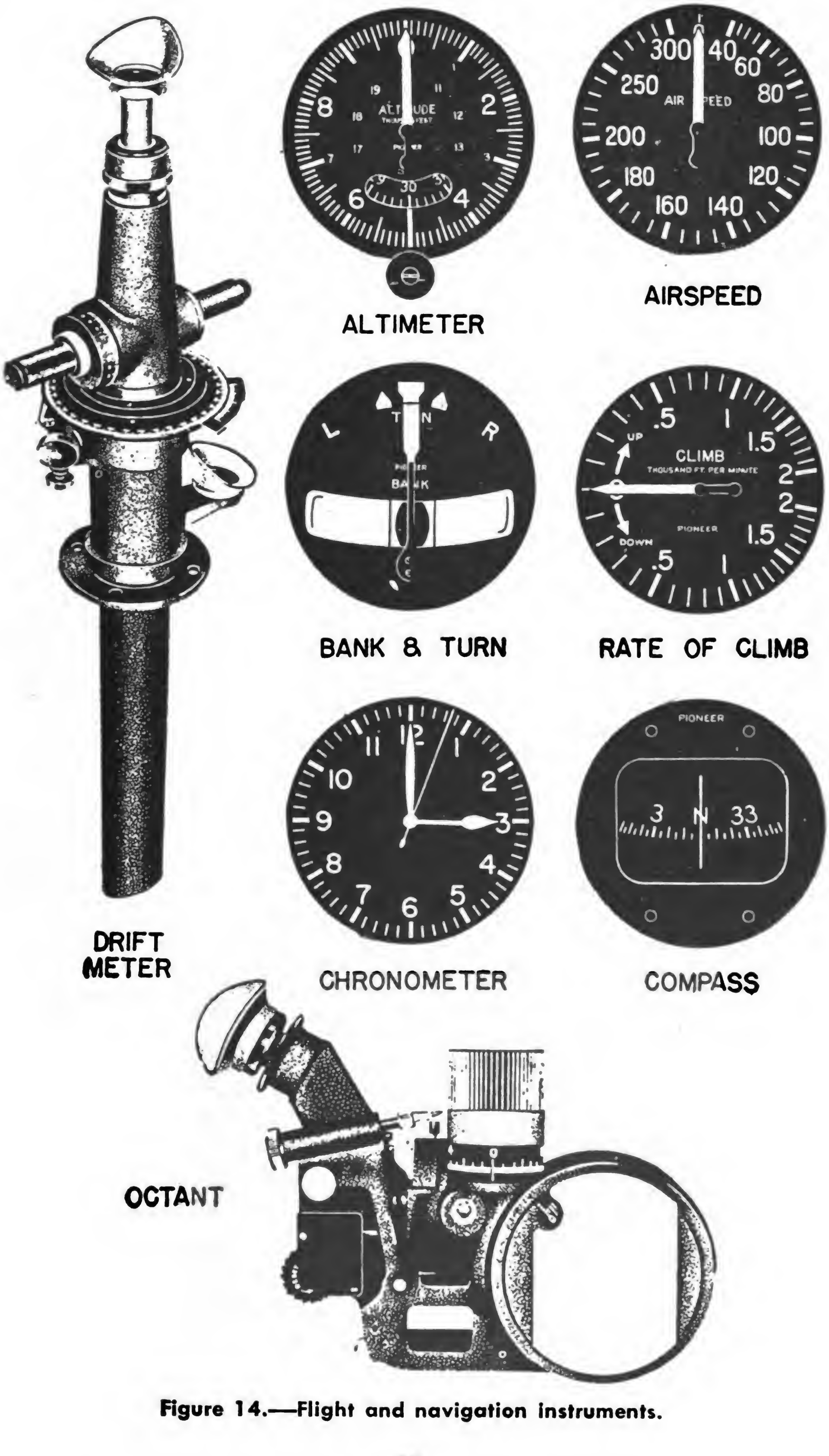


Figure 14.—Flight and navigation instruments.

climbing or gliding. During level flight it registers zero.

When you're flying blind, it's mighty hard to tell whether the airplane is flying on an even keel, nosing down or up, banking, or whatever. It's absolutely foolhardy to rely on your sense of balance or the feel on the seat of your pants, for airplanes have a habit of playing tricks on human machinery under such circumstances. The rate of climb indicator, bank and turn indicator, and ARTIFICIAL HORIZON instrument are a mighty fine threesome to rely upon instead—when you're in a tight spot with "ceiling zero."

The AUTOMATIC PILOT is a fairly recent development, but it has become an important factor in safe aviation. It allows the pilot to set the controls for steady, straightaway flight while he attends to the other important chores that must take part of his time and attention.

NAVIGATION INSTRUMENTS

Navigation instruments help you to arrive at your destination without getting lost. The main one used are shown in figure 14.

The COMPASS (there are several types) shows you the direction in which the airplane is heading with respect to magnetic north. The DRIFT INDICATOR tells you how the wind is trying to blow you off your course. The OCTANT or SEXTANT is used to get directional bearings from the sun and stars. The CHRONOMETER—or just plain CLOCK—is an instrument without which celestial bearings and other reckoning of position would be meaningless. The RADIO, which often provides information of great value, might also be listed as a navigation instrument.

ENGINE INSTRUMENTS

Engine instruments tell you about operating conditions in the engine and other parts of the power plant, and provide you with means of regulating engine operation.

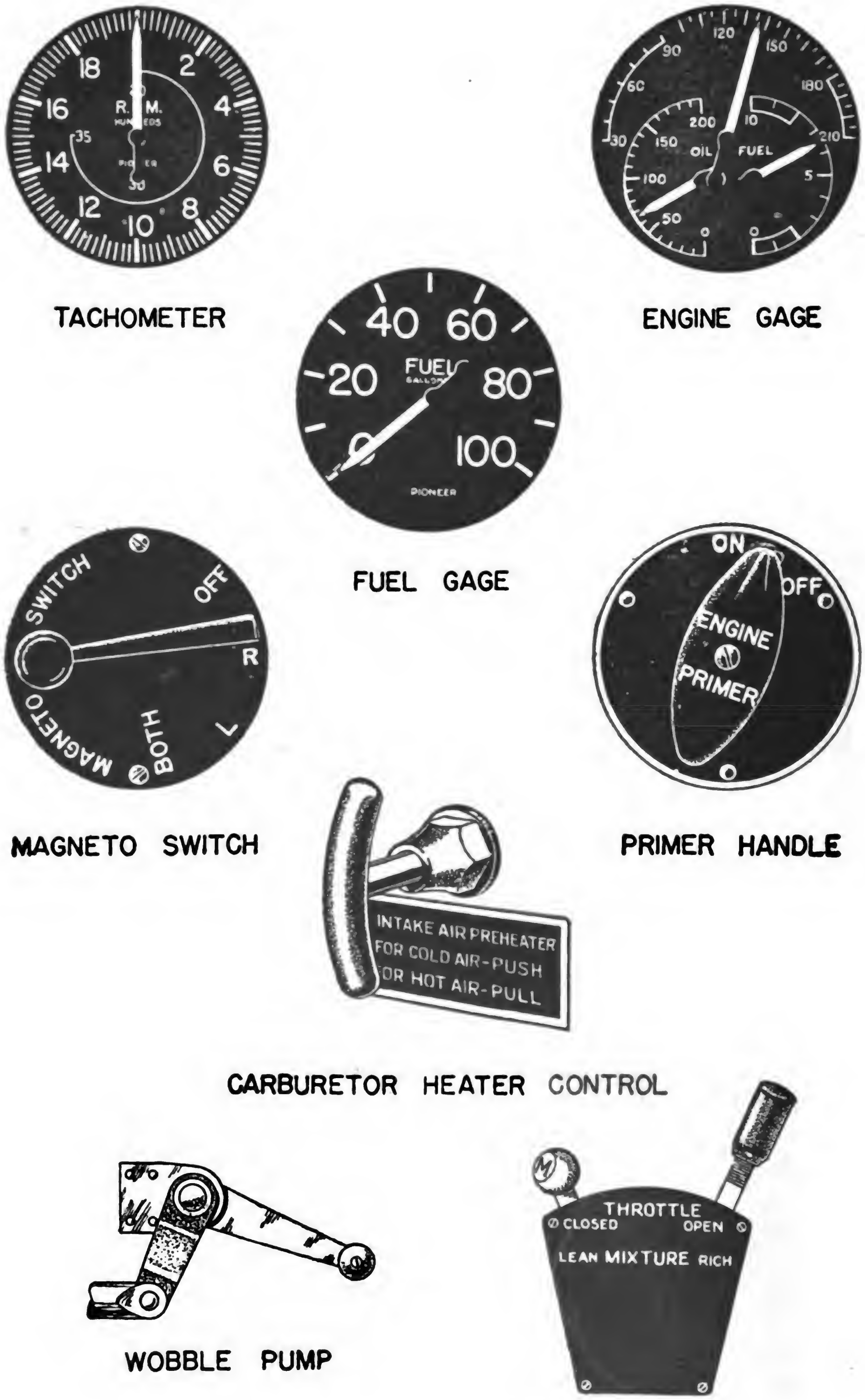
It's almost impossible to put too much emphasis on the importance of knowing what the power plant of your airplane is doing. It's true that a person who is thoroughly familiar with airplane engines can sometimes identify irregularities in operation merely by listening to the sound of the engine. But that's guesswork, at best. Only the engine instruments, like those in figure 15, can do a really reliable job.

The TACHOMETER is an instrument that tells you how many times a minute the engine crankshaft is turning. It's a valuable indicator of engine performance, because almost any sort of engine trouble results in a slow-down of the power plant's revolutions per minute (rpm).

Many airplanes are equipped with a combination instrument called the ENGINE GAGE UNIT, which shows the temperature of the engine oil, the oil pressure, and the fuel pressure—all on a single dial. In other airplanes, the three instruments may have separate dials, but they will function in the same way.

There are quite a few types of FUEL QUANTITY GAGES to tell you how much gas is in the fuel tanks. HYDROSTATIC gages give correct gasoline-level readings only after you pull and release a pump handle that's connected with the fuel system. ELECTRICAL gages and ordinary FLOAT gages are also used in airplanes for the purpose of determining gasoline levels.

Then there are THERMOMETERS. They keep you posted on the temperature of various parts of the



TACHOMETER

ENGINE GAGE

FUEL GAGE

MAGNETO SWITCH

PRIMER HANDLE

CARBURETOR HEATER CONTROL

WOBBLE PUMP

MIXTURE CONTROL

Figure 15.—Engine instruments.

engine, how hot or cold the air is outside the cockpit, and similar things.

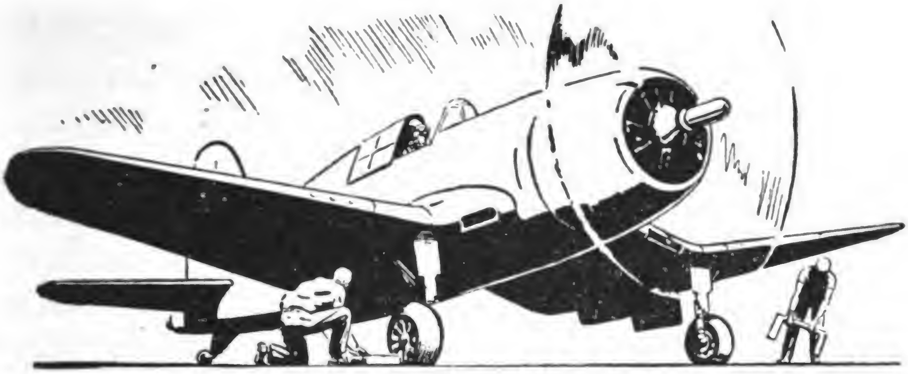
The MAGNETO SWITCH turns the engine ignition on and off. This switch generally has three ON positions, labeled "right" and "left" and "both," since almost all modern airplane engines have dual ignition systems.

The CARBURETOR AIR HEATER CONTROL adjusts the supply of heat to the carburetor air intake—important in preventing ice formation in this part of the fuel system when you're flying high.

Almost all airplanes are equipped with PRIMERS to make engine starting easier. A primer is usually hand operated from the cockpit and pumps a charge of liquid gasoline into the intake manifold.

The WOBBLE PUMP is used to build up the fuel pressure during starting so that gasoline can reach the carburetor, even though the engine-driven fuel pump is not operating. The wobble pump is likewise valuable as an emergency pump if the engine-driven pump breaks down. To shut off the whole fuel supply to the engine, you can close a FUEL SHUT-OFF COCK.

The mixture of gasoline and air reaching the engine cylinders can be regulated by adjusting the MIXTURE CONTROL. In an airplane the THROTTLE serves the same purpose as the gas pedal in an automobile—it controls the amount of fuel fed to the engine.



CHAPTER 5

ENGINES

WHAT THEY ARE

Engines are the "heart" of the POWER PLANT. Briefly, gasoline mixed with air is converted by the engine into power that rotates the propeller. Rotation of the propeller drives an airplane through the air. All Naval airplane engines in use today are of the INTERNAL COMBUSTION type, so called because the fuel burns inside the engine rather than outside (as, for example, in a steam engine).

When a fuel such as gasoline is mixed with air and burned, it forms a hot, rapidly expanding gas. If the mixture is made to burn inside a closed chamber, the hot gas exerts great pressure on the chamber walls. That's fundamentally what goes on in the CYLINDERS of an internal-combustion engine. Each cylinder, however, has one movable end, called a PISTON, which tends to be pushed away from the far end of the cylinder every time a charge of fuel is burned inside.

Simple, isn't it? All you have to do now is harness the movement of the piston and make it do the kind of work you want. Of course, there are many more details to be worked out before you end up by having an aircraft engine, but the movement of the pistons in the cylinders is still the basis of the operation.

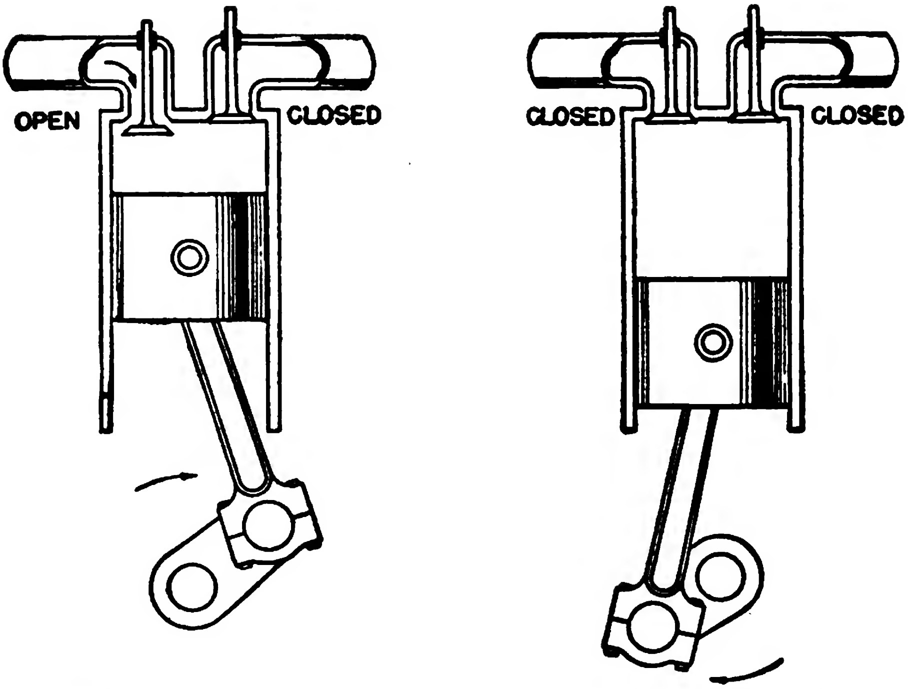
The force pushing the piston is passed to a CRANKSHAFT by means of a CONNECTING ROD, so that the crankshaft TURNS. Since the propeller is connected to the crankshaft, they spin around together. Once they are in motion, other pistons operate in a similar manner and the first piston is carried back toward the top of the cylinder, ready for another kicker of fuel.

VALVES in the top, or head, of the cylinder open and close to let out burned gases and take in fresh fuel. There are usually two valves in each cylinder. One controls the admission of fuel and is called the INLET, or INTAKE, valve. The other controls the leaving time of burned gases and is called the EXHAUST valve. These valves are operated by a system of gears and cams so they will open and close at exactly the right time.

FOUR-STROKE CYCLE

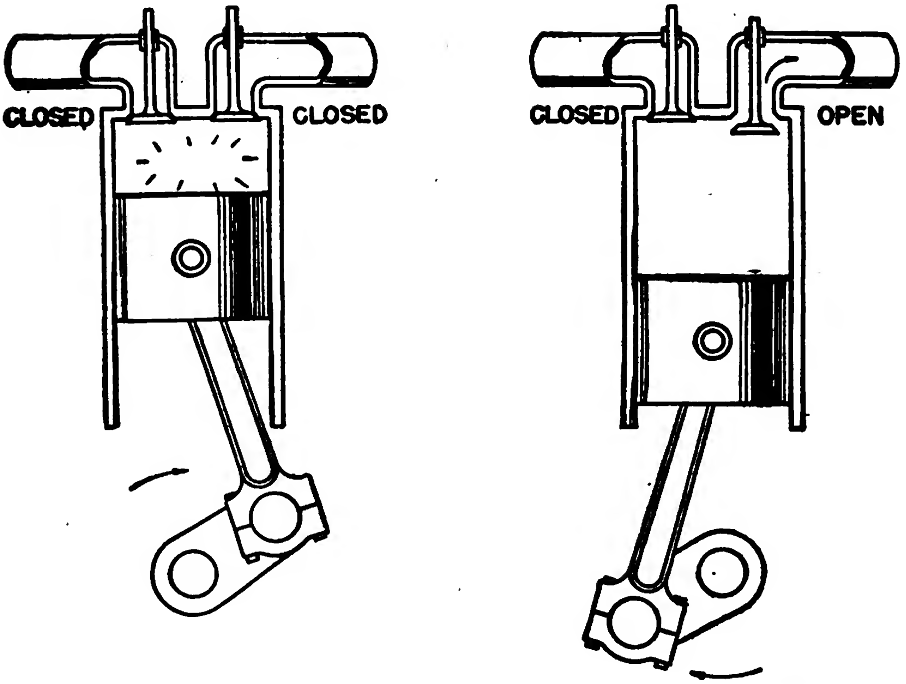
Each movement of the piston in the cylinder—whether up or down—is called a STROKE. The whole sequence of events—from the time a fuel charge enters the cylinder until it leaves as burned exhaust gas—is known as a CYCLE. Aircraft engines use a FOUR-STROKE CYCLE, and are called FOUR-CYCLE engines. In figure 16 you see the basic operations involved in the four-stroke cycle.

The first stroke, called the INTAKE STROKE, finds the piston moving down and the intake valve opening to admit a charge of fuel. The exhaust valve, of course, stays closed. The downward movement of the piston makes room for the introduction of the fuel into the cylinder through the intake opening.



INTAKE STROKE

COMPRESSION STROKE



POWER STROKE

EXHAUST STROKE

Figure 16.—The four-stroke cycle.

The second stroke, called the COMPRESSION STROKE, finds both valves are closed and the piston moves upward to compress the charge of fuel. This compression makes the fuel mixture burn more efficiently and produce more power than it would if not compressed.

Stroke number three is the POWER STROKE. The piston is up toward the top of the cylinder as far as it will go, and the fuel mixture is fully compressed into the small remaining space. Both valves are closed. An electric spark from the SPARK PLUGS ignites the fuel, which burns and expands rapidly, forcing the piston downward.

The fourth stroke, called the EXHAUST STROKE, finds the piston moving upward again. The exhaust valve opens and the piston forces the burned gases out of the cylinder. That's the end of the cycle, and the cylinder is ready to start a new one by drawing in a new charge of fuel.

As you have noticed, the piston makes two trips upward and two trips downward during a single cycle. That means the crankshaft makes TWO COMPLETE REVOLUTIONS during each four-stroke cycle. To turn the statement around, the cylinder FIRES ONLY ONCE during every TWO revolutions of the crankshaft.

Today, aircraft engines have a considerable number of cylinders. The power strokes of the separate cylinders are timed so that the crankshaft will receive a series of evenly spaced pushes in the course of each revolution it makes. The greater the number of cylinders, the more smoothness you have in engine operation. But the powerful monsters that drive modern airplanes through the air at fabulous speeds operate on exactly the same basic principles as the chugging little engine that first boosted Orville Wright into the air. The big difference lies in their size and relative efficiency.

One way of measuring the efficiency of an airplane engine is to compare the horsepower it produces with its weight. As a matter of fact, with engines both LIGHT ENOUGH and POWERFUL ENOUGH, man would doubtless have been able to fly long before the Wright brothers did the trick. BUT they were not available. Even the engine used by the Wrights at Kitty Hawk was dangerously close to being too heavy for the job. It produced ONLY 16 horsepower.

Engineers and other scientists have constantly been slugging away at the problems of cutting down engine weight and jacking up horsepower. Their refinements have made possible the great airplane engines of the present day which produce approximately ONE HORSEPOWER for EACH POUND of engine weight. Development of stronger and lighter metals has been responsible for much of the weight decrease. Better grades of fuel, produced by modern chemistry, have resulted in much higher power output.

Fighting airplanes of World War I were considered wonderful if they had 400-horsepower engines and could travel 120 miles per hour. Some modern fighters carry 2,000-horsepower engines, can fly at least 400 miles per hour, and reach ceilings undreamed of a few years ago.

TYPES OF ENGINES

All aircraft engines can be classified as either IN-LINE or RADIAL engines. In-line engines have their cylinders arranged in straight lines. There are a number of variations in the way the straight rows of cylinders may be placed with respect to

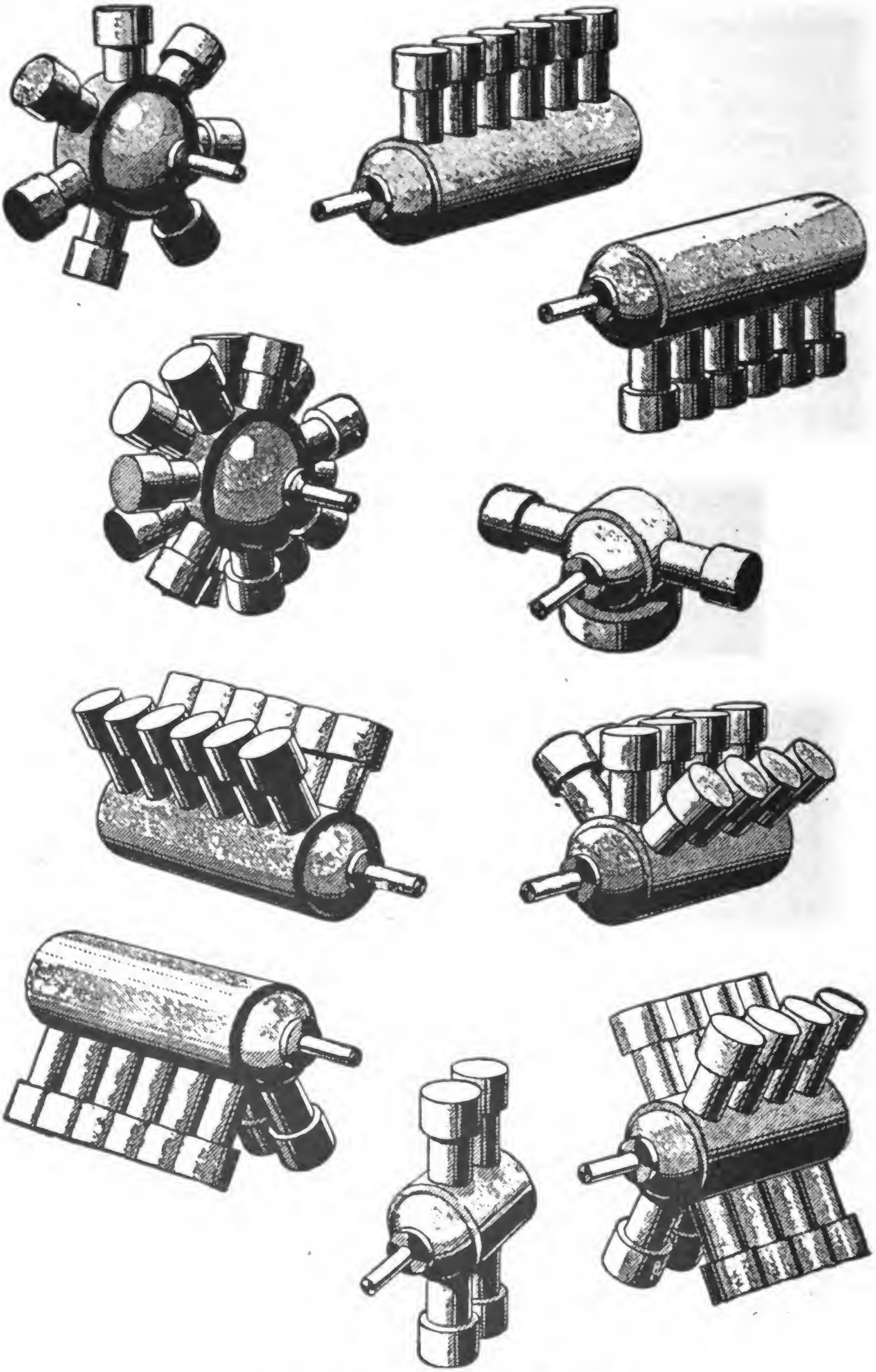
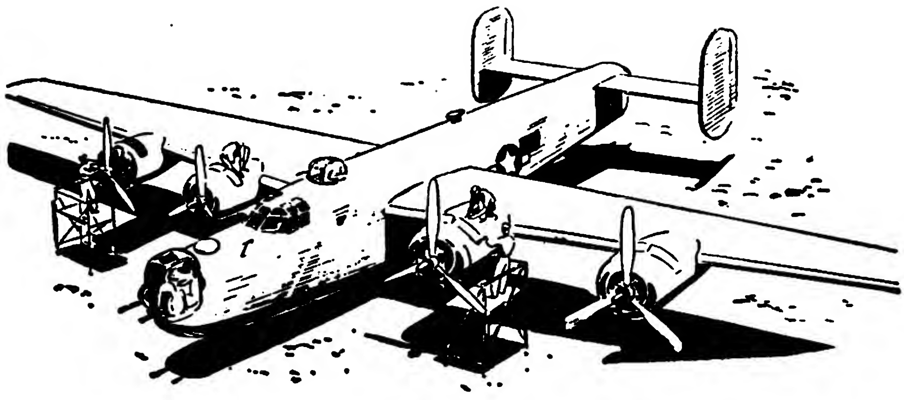


Figure 17.—Aircraft engine types.

the crankshaft. Sometimes you find the cylinders in a single vertical line. Sometimes they're in an **X**, a **W**, or a **V**. They may have two, three, or four banks of in-line cylinders. Certain in-line engines are cooled by air, but the majority are liquid-cooled. Figure 17 diagrams some of the cylinder arrangements used for in-line and radial engines.

Radial engines have their cylinders arranged in a circle around the crankshaft. Some have a single row of cylinders, while others are built with two or more rows. Radial engines are usually air-cooled, and have a natural advantage in weight because they don't have to carry a radiator full of liquid around with them.

Air-cooled radial engines predominate in the Navy's airplanes. The Army, however, uses liquid-cooled in-line engines to power a number of its craft. Both engines have advantages and disadvantages. Lightness is a factor favoring the air-cooled radial. In-line types are easier to streamline, and offer less resistance to the air.



CHAPTER 6

ENGINE SYSTEMS

WHAT THEY ARE

In any aircraft engine, old or new, there is a number of SYSTEMS that make it function. You have a MECHANICAL SYSTEM consisting of such parts as cylinders, pistons, connecting rods, and the crankshaft. You have a FUEL SYSTEM which feeds the mixture of gasoline and air into the cylinders. You have an IGNITION SYSTEM which controls the electrical spark and ignites the fuel mixture in the cylinders at just the right time. You have a LUBRICATION SYSTEM which oils the moving parts and keeps them running smoothly. And you have a COOLING SYSTEM which carries off the terrific heat generated by the engine in operation and prevents it from burning itself up.

MECHANICAL SYSTEM

A CYLINDER consists of two main sections—the BARREL and the HEAD. Both of these parts are covered with numerous COOLING FINS in air-cooled radial engines (which are the engines you are going to read about in this book because most Navy airplanes use radial engines). The cooling fins provide a large radiating surface so that the air can carry away the heat rapidly.

The EXHAUST and INTAKE valves are installed in the cylinder head, as are the SPARK PLUGS. Usually there are two spark plugs for each cylinder. Intake and exhaust PORTS provide the entrance and exit for charges of fuel and burned exhaust gases. The intake port is connected to the fuel induction system by means of the intake manifold. Exhaust ports are connected with the exhaust manifold, which collects the burned gases and passes them into the exhaust pipes.

A PISTON is a sort of metal plunger which forms the movable "end" of the cylinder and transmits

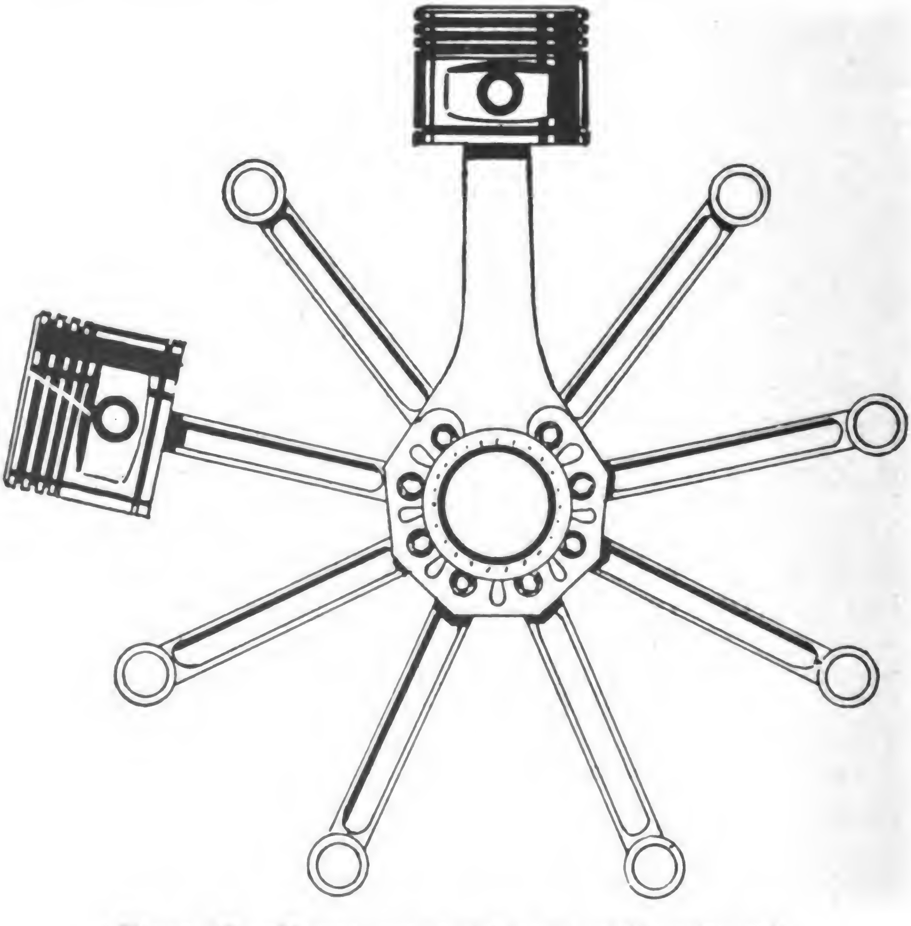


Figure 18.—Pistons, connecting rods, and master rod.

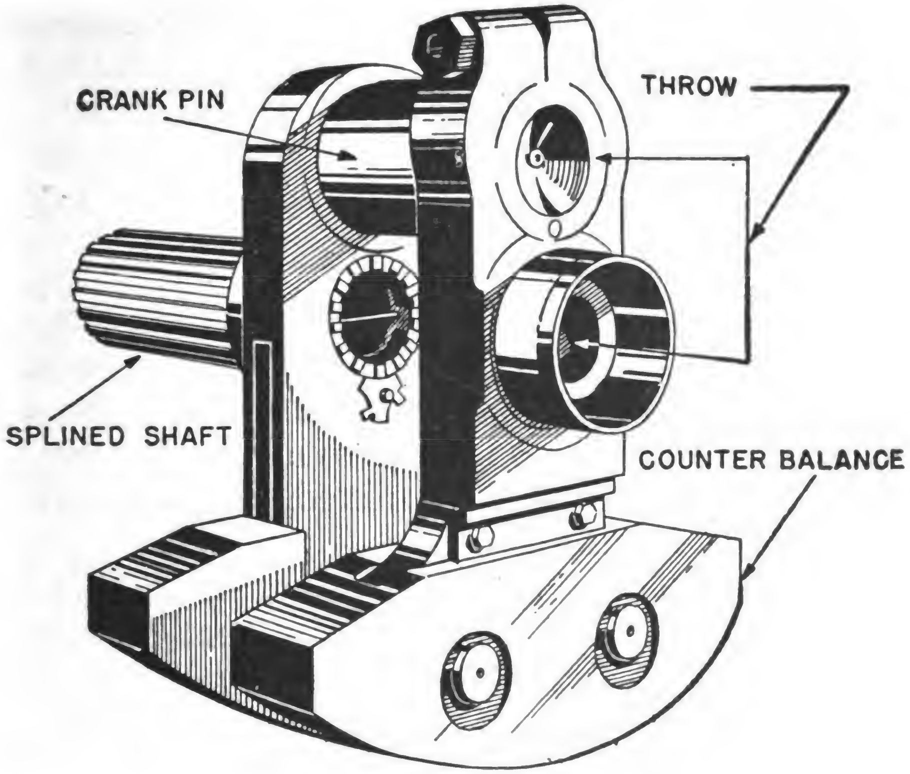


Figure 19.—Crankshaft.

the force of the expanding gases of combustion to the crankshaft by means of the CONNECTING ROD. The connecting rod is hitched to the piston by means of a WRIST PIN, and to the crankshaft (or to the master connecting rod, as the case may be) by a KNUCKLE PIN or by a BEARING. Figure 18 illustrates the relationship of these parts.

The CRANKSHAFT has one or more offset sections (depending upon the number of cylinder banks the engine may have) called THROWS. The round part of the throw to which the master connecting rod is attached is known as the CRANKPIN. To counteract the weight of the throw and permit the crankshaft to turn without jerking, a COUNTERBALANCE must be added to the opposite side of the crankshaft, as you see in figure 19.

The cylinders are fastened to a metal shell in which the crankshaft is housed. This shell is called the CRANKCASE, and is fitted with bearings which hold the crankshaft in position. Crankcases are usually made in several sections which are fastened together with bolts or studs.

FUEL SYSTEM

The FUEL SYSTEM includes the FUEL TANKS, the FUEL LINES (with their necessary pumps), various VALVES, STRAINERS, the SUPERCHARGER, and the CARBURETOR. Its basic job is to provide fuel in proper quantities, and correctly mixed, to the engine cylinders for burning.

In the simplest type of fuel system, the fuel flows from the tanks to the carburetor by GRAVITY. In other words, it just flows "down hill." This system, diagrammed in figure 20, would be the berries if it didn't mean that the tanks have to be fairly high ABOVE the engine to provide gasoline to the carburetor under pressure. Tanks, however, are usually in the airplane's wings. Actually, you rarely find gravity fuel systems in anything but small trainers.

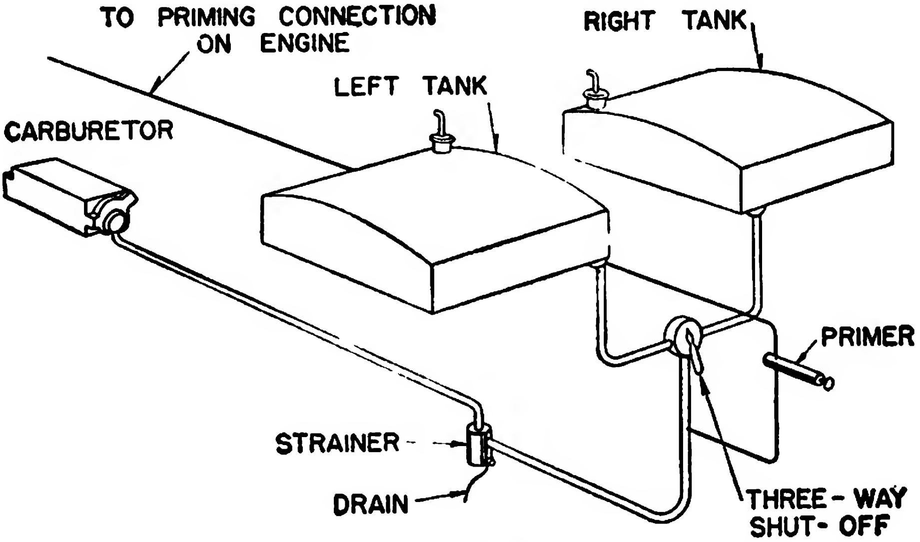


Figure 20.—Simple gravity fuel system diagram.

The majority of fuel systems include a MECHANICAL PUMP that supplies fuel from the tanks to the carburetor under pressure. With such a pump in the system, the tanks may actually be below engine level. Fuel comes from the tank through a SELECTOR VALVE and a STRAINER. Another item in this system is a hand pump—your old friend the WOBBLE PUMP. It supplies fuel under pressure to the carburetor for starting, since the mechanical pump doesn't function until the engine is running.

Sometimes, such as when the mechanical pump is out of commission, it may be necessary to pump all fuel by hand from tank to carburetor. It is hard to pump enough gasoline THROUGH the mechanism of the engine-driven pump by hand, so there is a BYPASS VALVE in the fuel line to carry hand-pumped fuel AROUND the engine pump in such cases.

Don't get the idea that mechanical fuel pumps are out of kilter half the time. Actually they're very reliable. Like any piece of machinery, however, they CAN go haywire, and need protection for such an emergency.

A mechanical fuel pump is operated by the engine. Generally it is mounted right on the crankcase and geared directly to the engine crankshaft. There are two kinds of engine-driven pumps—GEAR PUMPS and VANE PUMPS. The vane pump is most commonly used at present in service airplanes.

Too much pressure built up by a fuel pump can easily damage the carburetor, so a PRESSURE RELIEF VALVE is placed in the fuel line between the engine-driven pump and the carburetor. When a given fuel pressure is exceeded, the valve opens and some of the fuel flows into a return line and back to the tank.

The FUEL PRESSURE GAGE on the instrument panel is connected to the carburetor and tells you at all times just how much fuel pressure is being delivered to the carburetor. If the gage reading is lower than it should be, somebody better get busy and man the wobble pump or the engine will probably stop. It might not matter when you're on the ground, but an engine that stops during flight can be very disturbing to your mental health.

Most airplanes have two or more fuel tanks. One reason for this is the balancing of the airplane. As was pointed out before, fuel tanks are usually located in the wings. If only a single tank were used, the airplane would be "wing heavy" on one side. Also, it's WONDERFUL to have two or more tanks if one springs A LEAK.

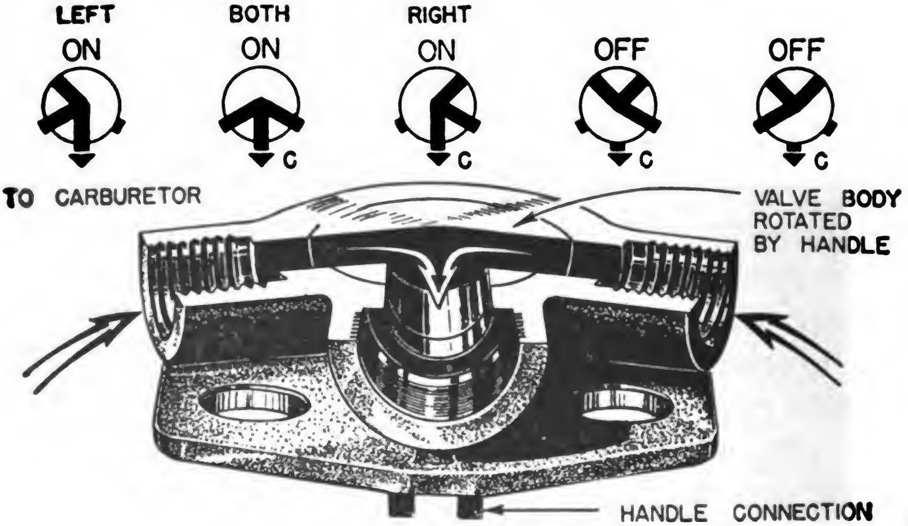


Figure 21.—Fuel selector valve.

Turning the SELECTOR VALVE to "on" position is the first step in starting an engine. There are several types of selector valves made, but all of them work in fundamentally the same way. The basic kind used with two-tank fuel systems is shown in figure 21, and has four "on" positions, marked "both," "right," "left," and "reserve."

The RESERVE position does not lead to a separate tank, but taps a lower section of one of the regular tanks. The reserve system is installed to ensure a supply of gas during take-off and landing, as well as to take care of pilots who RUN OUT OF GAS.

Fuel tanks are usually provided with a SUMP, which is a depression at the bottom of the tank to collect dirt or water and keep it from circulating into the fuel lines. The sump should be drained at regular intervals to dispose of collected foreign matter. The STRAINER, mentioned previously, is another device which prevents impurities from reaching the carburetor. It is a cup-like container, fitted with a wire screen which acts like a sieve and filters out solid particles.

The PRIMER is nothing more than a small pump. When the primer handle on the instrument panel is pulled back, fuel is drawn into the pump through its inlet valve. When the handle is pushed forward, the fuel is forced through an outlet pipe to the cylinder or intake manifold

In the CARBURETOR, gasoline and air are mixed in the proper proportions for the most efficient production of power. Gasoline alone won't even burn unless air is present to provide oxygen for the combustion process. However, if gasoline is broken up into extremely fine drops, as in a spray, and mixed with air, it will burn very rapidly. The purpose of the carburetor, then, is to convert liquid gasoline into the smallest particles possible, and to mix the particles with air.

There are three general types of carburetors. The SIMPLE FLOAT TYPE is used on small engines, such as those in some trainer planes. The DIAPHRAGM TYPE, an anti-icing variety, is used on larger engines. The INJECTION TYPE, also anti-icing, is likewise used on larger engines. Don't be confused because there are different types of carburetors. They ALL perform the SAME FUNCTION. Fundamentally, "it ain't what they do, it's the way that they do it" that makes them at all different.

Operating conditions make necessary some variation in the proportion of air to gasoline mixed by the carburetor, but on the average it will be about 15 parts of air to 1 of gasoline. Changes in this proportion can be made by adjusting the MIXTURE CONTROL HANDLE. A RICH mixture contains a higher proportion of gasoline to air. A LEAN mixture increases the percentage of air being mixed with a given amount of gasoline.

Since the air is thinner at high levels and consequently is at a lower pressure, changes in altitude have quite an effect on the normal carburetor mixture. Most airplanes, therefore, have an AUTOMATIC MIXTURE CONTROL UNIT which regulates the fuel-air mixture so that it reaches the engine in the same relative proportion regardless of the altitude and pressure of the atmosphere.

Mixture control alone, unfortunately, isn't enough to provide the means of obtaining sea-level horsepower at higher altitudes. The quantity, or weight, of air-fuel mixture that enters a cylinder with the intake stroke of the piston varies according to the density of the air. The weight of a given volume of air taken in at high altitude is LESS than it would be at lower levels. So, for high-level flying, it is necessary to FORCE a constant weight of air-fuel mixture into the cylinders in order to maintain the horsepower. This is done by means of a SUPERCHARGER.

A supercharger is essentially just a big air pump. The types in use at present are driven by gears from the crankshaft, or by a turbine operated by the pressure of gases from the engine exhaust line. They can be put in operation by the pilot at will. A TWO-STAGE supercharger is standard equipment on many modern military airplanes. One blower forces air into the carburetor. The other delivers air-fuel mixture to the cylinders, under pressure.

Often it's necessary to provide heated air for the carburetor to prevent the formation of ice under certain weather conditions. One method you'll find in use is that which draws air for the carburetor from BEHIND THE HOT ENGINE CYLINDERS. Another system draws air around the hot EXHAUST MANIFOLD before it enters the carburetor intake.

As you undoubtedly know, aircraft engines operate at extremely high temperatures. Aviators used to find that cylinder heads got so hot that engines kept running, or perhaps kicked backward, after the ignition switch was shut off. To correct this bad habit, carburetors are often equipped with an IDLE CUT-OFF, which will stop the flow of fuel to the engine. Obviously an engine, no matter how hot, can't keep running without fuel.

IGNITION SYSTEM

What makes the fuel burn, once it has been delivered to the cylinders? The answer is the IGNITION SYSTEM. Ignition, if you look in the dictionary, means "setting on fire." In airplane engines the "setting on fire" of the fuel is accomplished by the use of SPARK PLUGS and ELECTRIC CURRENT. You remember from the description of the four-stroke cycle that at the start of the power stroke an electric spark from the spark plugs ignites the fuel, which then expands by combustion and forces the piston downward in its cylinder.

All service types of engines use two spark plugs for each cylinder. One purpose of this DUAL IGNITION is to provide better combustion, as a charge of fuel mixture will burn more evenly if ignited at two points at the same instant.

Some airplanes use a battery system of ignition, much like that found in an automobile. But most airplane engines obtain ignition current from MAGNETOS. A magneto is a special type of electric generator which produces pulses of high voltage current that will jump across the gaps between the arc points of spark plugs.

To make a spark plug "spark" at the proper instant, there is a device called a DISTRIBUTOR in the electrical circuit connecting the magneto to the spark plug. A revolving arm, or ROTOR, of the distributor brushes past CONTACT POINTS in the distributor's outer shell, making a series of electrical contacts which allow a surge of current to travel to the spark plugs in proper firing succession and at just the right instant.

Most dual ignition systems require TWO magnetos. One spark plug in each cylinder of the engine is fired in turn by the first magneto. The other spark plug in each cylinder is fired by the second magneto. The distributors, of course, are timed so that electrical impulses are delivered to both spark plugs in a single cylinder at the same moment.

Magnetos, obviously, cannot furnish any current unless the engine is turning, since they depend on gearing from the crankshaft to make them work. Many airplanes, therefore, have small BOOSTER MAGNETOS installed in their engine ignition systems. These are geared to the starters so as to provide a spark when the starter is engaged and the main engine-driven magnetos are not turning at all, or when they are turning too slowly to provide a good hot spark.

LUBRICATION SYSTEM

If you want to see a veteran railroad trainman stew in his own juices, simply suggest to him that there's a "hot box" on one of his cars. Likely as not he'll jump to the emergency cord and bring the train to a lurching, grinding stop. A trainman knows only too well that a "hot box" can cause serious trouble, and no fooling. It means the axle of a wheel isn't properly LUBRICATED, and something has to be done about it—DOUBLE QUICK—or there may be a bad break-down.

Lack of lubrication between moving metal parts means trouble in almost any kind of mechanism, and an aircraft engine is no exception to the rule. Metal rubbing directly against metal results in excessive FRICTION. In turn, friction generates heat, which has a tendency to expand metal parts until they swell out of shape. Add together the grind of constant high-speed rubbing and the distortion caused by heat and the result, in a precision-made engine, is WRECKAGE.

By using a lubricant—OIL, if you prefer that word—metal surfaces that move in contact with each other are both coated with a thin ANTIFRICTION FILM. Between the two films, other layers of oil slide in microscopic drops like tiny ball bearings, protecting the metal surfaces from harm.

It is quite a problem to keep the rubbing metal surfaces in an aircraft engine supplied with all the oil they need. That's the job of the LUBRICATION SYSTEM. Some engine parts need only be kept COATED with oil, while other parts must constantly receive oil UNDER PRESSURE. Adequate lubrication can't be accomplished, therefore, merely by running around with an oil can and squirting a few drops here and there. Proper equipment to supply oil where it's needed during engine operation must be BUILT-IN as an integral part of the engine.

Automobile engines have WET-SUMP lubricating systems, which carry oil directly in the crankcase and have no need for external tanks. This arrangement isn't satisfactory for most aircraft engines, however. You can't, for example, carry very much oil in the crankcase of a radial engine without running the danger of flooding the cylinders. There's the same problem, too, in an inverted in-line engine where there are cylinders BELOW the crankcase. Diving and climbing would, in many airplanes, bring up similar problems—not to mention what would happen in case such an airplane was flying upside down.

You'll find that practically all aircraft engines are of the DRY-SUMP type. The principles on which both wet- and dry-sump engines function are the same except for the matter of oil storage, however. As you are most interested in modern airplane engines, this book will be limited to discussion of the dry sump.

You can divide the lubrication equipment of an airplane into the EXTERNAL SYSTEM and the INTERNAL SYSTEM.

The purpose of the external system shown in figure 22, is primarily to get the oil from the tank to the engine and back again. The internal system, which is entirely inside the engine, conveys oil to the specific parts that must be lubricated.

The OIL TANK of a dry-sump system must be large enough to hold all the oil necessary for normal engine operation. In addition, it must have extra space to allow for foaming and expansion of oil when heated. At the top of the tank you'll find a VENT PIPE which leads back to the engine crankcase so that any oil forced out of the tank by excessive foaming will be saved. As the crankcase is ventilated to the outside air through the CRANKCASE BREATHER, air is allowed to enter the oil tank through the vent pipe. Without such a means of letting in air, the oil wouldn't run out of the tank.

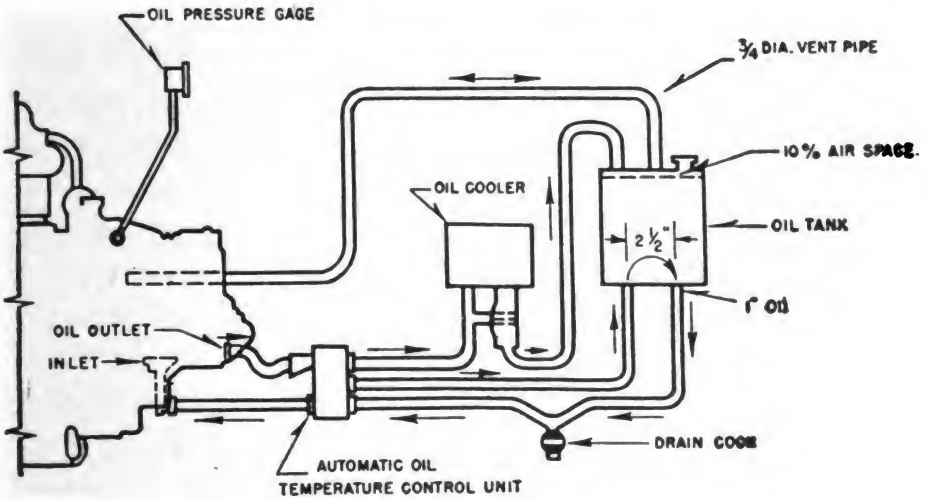


Figure 22.—External lubricating system.

Oil passes through a pipe from the engine to an automatic oil TEMPERATURE-CONTROL UNIT and from there into the tank. The temperature-control unit "decides," by means of a thermostatic valve or a viscosity valve, whether the oil returning from the engine is warm enough or cool enough for normal operation. If it is too warm, the oil is automatically passed through an OIL COOLER, which is much like a small automobile radiator. If, on the other hand, the oil is too cool (as when you're starting the engine), the temperature-control unit causes the oil to return to the tank through an inlet, very close to the tank outlet leading back to the engine. The engine heat thus keeps warming the same oil over again until it is at a proper temperature.

A powerful OIL SUPPLY PUMP, mounted on the crankcase, pumps the oil from the tank through the engine. Another kind of pump, called the SCAVENGER PUMP, is used to remove the oil from the engine and pump it back to the tank.

An OIL FILTER is built into many external oil systems in airplanes. As you would assume from its name, it is a device for cleaning the oil. There are several types of oil filters, but they all serve the same purpose—GETTING RID OF DIRT.

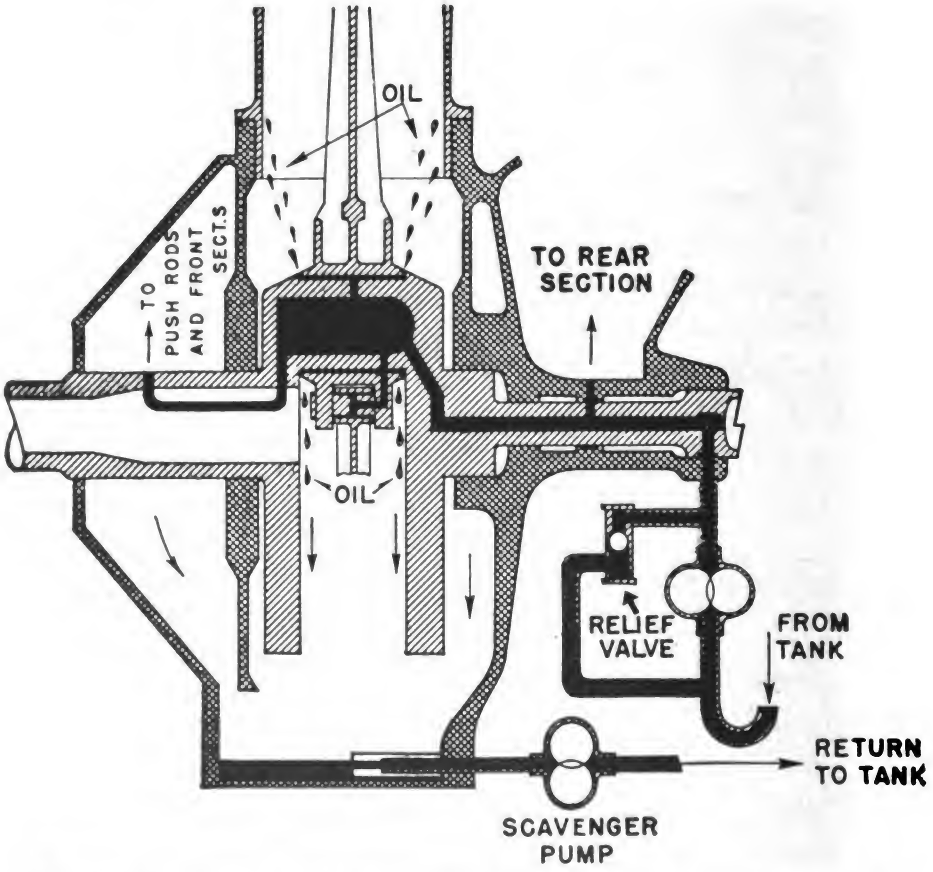


Figure 23.—Internal lubrication system (diagram) for radial engine.

The internal oil system is, for the most part, made up of a series of small channels and holes leading to the various parts of the engine and its accessories which need lubrication. If you study figure 23 for awhile, you'll see how the internal system works. The crankshaft, for example, is made hollow so it can carry oil under pressure to the various bearings on its surface. Holes drilled from its bearing surfaces to the hollow interior keep the bearings supplied with oil.

If oil is delivered to the engine under too much pressure, excess oil will squirt out into the crankcase and probably work up into the cylinders where it can foul the spark plugs or form an undesirable coat of carbon. The oil pressure, therefore, must be kept at a constant figure, and should not be permitted to get too high. An oil-pressure safeguard is provided by the RELIEF VALVE, which bypasses excess oil back to the tank inlet pipe and doesn't let it reach the engine.

COOLING SYSTEMS

When in operation, an aircraft engine is really "hot stuff." So hot, in fact, that it would burn itself up in no time if there weren't some sort of COOLING SYSTEM built into it to carry off most of the heat generated by the combustion of fuel in the cylinders.

You recall that aircraft engines are of two types—air-cooled and liquid-cooled—and that both types have points in their favor. Air-cooling an engine is a lot like using an electric fan to cool yourself off on a hot summer afternoon. Liquid-cooling an engine can be compared to hopping into a cool shower bath. Either way—you HELP TO BEAT THE HEAT.

An airplane carries its own fan—the PROPELLER—around with it. Cool air from the propeller stream—plus the air blast created by the motion of the airplane in flight—if steered directly into contact with the hot cylinders, provide an effective means of getting rid of engine heat. The more cylinder surface you have exposed to the blast of air, the better the cooling process works. That is one of the main reasons for having the cylinders of an AIR-COOLED engine project out from the crankcase—so the air can get at them. And that is the reason for putting COOLING FINS on air-cooled engine cylinders and cylinder heads—to increase their radiating surface.

Several other devices are usually provided to increase the efficiency of air-cooling systems. If there is more than one row of cylinders in a radial-type air-cooled engine, AIR DEFLECTORS, or "baffles," are often installed to direct a sufficient flow of air to the rear row of cylinders. The collar-like COWLING around the engine is also a big help, as are the COWL FLAPS, which provide airflow control. Figure 24 shows you these two devices.

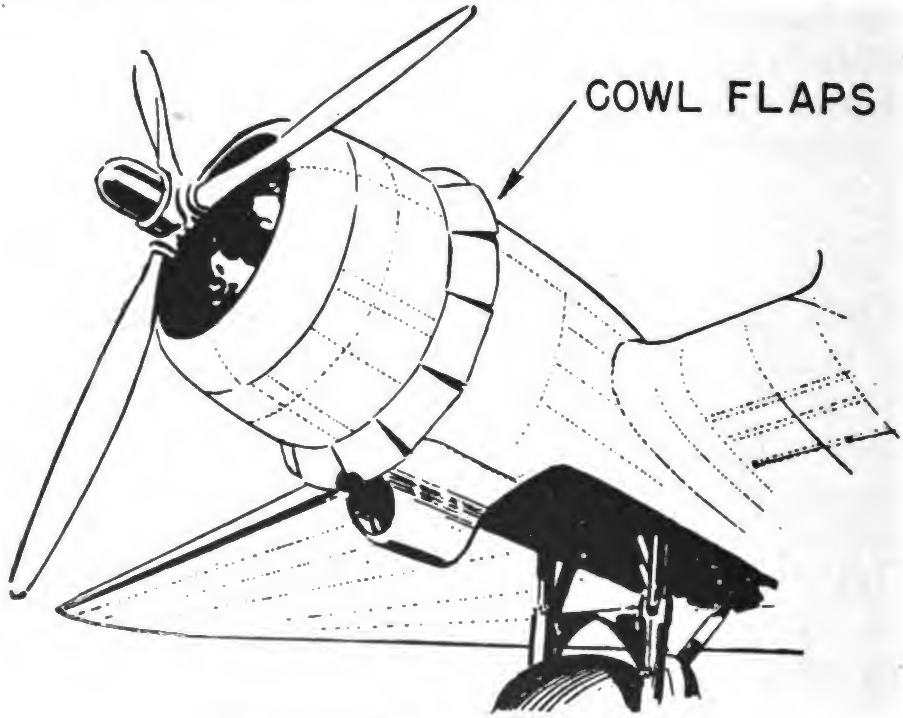


Figure 24.—Engine cowling and flaps.

You can check on the operating temperature of an air-cooled engine by readings from a dial on the instrument panel in the cockpit. The apparatus which operates the dial is called a THERMOCOUPLE, and is connected directly to one or more of the engine cylinders.

A liquid-cooled engine also depends on the airstream from the propeller to keep its temperature down to normal. Instead of flowing over the cylinders, however, the air passes through a LIQUID-FILLED RADIATOR. The individual engine cylinders are surrounded with WATER JACKETS in which the coolant (the cooling fluid) circulates. The water jackets are connected to the radiator by a system of plumbing (including pipes, flexible hose connections, and drain plugs).

The radiator itself is made up of a network of small tubes through which the coolant is made to flow by means of a pump. An auxiliary EXPANSION TANK, controllable RADIATOR SHUTTERS and other attachments are frequently included in liquid-cooled systems.

Some progress has been made recently in the development of AIR-COOLED IN-LINE ENGINES for airplanes. They combine the light weight of the air-cooled engine with the smaller frontal area of an in-line engine, and are now installed in some Naval airplanes. Their efficiency depends on the principle of PRESSURE COOLING. An air chamber is provided adjacent to the cylinders, with its open end facing forward. The forward velocity of the airplane, as well as the fan action of the propeller, build up air pressure in this chamber. The air escapes between the cylinders, and its flow is controlled by BAFFLES, an AIR SCOOP, and COWL FLAPS.

CHAPTER 7

PROPELLERS

WHAT THEY ARE

An engine is installed in an airplane for one main purpose—to spin the PROPELLER. Don't for a moment get the idea that this is a menial or degrading task beneath the dignity of such a roaring giant as a modern airplane power plant. After all, the propeller is a mighty important piece of equipment itself. What's more, without teamwork between the engine and the propeller, your airplane would be as much a landlubber as a mummy in a museum.

If you take a look at the blades of an electric fan, you'll see a basic resemblance to the blades of a propeller. Notice that the fan blades CURVE slightly from edge to edge and are fastened to the hub of the fan at a SLANT. The curvature (or camber) of each blade makes it look very much like a THIN AIRPLANE WING. And the slant at which the blade is set into the rotating hub determines its "angle of attack."

But such statements indicate that propellers are like ROTATING AIRPLANE WINGS. And that's absolutely RIGHT!

When the engine turns a propeller, what happens? Simply this—

Relative motion is set up between the wing-like propeller blades and the air. These blades, which are really a series of airfoils, set up a "lift" action similar to that of a wing moving through the air. Of course, this lift is actually a PULL or a PUSH because the propeller blades operate in a direction at about RIGHT ANGLES to the wing.

Naturally, as the propeller pulls or pushes itself through the air, it also carries along anything that happens to be hitched onto it—such as the engine and the rest of the airplane. You can readily see how important it is to have propellers attached securely to their engines—and engines fastened firmly to the airplane.

Although the primary function of a propeller is to make the airplane move forward through the air, there are some important secondary functions. The propeller helps to set up the air blast required for cooling the engine cylinders or radiator. And in tractor-type airplanes (those which have their propellers in front of the wings) the propellers help to furnish a relative wind to assist the wings in lifting.

Propellers are made with from one to four blades. One-bladed propellers are rare, but have been tried experimentally. The two-bladed type is the most common except on large transports and bombers, which usually have three-bladed propellers. The first airplane propellers were made of wood, and even today wooden propellers are found on some small engines. Most airplanes of modern manufacture, however, are equipped with METAL propellers of either forged aluminum alloy or steel construction.

A propeller must be capable of withstanding severe stresses, which are greatest near the HUB.

These stresses are caused by CENTRIFUGAL FORCE, which tries to make a spinning blade pull away from the hub; by TORQUE or twist; and by the THRUST, which tends to bend the blade forward. Propellers must be rigid enough to prevent a type of vibration known as FLUTTERING, in which the ends of the blades twist back and forth rapidly. Fluttering is likely to weaken a blade, and can cause fatigue failures. In turn, failure of a propeller blade is likely to wreck the engine.

HOW THEY WORK

For reasons you have already learned, a turning propeller tends to move forward through the air. Its actual motion with respect to the air is somewhat like that of a screw being driven into a block of wood by means of a screwdriver. If the air were a solid medium like wood, the distance that a propeller would move ahead through the air during each revolution is called the GEOMETRIC PITCH of the propeller. Actually, since it is turning in air instead of wood, a propeller does not move ahead quite as far as it would in a solid medium. The distance it actually moves is known as the EFFECTIVE PITCH. The difference between geometric pitch and effective pitch is called the SLIP. Figure 25 diagrams the difference between geometric pitch and effective pitch.

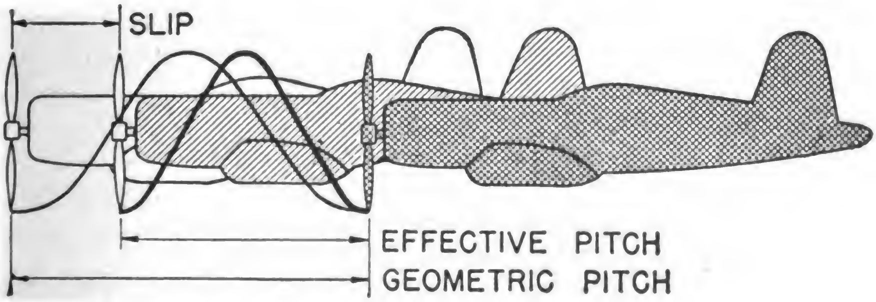


Figure 25.—Geometric pitch vs. effective pitch.

One arm, or "limb," of a propeller, from the center to the tip, is called a BLADE. The surface of the blade which corresponds to the top surface of an airfoil (that is, the surface that first greets new air) is known as the BLADE BACK. The surface facing to the rear is the BLADE FACE. The central portion of the propeller which is fitted to the crankshaft and carries the blades is called the HUB. The thickened portion of the blade near the center of the propeller is referred to as the blade ROOT. The portion of the blade farthest from the hub is the TIP.

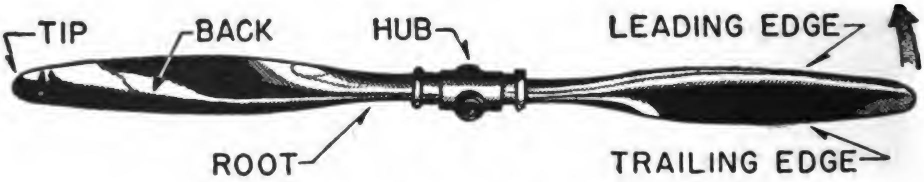


Figure 26.—Parts of the propeller.

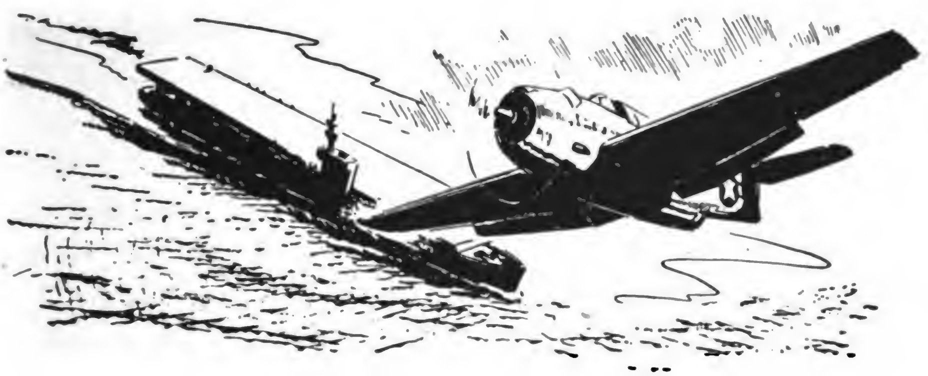
Figure 26 shows you a propeller with its parts labeled.

PROPELLER TYPES

Many different types of metal propellers are in use today. The simplest form is the one-piece type, which is forged and machined out of a single piece of aluminum alloy. Another relatively simple type is made with a steel hub, having aluminum blades fastened to it.

More complex propellers incorporate mechanisms which make it possible to change or adjust the pitch of the blades. It has been found that, when an airplane is moving at relatively low speed during take-off and climb, the pitch of the blades should be LOWER (permitting more revolutions per minute) than during level cruising flight. The TWO-POSITION CONTROLLABLE-PITCH PROPELLER was designed to accomplish shifts to high pitch during flight. Only high and low pitch adjustments are possible with this mechanism.

Often, of course, you want to use a pitch in between these two extremes. The CONSTANT SPEED PROPELLER makes it possible to obtain many pitch settings. Constant-speed propellers are operated either by electricity or by oil pressure and, within reasonable limits, keep the blades at the proper pitch angle for whatever maneuver the airplane is called upon to make. Some constant-speed propellers have a further refinement which permits alinement of the blades with the direction of flight, so that if one engine stops, you can prevent its propeller from "windmilling." Propellers with this feature are designated as FULL-FEATHERING propellers.



CHAPTER 8

NAVAL AVIATION

FORWARD FROM FORT MYER

In 1908, the Wright brothers demonstrated a new flying machine to a board of military officials gathered at Fort Myer, Va. The NAVY DEPARTMENT detailed two officers to report on the demonstration. They officially recommended that an airplane equipped with floats be tested in operations from the water.

That was the real beginning of NAVAL AVIATION. In 1910, Capt. W. I. Chambers approached the Wrights with a proposal that they fly an airplane from the deck of a battleship. The Wrights, however, believed that such a venture was too hazardous and declined the invitation.

Meanwhile, in a bicycle shop at Hammondsport, N. Y., Glenn H. Curtiss was busy building engines for bicycles. The light-weight Curtiss bicycle engines attracted the attention of a California airship builder who was up against apparently unsolvable engine difficulties. This chap made a deal with Curtiss to produce engines for his motor balloons. This was the beginning of Glenn Curtiss' interest in aviation. In due time he produced an AIRPLANE all his own—the "Junebug." It was followed by other successful airplanes of Curtiss design, and Curtiss soon was known throughout the world as a leading figure in aviation.

Captain Chambers proposed that Curtiss arrange a demonstration flight from a battleship deck. Curtiss, answering opportunity's knock, agreed to try. The U. S. S. *Birmingham,* then lying at Hampton Roads, Va., was chosen for the trial. A 60-foot wooden platform was constructed on her bow to provide a take-off runway.

Picked by Curtiss for this important task was a pilot named Eugene Ely. In November 1910 he gave his airplane the gun on the *Birmingham's* deck, roared down the platform and calmly flew to TERRA FIRMA—dry land to you.

Opportunity had not gone begging. Sensing the favorable impression Ely's flight had made, Curtiss lost no time in offering to teach a Naval officer to fly. The Navy responded by ordering Lt. T. G. Ellyson to report to the Curtiss camp.

Before enthusiasm could cool off, Curtiss also cooked up another demonstration with even more punch to it than the first. Taking off from the Presidio in San Francisco, Pilot Ely flew to the U. S. S. *Pennsylvania,* at anchor in the harbor, and landed aboard a 120-foot platform on her deck. Later he turned about, took off, and flew back to shore.

OF WHAT USE was the airplane to the Navy? That was a fair question. To be useful, the airplane should IMPROVE rather than lessen the efficiency of a fighting ship. The platform on the *Pennsylvania* INTERFERED with the normal operation of some of her guns, making them useless for action.

The Secretary of the Navy informed Curtiss that the airplane would be useful only when it could fly alongside a battleship, alight on water, and be HOISTED ABOARD without using any false deck. With Lieutenant Ellyson's help, the Curtiss organization built, tested, and discarded float after float in an effort to find suitable methods for airplanes to alight on water. In January 1911 a floating airplane was ready. It flew out to the *Pennsylvania* and was hoisted aboard. Later when lowered again to the water by crane, the seaplane was flown back to shore.

Here was something the Navy COULD use. Captain Chambers was detailed to the Bureau of Navigation (now Bureau of Naval Personnel) to devote all his time to the establishment of a NAVAL AVIATION SERVICE. He went after more airplanes and pilots. A camp was established near Annapolis, Md., and the first Naval aviation organization began functioning. By 1912 the Navy boasted 10 pilots and 3 airplanes.

Progress continued slowly until war came to America in 1917 and brought the Navy face to face with the problem of IMMEDIATE expansion. One air station, 38 Naval aviators, 163 enlisted men, 54 airplanes—that was Naval aviation when America entered World War I. More . . . MORE . . . MORE, airplanes were needed. The Navy built its own aircraft factory at the Philadelphia Navy Yard. In terms of World War I requirements it did a bang-up job.

At the time of the Armistice, 183 twin-engine flying boats had been delivered by this factory. In addition, 21 Naval Aviation Schools and stations were in operation, 22 aviation bases had been established abroad, and 2,107 airplanes, 2,049 officers, and 43,452 enlisted men were attached to the Navy's air arm.

Just as the war ended, Curtiss delivered four large four-engine flying boats to the Navy. They comprised the later-famous "NC" Division. In

May 1919 the NC–1, NC–3, and NC–4 flying boats took off from Newfoundland for Europe. Heavy fogs made it necessary for the NC–1 and NC–3 to come down near the Azores. But the NC–4 MADE IT! With Lt. Comdr. A. C. Read in charge, it reached the Azores a day after the Newfoundland take-off and proceeded thereafter to Portugal and England. It was the FIRST AIRPLANE TO FLY ACROSS THE ATLANTIC!

The production of new airplane types fell off during the decade following the war. But the Navy made strides in the air, nevertheless. The AIRCRAFT CARRIER was developed. In 1921 an act of Congress authorized the establishment of the Navy's BUREAU OF AERONAUTICS. President Harding named Rear Admiral W. A. Moffett as its first chief. In the years that followed, Naval aviation compiled an impressive list of aviational FIRSTS, and developed countless improvements in the techniques and machinery of military flying.

Today the soundness of the Navy's planning is being proved in all theaters of combat. Naval aviation has MET THE TEST, and will continue to meet it. Its success could not have been the product of haste and sudden necessity, however. In point of fact, it has been the result of the Navy's dissatisfaction with things that were merely "good enough," and the pioneering spirit that such dissatisfaction engendered.

It was Uncle Sam's Navy—YOUR Navy—that first brought out the dive bomber, the torpedo bomber, and the catapult used for launching seaplanes from the decks of cruisers and battleships. It was YOUR Navy that fostered the development of the air-cooled radial engine which has now reached such high stages of perfection. And it was YOUR Navy that insisted on the inclusion of heavy firepower, heavy armor, and self-sealing gasoline tanks in its airplanes for the protection of pilots and crews.

DESIGNATION SYMBOLS

Naval aircraft are divided into a number of classes, according to the missions they are designed to perform. A system of symbols has been worked out to make it simpler for you to identify these classes.

Each general classification of aircraft has its own designation in the Navy.

"V" DESIGNATES HEAVIER-THAN-AIR CRAFT.
"Z" DENOTES LIGHTER-THAN-AIR CRAFT.
"VL" IDENTIFIES GLIDERS.
"VH" DESIGNATES HELICOPTERS.

The mission for which each craft has been designed is indicated by the addition of another letter or, in cases where it performs two functions, by two letters. Where two letters are used, the first indicates the primary function and the other denotes the secondary function. Such mission-identifying letters follow the general aircraft designation.

Ambulance	VA
Bombing	VB
Fighting	VF
Observation	VO
Patrol	VP
Scouting	VS
Torpedo	VT
Training	VN
Transport (multi-engine)	VR
Transport (single-engine)	VG
Utility	VJ
Bombing-Torpedo	VBT

Observation-Scouting	VOS
Patrol-Bombing	VPB
Scout-Bombing	VSB
Scout-Observation	VSO
Scout-Training	VSN
Torpedo-Bombing	VTB
Utility-Transport	VJR

When you're referring to an individual model of any class of airplane, you add on a number identifying the model (unless it is the first model), a letter indicating the manufacturer, and a dash followed by a number denoting the modification of the model. The letter "V" at the beginning is omitted. Thus, the airplane known as PB2Y–2 tells its story right in its symbols. The letters and numbers indicate that it is a patrol bomber, the second model made by Consolidated-Vultee Aircraft Corp. (for which company the symbol "Y" is used), and that the airplane model in question has been modified to some degree from the original design.

Naval aircraft manufacturers are designated by the following letters.

A—Brewster Aeronautical Corp.
    Allied Aviation Corp.
B—Beech Aircraft Company.
    Boeing Aircraft Company.
    Budd Manufacturing Company.
C—Curtiss Airplane Div. (Curtiss-Wright Corp.).
    Culver Aircraft Corp.
    Cessna Aircraft Corp.
D—Douglas Aircraft Company, Inc.
    Radio Plane Corp.
    McDonnell Aircraft Corp.

E—Gould Aeronautical Corp. (Division of Pratt, Read & Co., Inc.).
Piper Aircraft Corp.
F—Grumman Aircraft Engineering Corp.
Fairchild Aircraft Corp. (Canada).
Columbia Aircraft Corp.
G—Goodyear Aircraft Corp.
H—Howard Aircraft Company.
Hall Aluminum Company.
J—North American Aviation.
K—Fairchild Aircraft Corp. (U. S. A.).
L—Bell Aircraft Corp.
Langley Aviation Corp.
M—Glenn L. Martin Company.
General Motors Corp., Eastern Aircraft Div.
N—Naval Aircraft Factory.
O—Lockheed Aircraft Corp.
P—Piper Aircraft Corp. (Glider).
Q—Bristol Aeronautical Corp.
Stinson Aircraft Corp.
R—Interstate Aircraft & Engineering Corp.
American Aviation.
Brunswick-Balke-Collender.
Aeronca Aircraft Corp.
Ryan Aeronautical Company.
S—Sikorsky Aircraft (Division of United Aircraft Corp.).
Stearman Aircraft (Division of Boeing Aircraft Company).
Schweizer Aircraft.
T—The Northrop Corp. (Douglas Aircraft Company, Inc.).
Taylorcraft Aviation Corp.
Timm Aircraft Corp.
U—Chance-Vought Aircraft (Division of United Aircraft Corp.).

V—Vultee Aircraft, Inc.
Vickers, Ltd.
Vega Aircraft Corp.
W—Canadian Car and Foundry.
Waco Aircraft Company.
X—Experimental.
Y—Consolidated-Vultee Aircraft Corp.

MEET THE AIR FLEET

How does the Navy's air fleet stack up in this war?

It's TOPS!

In each major combat type—fighters, dive bombers, and torpedo planes—the Navy has airplanes far superior to corresponding types with which it fought so successfully during even the earlier months of the war. These new types have increased the advantage over the enemy in those crucial split-seconds of action that spell the difference between victory and defeat. They have more power, more speed, more range, than any comparable airplanes yet seen in action.

Similar improvements in the Navy's patrol, transport, scouting, and cargo planes give the good men in these important branches of the service greater and greater assistance in carrying out their vital missions.

Turn the page and meet the AIR FLEET—some of the outstanding airplanes of Naval Aviation.

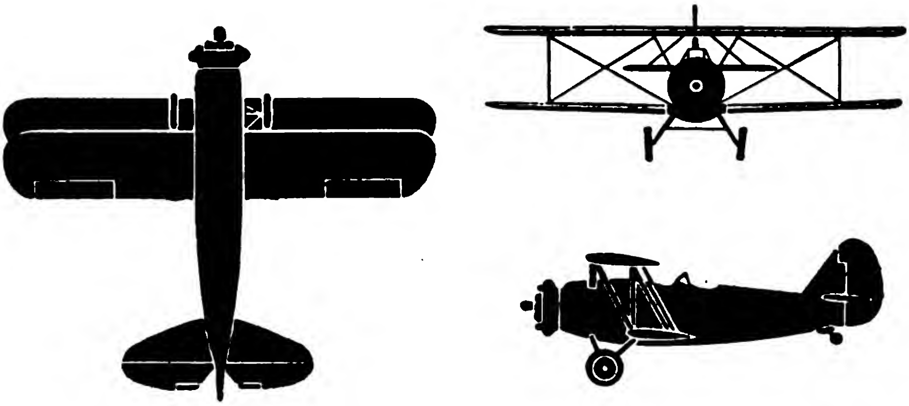
N3N—THE "YELLOW PERIL"

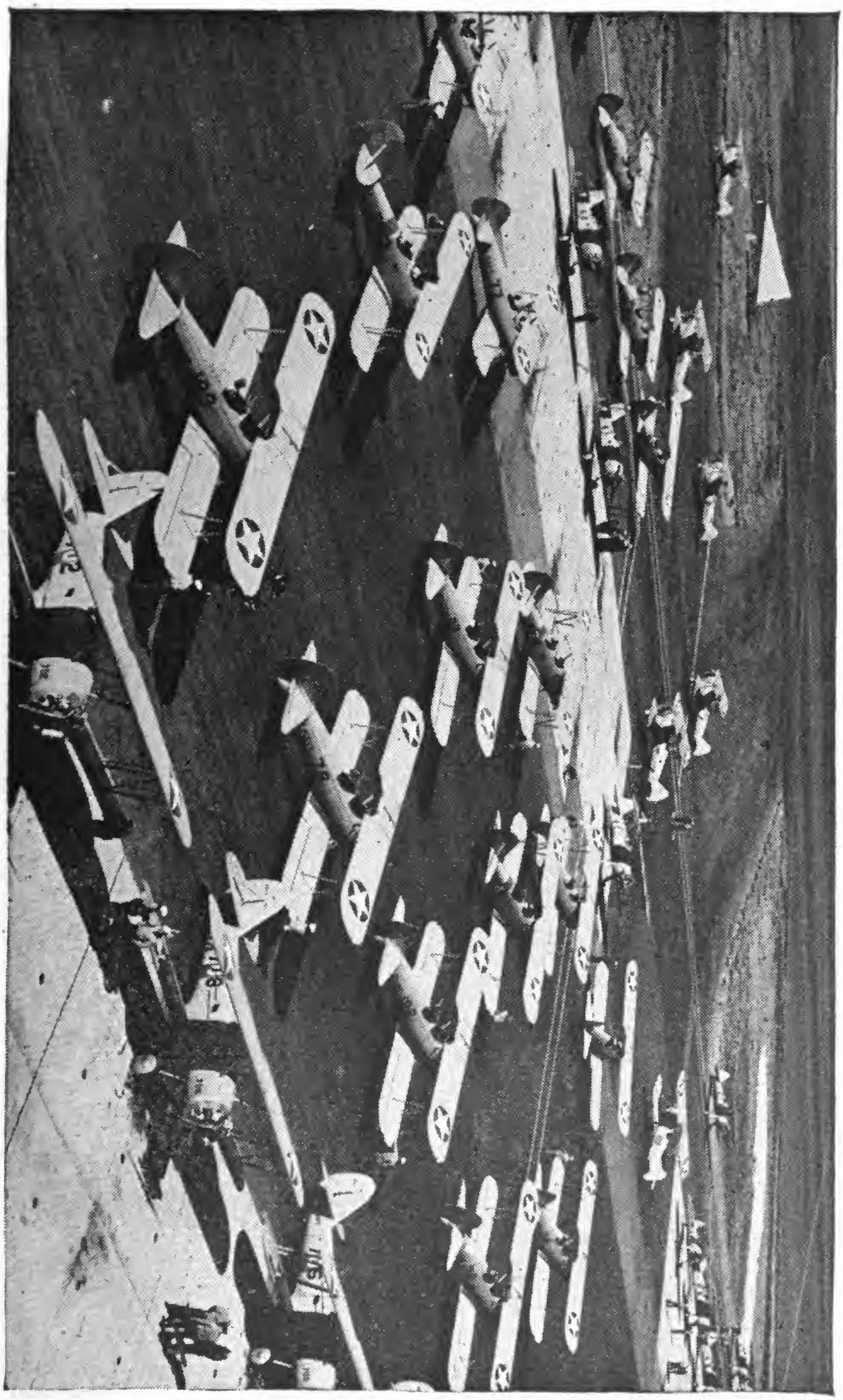
Naval Primary Trainer
Wheel or float landing gear
Biplane
Radial engine (1)

Tough and rugged, built to stand all the normal punishment a tenderfoot aviation cadet will give it, the "Yellow Peril" is a familiar sight at all Naval primary training bases. In the N3N the cadet learns the basic fundamentals that the Navy believes to be the foundation of a super-airman.

N3N trainers are built at the Naval Aircraft Factory. They can be equipped with either wheels or floats for landing. A Wright R–760 radial engine provides the power.

The "Yellow Peril's" upper wing is of the parasol type. Its cockpits are fitted with dual controls, and are of open construction. Fixed wing floats outboard of the wing struts are part of the standard equipment when N3N is fitted for landing on the water.





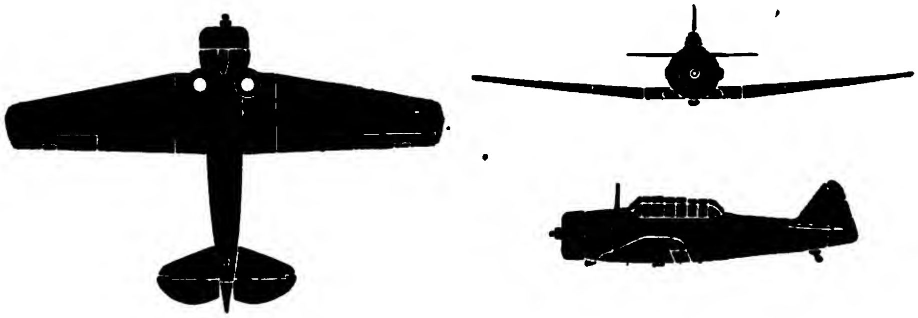
SNJ—THE "TEXAN"

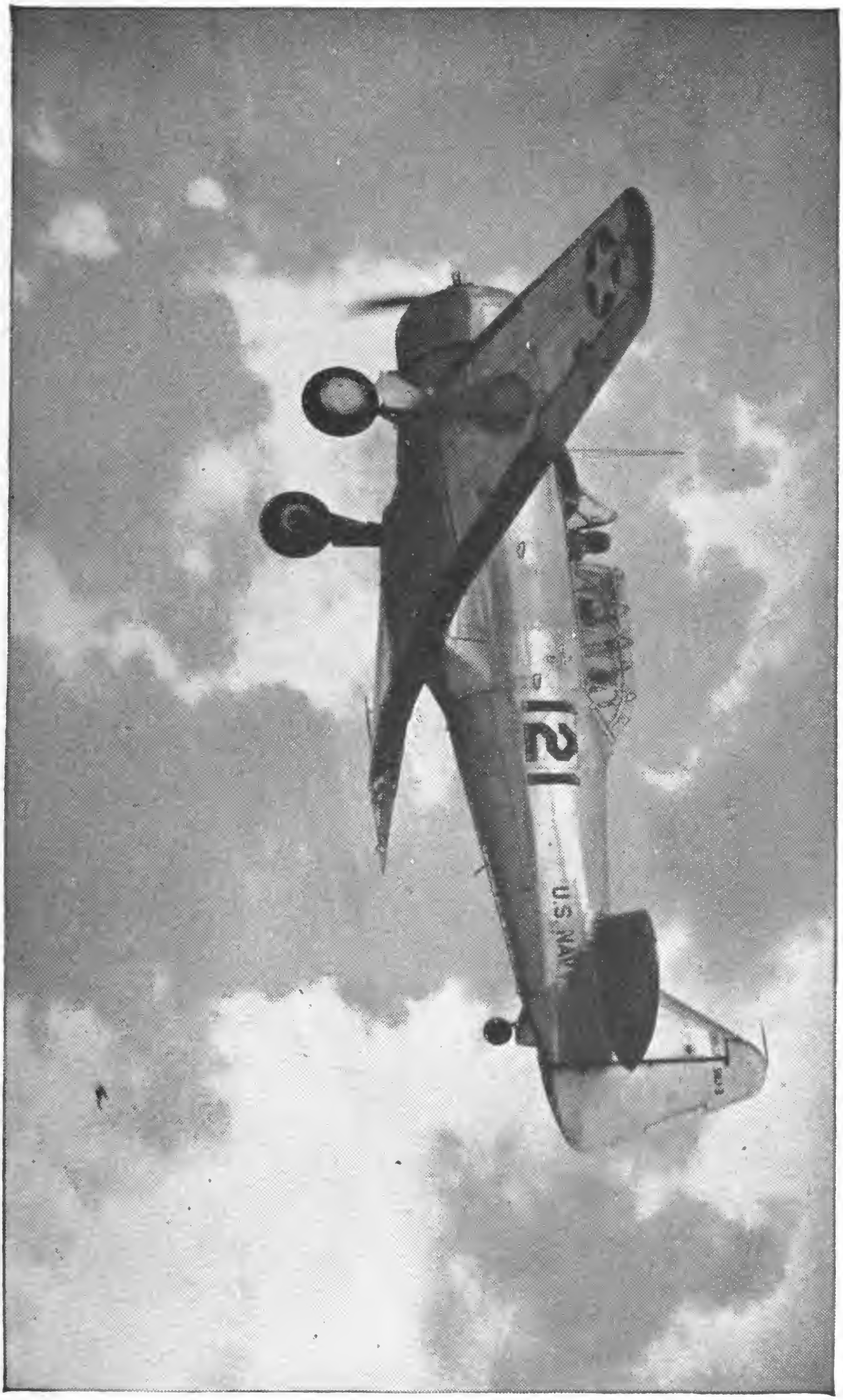
North American Advanced Trainer
Land-based
Low-wing monoplane
Radial engine (1)

When an aviation cadet successfully completes his basic primary training, he "graduates" to such service-type trainers as the SNJ. The "Texan," one of the most commonly used intermediate trainers, introduces the cadet to the more specialized flying he must learn before handling actual combat craft.

Power for the "Texan" is provided by a single Pratt & Whitney R–1340 radial engine, which gives it much higher performance than primary trainers.

You can recognize the SNJ by its dihedral swept-back wing, its triangular single fin and rudder, and its retractable landing gear. In general, this airplane resembles a fighter, and has most of a fighter's features.

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U.S. NAV

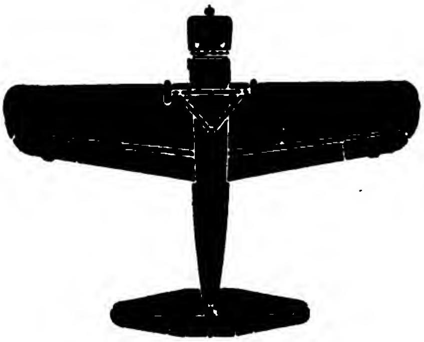
OS2U—THE "KINGFISHER"

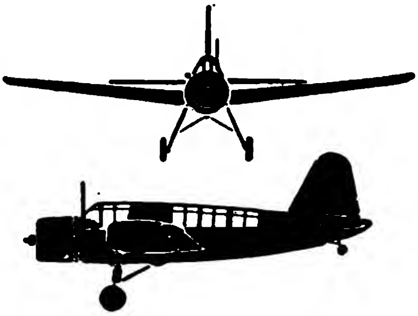
Chance-Vought Observation Scout
Land- or ship-based
Low-wing monoplane
Radial engine (1)

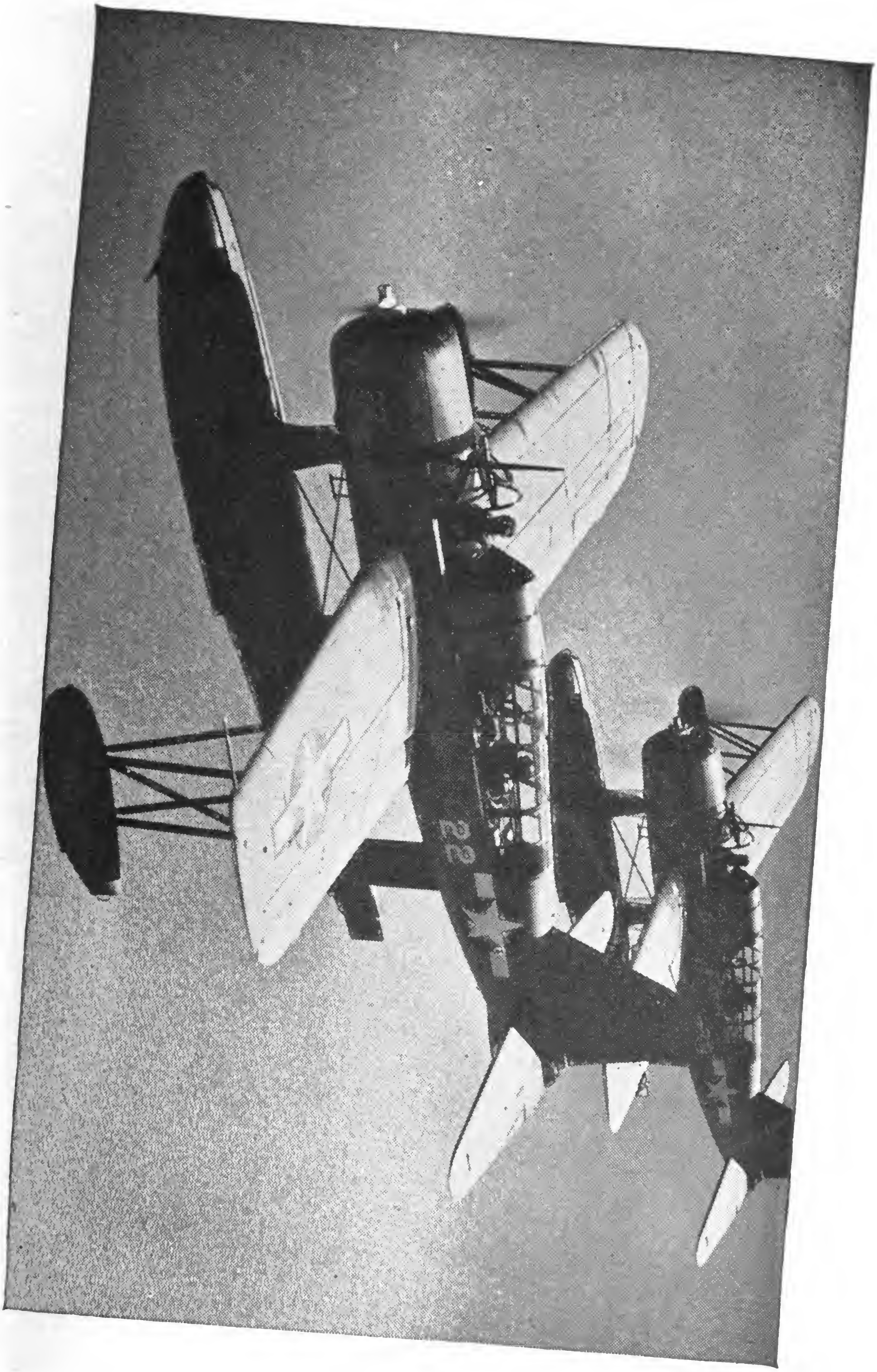
Often called "the eyes of the Navy," the "Kingfisher" has one principal function—to spot gunfire for the fleet. Some airplanes of this model are equipped with wheels for scouting operations from land bases. Others are fitted with a single float for use when this airplane is catapulted from battleships or cruisers.

The OS2U is powered by a Pratt & Whitney R–985 radial engine, and carries a two-man crew. Its top speed is around 175 miles per hour, but the type of work for which it was designed does not require high speed.

Notice that its wing has a straight leading edge and a tapered trailing edge. The long, high cockpit enclosure—"greenhouse"—extends nearly to the tail. The tail fin and rudder are tall and triangular. The landing gear is fixed.







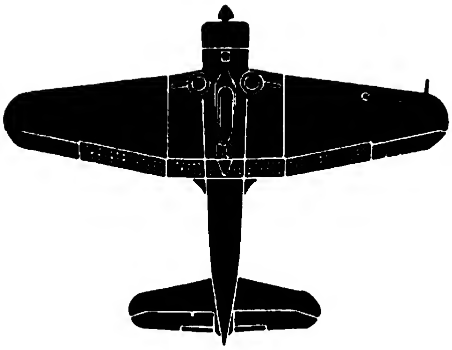
SBD—THE "DAUNTLESS"

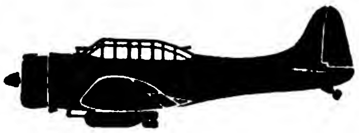
Douglas Scout Bomber
Carrier-based
Low-wing monoplane
Radial engine (1)

One of the most rugged airplanes ever built, the "Dauntless" literally has "nine lives" in combat service. Its exploits in action—such as its many conquests in the Coral Sea battle and at Midway—speak for themselves. A 1,000-pound bomb is carried in a cradle under its center section, and bomb racks are also fitted under the wing roots.

The "Dauntless," powered by a single Wright R–1820 radial engine, will develop a speed of about 250 miles per hour in level flight. It was long considered to be the finest carrier-based dive bomber in the world.

You'll remember the "Dauntless" in your mind's eye by its perforated wing flaps, rounded wing tips, and the prominent undercurve in its fuselage. The trailing edge of the wing is gracefully streamlined into the tapering fuselage.





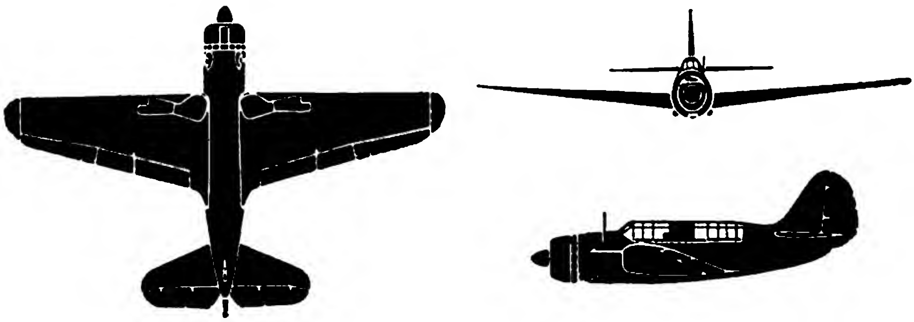
SB2C—THE "HELLDIVER"

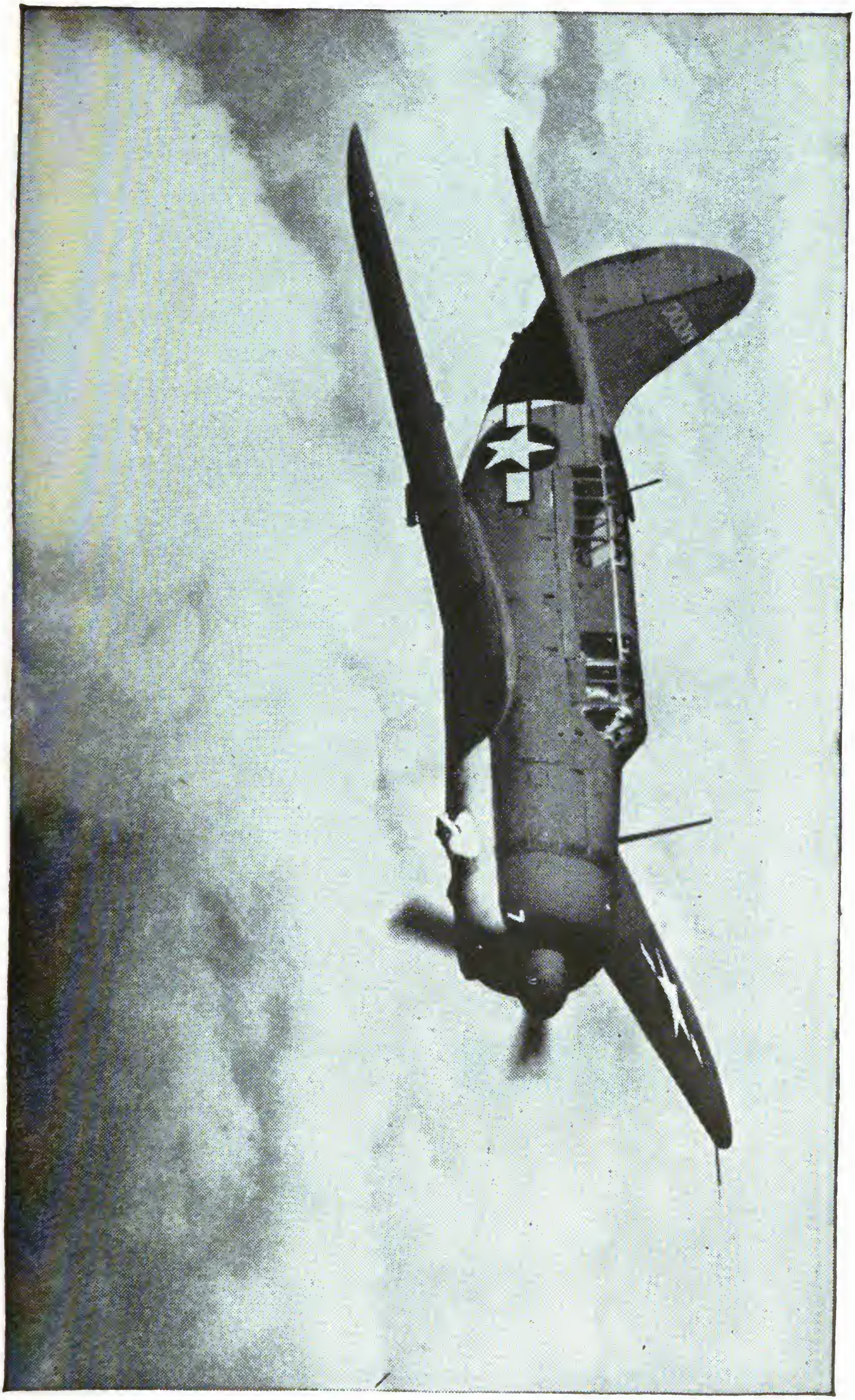
Curtiss Dive Bomber
Land- or carrier-based
Mid-wing monoplane
Radial engine (1)

Designed to carry torpedoes, depth charges, or large bombs, the "Helldiver" can be operated either from carriers or from land bases. Some models of this airplane, in fact, are equipped with twin-float landing gear.

The "Helldiver," many fliers believe, is one of the world's deadliest dive bombers. It is faster and probably carries heavier bomb loads than the German "Stuka." It is one of the largest single-engine airplanes in operation.

The wings have full dihedral, and the sharply-tapered trailing edge is faired into the fuselage. The fin has pronounced taper along its leading edge. Power is supplied by a single Wright R–2600 radial engine, and the airplane is capable of level flight at speeds over 300 miles per hour.



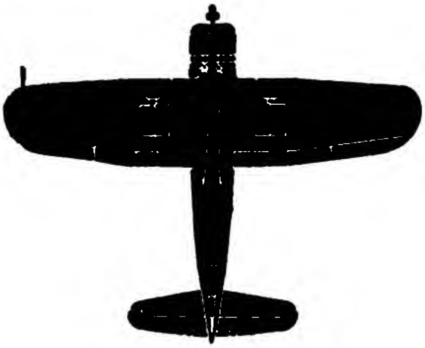


F4U—THE "CORSAIR"

Chance-Vought Fighter
Carrier-based
Low-wing monoplane
Radial engine (1)

One of the fastest carrier-borne fighter airplanes in the world today, the F4U "Corsair" is capable of speeds well over 365 miles per hour. It is powered by a single Pratt & Whitney R–2800 radial engine. The large inverted gull wing was designed to give added clearance for the long propeller blades which are required to absorb the output of the power plant.

The lower wing position caused by the gull design also increases the "air cushion" effect during landings. Distinguishing features of the "Corsair" include a round fuselage, equally tapered fin and rudder of rounded design set forward of the elevators, a medium-length blunt nose, and rounded wing tips.



F4F—THE "WILDCAT"

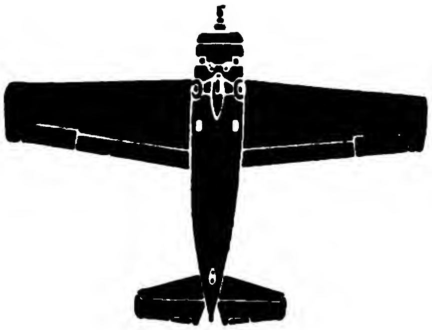
Grumman Fighter
Land- or carrier-based
Mid-wing monoplane
Radial engine (1)

The "Wildcat," called the "Martlet" by the British, is an excellent piece of fighting equipment. Many considered it the best carrier-based fighter in battle service until the coming of the "Corsair." Its performance at high altitudes is almost equal to that of the famous Japanese "Zero."

The exploits of Navy flyers in "Wildcats" will live long in military aviation's annals. Lt. Comdr. O'Hara was flying one when he shot down five enemy aircraft during a single operation.

Power for the "Wildcat" is provided by a single Pratt & Whitney R–1830 radial engine, and the airplane's top speed is more than 310 miles per hour.

The "Wildcat's" wing is dihedral from the wing roots outward. Other identifying features are its square-tipped wing, squarish tail group, a tail tip that looks unfinished because it houses an arrester hook for carrier landings.



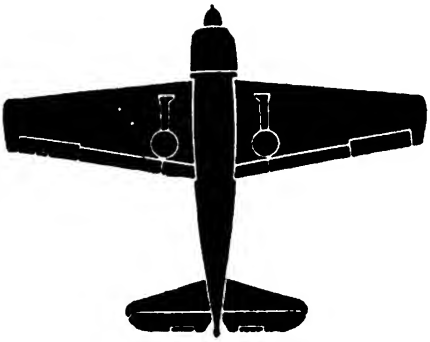
F6F—THE "HELLCAT"

Grumman Fighter
Carrier-based
Low-wing monoplane
Radial engine (1)

Advance notice on this tough new Navy fighter indicates that it is one of the finest performers in military aviation history. It was designed to become the eventual successor to the F4F, another illustrious fighter airplane from the same manufacturer's assembly lines.

The "Hellcat" combines high speed, heavy armor, high service ceiling and good maneuverability. Its single radial engine is a powerful Pratt & Whitney R–2800, which makes this model capable of speeds approaching 360 miles per hour. The armament is heavy, and in addition light bombs can be carried.

You can tell a "Hellcat" from other models by several distinguishing features. The inboard sections of its wing are horizontal, while the outboard sections are dihedral. Its fuselage is deep, stubby and egg-shaped in cross-section. The wing tips are sheared off almost square.




L2
L19
L18

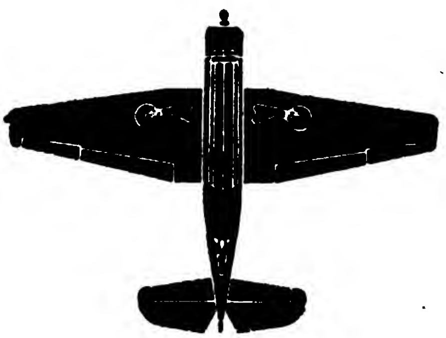
TBF—THE "AVENGER"

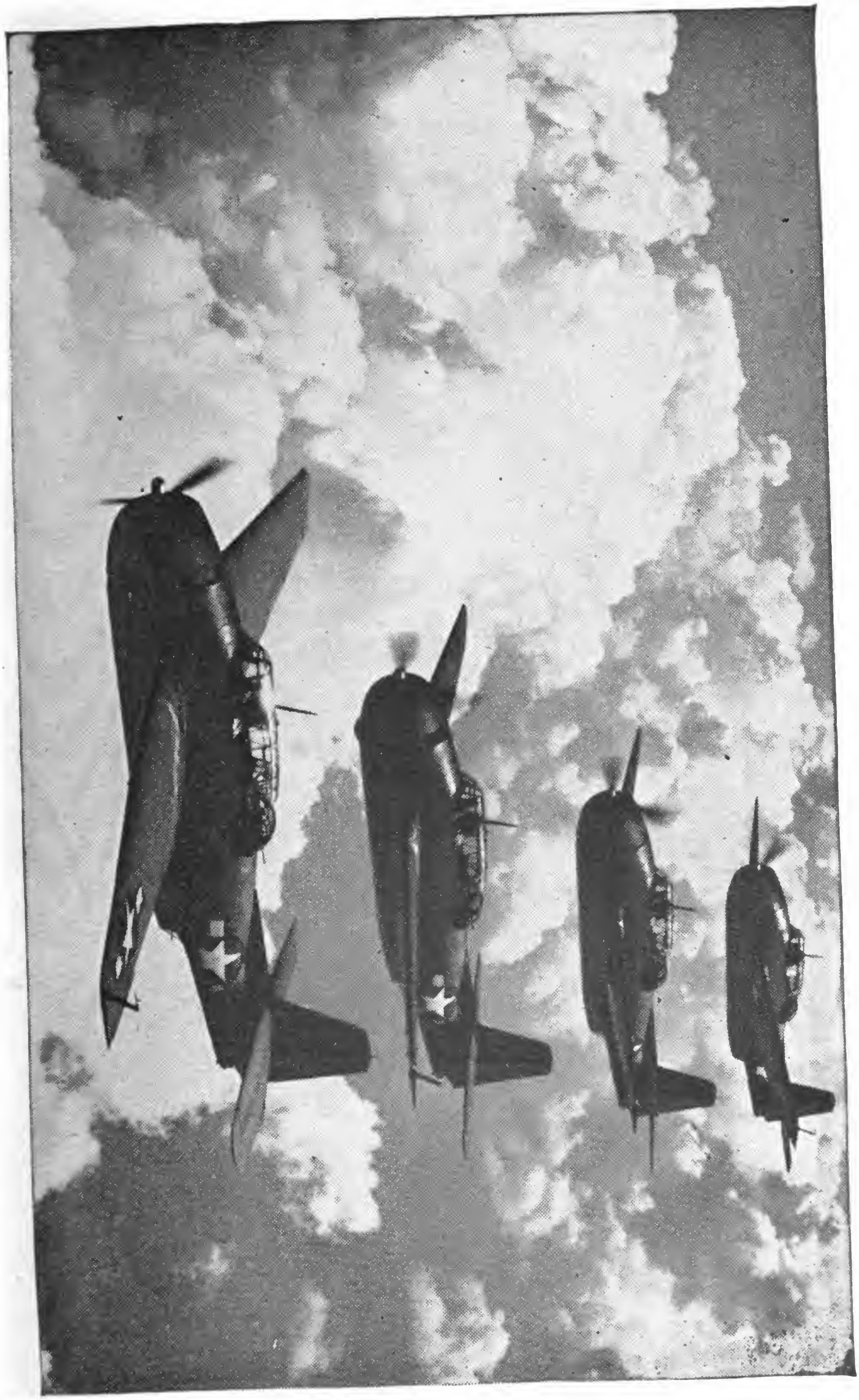
Grumman Torpedo Bomber
Land- or carrier-based
Mid-wing monoplane
Radial engine (1)

The "Avenger" is probably the best carrier-based torpedo plane that has appeared in World War II. It first gained wide fame because of its excellent work in the Battle of Midway. An extremely versatile airplane, it has also been used as a bomber, for scouting and for submarine patrol work from land bases.

Its deep fuselage permits it to carry a large torpedo or approximately 2,000 pounds of bombs. Power is supplied by a single Wright R–2600 radial engine, and the maximum speed is in the neighborhood of 270 miles per hour.

You'll know the "Avenger" by its large cockpit enclosure with the "bubble" gun turret forming the after part of it. The fin and rudder are high and angular. The thick wings taper sharply in their outer panels, and have square-cut tips.





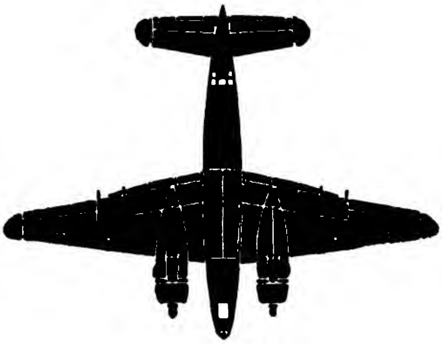
PV—THE "VENTURA"

Vega Patrol
Land-based
Mid-wing monoplane
Radial engines (2)

The land-based "Ventura," along with the PB4Y "Liberator," provide the Navy with long-range craft for patrol missions. At the Battle of Midway, for instance, good patrolling discovered the Jap invasion fleet before it had a chance to seize and establish a base. Other types of patrol mission include antisubmarine patrol, convoy guarding, transport, and rescue work.

The PV carries a four-man crew and is powered by two Pratt & Whitney R–2800 radial engines. It attains speeds of more than 300 miles per hour. Its service ceiling is over 32,000 feet. The engines are underslung in long nacelles on the wings.

You'll know the "Ventura" by its egg-shaped twin fins and rudders, the power turret aft of the wing's trailing edge, and the bottom line of its fuselage—which is broken to accommodate the tunnel guns. Both edges of the wing have a marked taper.



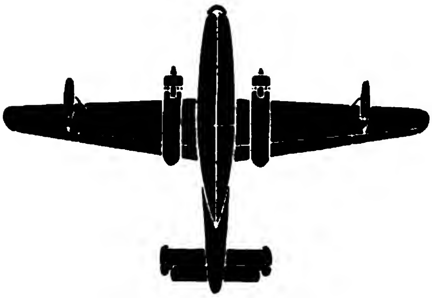
PBM—THE "MARINER"

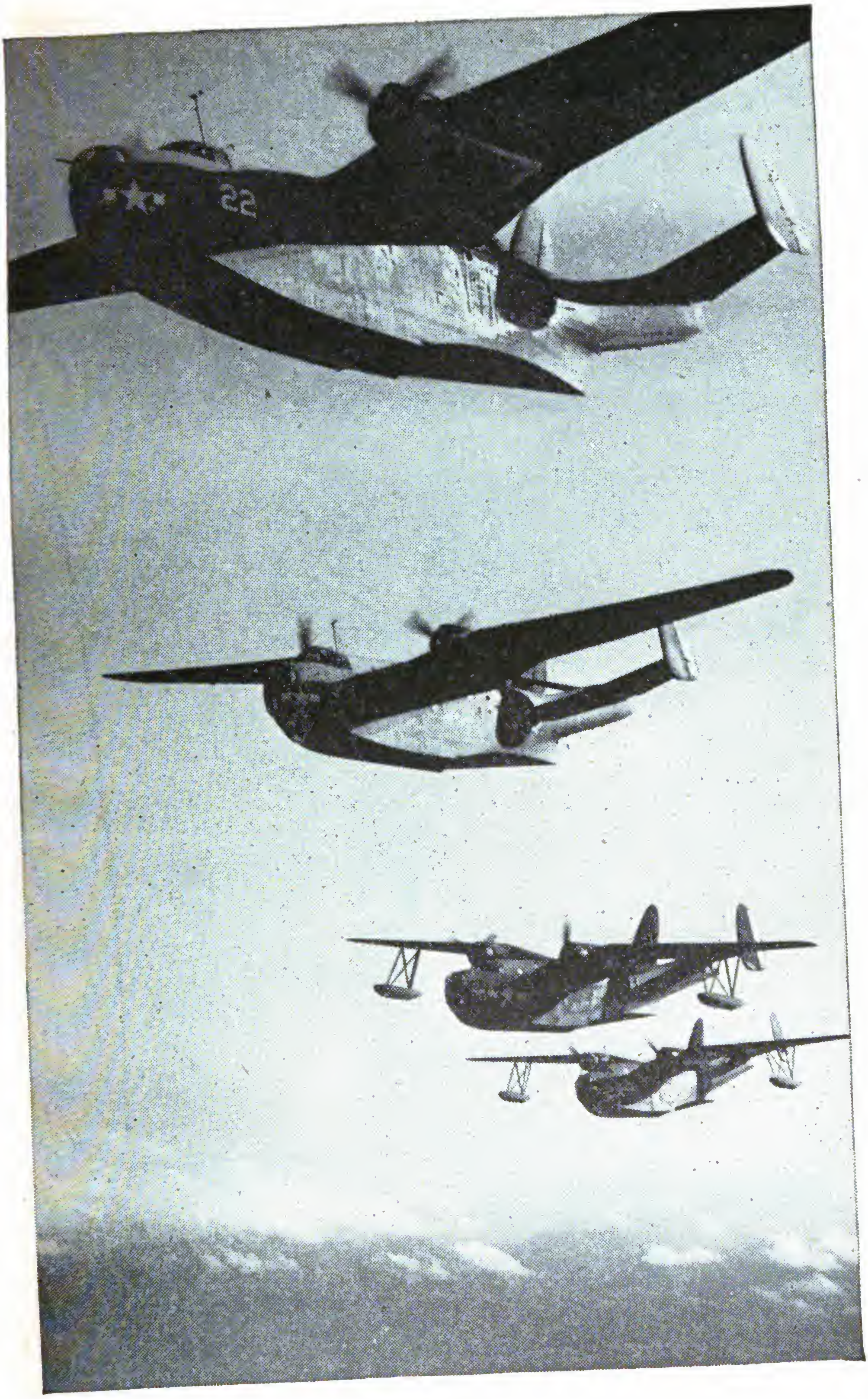
Martin Patrol Bomber
Flying boat
High gull-wing monoplane
Radial engines (2)

The "Mariner" is a highly serviceable long-range flying boat, and has been giving excellent results over rough seas and under otherwise strenuous conditions of operation. It carries two torpedoes or an equivalent weight in bombs under its wings. Some of the "Mariner" models are being used for over-water transport service, with armament removed.

Two Wright R–2600 radial engines power the PBM. Its service ceiling is about 17,000 feet and its top speed around 205 miles per hour. Recent models have three power-driven gun turrets for protection against attack, and carry nine-man crews.

The gull wing is a distinguishing feature of the "Mariner," as are the twin fold-in fins and rudders and the dihedral tail plane. The hull tapers back toward the tail, and there is a sharp step on the underside of the fuselage.

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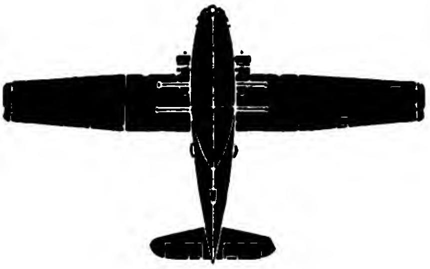
PBY—THE "CATALINA"

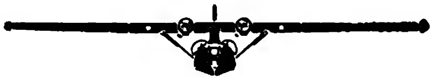
Consolidated Patrol Bomber
Flying boat
Parasol-wing monoplane
Radial engines (2)

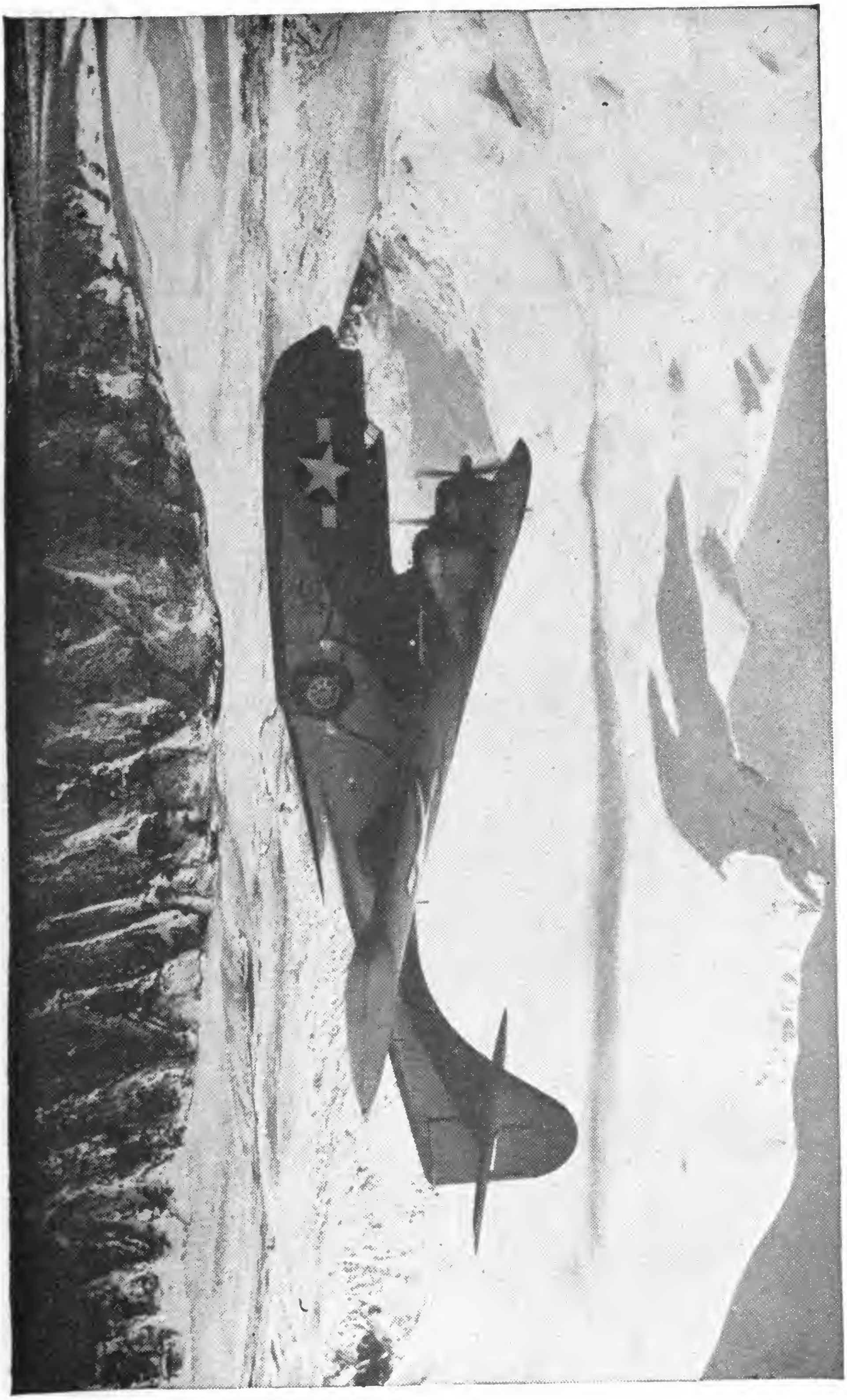
A capacity for staying aloft for long periods of time makes the "Catalina" well suited for long sub-spotting and convoy-guarding patrols. The "Cat" will long be remembered for its work in tracking down the German battleship *Bismarck* after the pot-shot sinking of the British *Hood*. In the Aleutians and Solomons it was used as a torpedo bomber, and in other situations it can carry eight depth charges or two 2,000-pound bombs.

The PBY is equipped with two Pratt & Whitney R–1830 radial engines, and attains speeds of around 170 miles per hour. There are two large "blister" turrets on its hull behind the wing.

The parasol wing is nearly rectangular and is mounted above the hull on a streamlined superstructure pylon. The hull bottom has two steps, and sweeps upward toward the high single fin and rudder. The retractable wing floats fold upward to form the wing tips during flight.







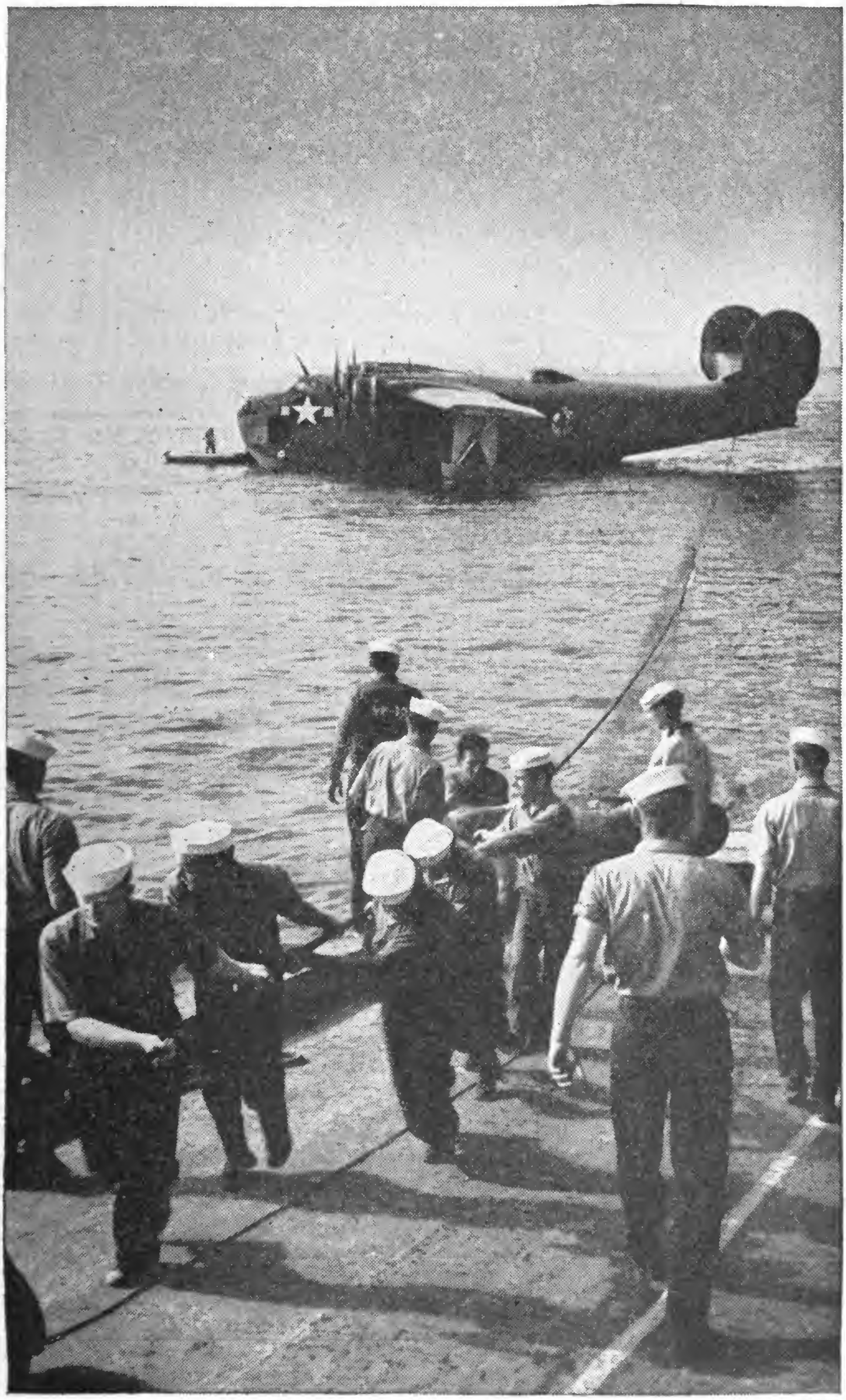
PB2Y—THE "CORONADO"

Consolidated Patrol Bomber
Flying boat
High-wing monoplane
Radial engines (4)

The "Coronado" is a long-range flying boat of large size and power. It is used mainly as a patrol bomber, but in many cases has been converted for transport.

PB2Y has an approximate top speed of 219 miles per hour and a service ceiling of around 20,000 feet. Its power plants are four Pratt & Whitney R–1830 radial engines.

The leading edge of the PB2Y wing is tapered, but the trailing edge is straight. The wing floats, as on the "Catalina," are retractable, and fold upward to form the wing tips when the airplane is aloft. Prominent steps on the bottom of the deep hull taper toward the rear. Large, rounded twin rudders are mounted outboard on the dihedral tail plane.



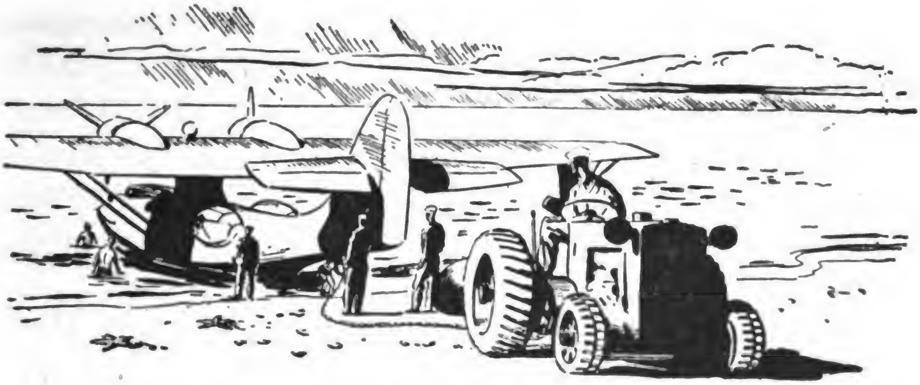
PB4Y—THE "LIBERATOR"

Consolidated Patrol Bomber
Land-based
Mid-wing monoplane
Radial engines (4)

This heavy bomber, used so effectively in all theaters of World War II by the British and the U. S. Army Air Forces, is also at work for the Navy as a patrol bomber and transport. It has powerful armament, and is highly maneuverable for an airplane of its size. Both of these factors help to reduce the number of fighter airplanes needed for its protection.

Four Pratt & Whitney R–1830 radial engines drive the "Liberator" at speeds up to 310 miles per hour, which is very fast for an airplane this large. Its service ceiling is upwards of 30,000 feet.

The "Liberator's" wing is long, narrow, and equally tapered at the leading and trailing edges. The fuselage is deep and bulky, but has a very "clean" appearance. The large, rounded twin fins and rudders are set flush with the outer ends of the stabilizer plane.



CHAPTER 9

HANDLING

KNOW YOUR STUFF

Your life would be just one long, sweet dream if an airplane needed as little between-time attention as, say, your wristwatch. You'd merely have to clean and oil it once every year or so, and then plain forget about it. Wonderful! But that isn't the way it works out. There is real work, and plenty of it, involved in handling airplanes.

As you'd expect, the methods of handling airplanes differ according to the type of airplane, where the airplane may be, and the kind of weather that's being ENJOYED in the vicinity. You won't, for instance, run into the same handling problems with patrol or seaplanes that you will with landplanes. And you will handle landplanes differently on aircraft carriers than you will at air stations. You also use a different set of rules when a gale is blowing up than when the weather is calm. Any change in circumstances calls for corresponding changes in your course of action. But these differences are all just a matter of common sense.

The way to become efficient at airplane handling is to prepare for ANY situation that may come along. Mistakes can cause a lot of damage to valuable equipment. Get yourself a good grip on the fundamentals and YOU WON'T MAKE MISTAKES. And if a situation arises that you can't cope with, don't be afraid to ASK somebody who knows.

SECURING LANDPLANES

Ideally, an airplane, when not in use, should be sheltered in a hangar. But you don't find hangars in every wheatfield, and very often airplanes have to be put to bed out-of-doors. Because of differences in weather conditions, location, and the varying characteristics of planes, methods of securing will vary a little but the FUNDAMENTALS won't.

Almost all AIR STATIONS can boast of concrete-surfaced PARKING AREAS. These areas are usually equipped with ringlike fittings called "pad eyes," sunk in flush with the concrete surface. You'll see a pad eye in figure 27. They're mighty handy when available. The airplane is simply placed in position, and wing and tail lines are secured to the pad eyes.

STAKING OUT an airplane in the open, AWAY FROM THE STATION, is a different story. You frequently have to use whatever equipment has been brought along with you, plus what you can dig up by foraging. At air stations, for instance, CHOCKS for the wheels are always at hand. "On location," however, you may have to scout around for some logs to use as chocks, or even be forced to dig holes in which to sink the wheels to prevent the airplane from rolling away. In other words, it takes some INGENUITY to do your job when you're "roughing it."

Here are some basic commandments on the securing of landplanes. They'll apply to almost all conditions you're likely to run up against.

Look for a PROTECTED location. If there isn't any place that's better than another, HEAD the airplane INTO the wind, otherwise the force of a strong wind will hit the control surfaces in the opposite direction. Such surfaces aren't built to "take it", and they are quite likely to become warped or otherwise damaged.

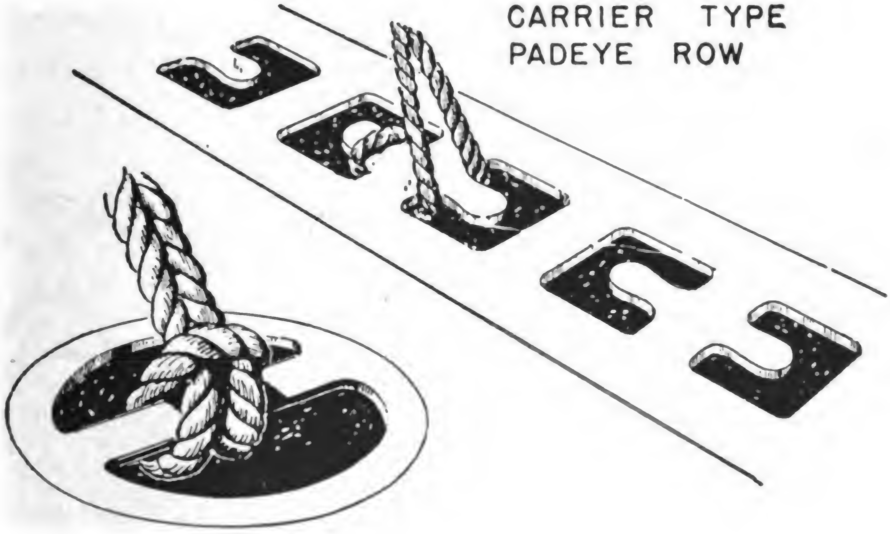


Figure 27.—Pad eyes for securing airplanes.

Chocks should be placed both ahead of and behind the wheels to prevent the plane from rolling forward or backward.

The fuselage should be GROUNDED by means of an electrical conductor to provide a ready passage for static electricity. This is for the same reason that you ground a gasoline truck—to eliminate a possible cause of fire or explosion.

All controls should be placed in neutral position and LASHED or SECURED with parking harness. The parking harness (many models resemble a tin can bottom-side up with wires attached) keeps the wind from WHACKING THE HELL out of the stick and rudder. The can goes over the end of the control stick, with two lines reaching to the rudder pedals and two other lines stretching back to clamps on the side of the pilot's seat. Another type of parking harness, consisting simply of wires with padded midsections and S-hooks at the ends, is shown in figure 28.

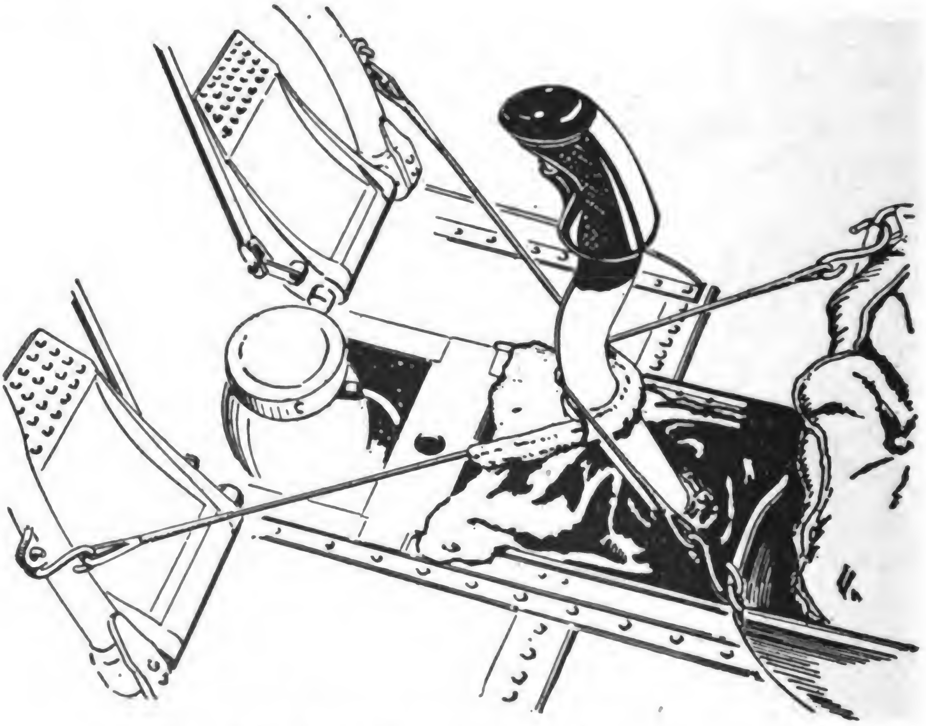


Figure 28.—Parking harness for airplane controls.

Next, the airplane should be TIED DOWN. You'll find tie-down rings on the wing and a shackle on the tail—put there for that express purpose. And here's where the pad eyes or stakes come into the picture—they're the HITCHING POSTS for the flying horse on which you're working.

If you're using STAKES because there aren't any pad eyes on the field, you'll find the CORKSCREW type, such as you see in the circle in figure 29, takes a better grip on Mother Earth than other kinds. If corkscrew stakes aren't available, plain metal ones (made of angle iron) or even the wooden variety are serviceable.

CABLE IS NUMBER ONE ON THE HIT PARADE for securing purposes. MANILA LINE is quite suitable, however, if you leave enough slack to allow for shrinkage when wet. In most circumstances one line on the tail and two for each side of the wing will be aplenty. Manila lines for securing should be WHIPPED at one end and have an EYE SPLICE at the other.

The first step in a tie-down is to REEVE THE LINE THROUGH THE RING IN ONE WING, and then through the PAD EYE (or stake ring). A rolling hitch and a half hitch will secure the line. Tension will tighten the knotting but will leave it easy to unlash, which is a big advantage. Now go after the other side of the wing with the same medicine, and then the tail. And there you are. It's done.

YES, but didn't you hear the head man in the "weather factory" tapping his barometer and promising a whip-snapper wind for tonight? Out you go, on the double, to DOUBLE UP the lines and anchorages. And take along a batch of BATTENS with you. They're those wooden sticks for lashing the airplane's control surfaces in neutral position. A glance at the bottom picture in figure 29 will show you how to attach battens properly.

If the weather's REALLY TOUGH, it may be a good idea to lash SPOILER BOARDS across the leading edges of the wing. Spoiler boards break up the smooth flow of air over the wing surfaces, and effectively knock out the possibility of your airplane turning itself into an unmanned kite.

WHOA! C'm'on back. Did you make certain that all the ENGINE, COCKPIT, and PROP HUB COVERS are securely in place? Before you head for chow, these covers better be lashed down with line if heavy weather is on the way.

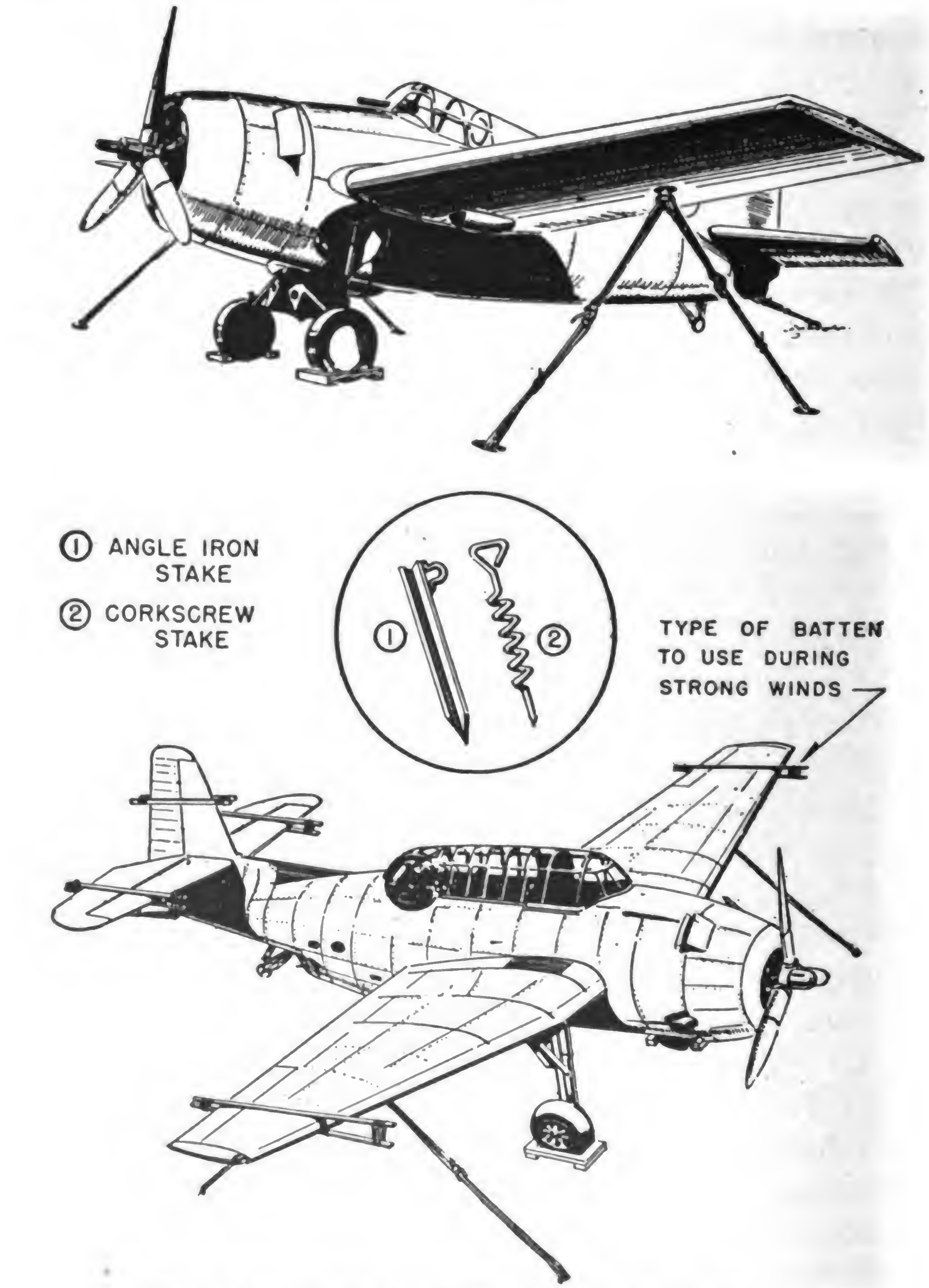


Figure 29.—Method and gear for securing landplanes.

LANDPLANES ON THE LINE

Along come flight schedule instructions, and it's time for you to break up the scuttlebutt. The line and leading chiefs are out by the hangar, ready to get their crews into action. First off, it's the responsibility of the duty section to see that all airplanes are SPOTTED ON THE LINE according to instructions.

Once the lineup is ready, it's time for the plane crews to take over, warm up the engines and otherwise see that the airplanes are in all ways set for their missions. Then, at the scheduled moment, the engines are again started and the planes turned over to their pilots.

You, there, on the plane crew! As that pilot taxies away from the line you should STICK WITH HIM until he's clear of the parking area. He's depending on your sharp eyes and steady arms to keep his airplane from rubbing noses with the neighbors.

Finally, that fellow in the pilot's seat is going to be expecting a line crew "reception committee" to MEET HIM AT THE EDGE OF THE PARKING AREA upon his return, ready to assist and guide him to the particular parking spot indicated by the line chief. Parking an airplane isn't like parking a convertible on Main Street. It's a job for more than one man.

CARRIER OPERATING

You'll find the methods of carrier handling vary somewhat. But the basic procedure is the same on all of them, and their high-powered efficiency depends on every man of their crews being an expert in his field, as well as being capable of complete and thorough TEAMWORK.

A detailed knowledge of all the SAFETY precautions that must constantly surround his job is vital to everyone on a carrier. Petty officers really have to be on their toes, and know the duties of the men under them so well that safety comes through the SHEER EFFICIENCY of all operations.

Moving the planes on a carrier is a job that's handled by means of either a SMALL TRACTOR or GROUPS OF MEN. When manpower is used for this push-pull task, you and many of your shipmates will be organized into HANDLING CREWS.

Each handling crew takes care of one airplane. It consists of six to eight, or even a dozen men, with the senior man designated as CAPTAIN. Two men are assigned to handle affairs at the right wing, two at the left wing, and two at the tail. The group captain usually takes his station at the TAIL so that he may watch for the signals from FLIGHT DECK PLANE DIRECTORS. When airplanes are being moved on the flight or hangar deck, one EXPERIENCED man from the PLANE crew, preferably the plane captain, MUST be in the cockpit to tend the brakes.

Handling crews stay with their respective airplanes until they're SECURED or, if the airplanes are to be struck below, until they're TURNED OVER TO THE HANGAR DECK CREW. This means that everybody on the handling crew stays with his airplane even while it is being taken down on the elevator to the hangar deck.

Airplanes have to be packed in almost like sardines in some places aboard a carrier, and clearances naturally are pretty slim. So you just can't afford to suffer any mental lapses when you're around a flock of airplanes that are turning up. Remember—YOU CAN'T SEE A WHIRLING PROP! You'll also find that decks frequently are WET AND SLIPPERY, and that slip-streams from airplanes ahead have a blast that can easily KNOCK YOU OFF YOUR FEET OR INTO ANOTHER PROPELLER if you're not careful. Always CRAWL UNDER THE FUSELAGE when passing from plane to plane, and look in all directions BEFORE making ANY move. If you don't, there may not be any "next time." Remember, you're more handsome all in one piece.

SECURING ON A CARRIER

You've already learned about staking out an airplane, so you have a head start on the problem of securing airplanes on the deck of a carrier. Primarily it's the same operation, only simpler in certain respects. Here you always have TIE-DOWN STRIPS sunk into the flight deck for you, and pad eyes sunk into the hangar deck. The most important difference is that airplanes on a carrier must be handled in much less space than on a field, hence, greater care must be taken to avoid damage. Easy does it!

Airplanes parked in what is called the "take-off spot" on the flight deck are allowed an EIGHT INCH CLEARANCE. No part of one airplane can be closer than eight inches to any other airplane or obstruction, because the CARRIER ROLLS AND PITCHES. If there is any slack in the tie-down lines and the deck is damp, a clearance of less than eight inches may mean that one airplane will slide into another.

Just as on land, the wings and tail of a carrier-based airplane are SECURED WITH LINES when parked, and the wheels are blocked with C-SHAPED CHOCKS, such as you see in figure 30. And if rough weather's ahead, securing lines should be DOUBLED.

An airplane is never parked without having its TAIL-WHEEL LOCKED FIRST. An unlocked tail-wheel can cause all sorts of trouble, since it permits an airplane to follow its tendency to roll with the ship.

BEACHING SEAPLANES

Seaplanes taxiing onto the beach are given SIGNALS by a member of the beach crew. FLAGS are used in the daytime, and LIGHTS at night. A white flag or light indicates that all's well for an approach. Red signals mean that the plane should remain clear of shore for the time being.

There are plenty of good reasons why seaplanes have to be handled with "kid gloves" when approaching the beach or ramp. The final decision on approach is up to the PILOT. He bases his judgment on WIND DIRECTION and other general WEATHER CONDITIONS, but these same conditions usually create special problems for the BEACHMASTER, and for the WADER CREW which works in the water.

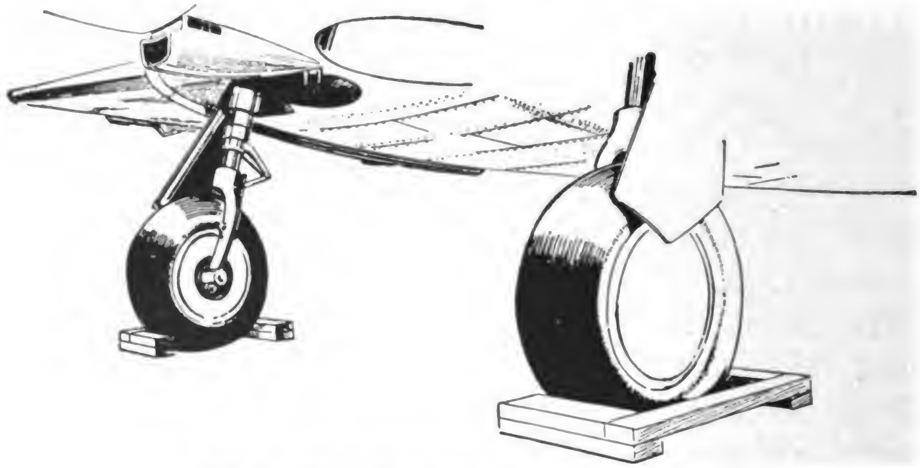


Figure 30.—Airplane chocks in place.

In light winds, or when the blow is toward or from the beach, the handling problems are fairly simple. STRONG WINDS PARALLEL TO THE BEACH are decidedly something else again, and call for extra precautions as well as additional assistance in settling the plane on a HANDLING TRUCK, or in attaching the necessary BEACHING GEAR. Take a look at figures 31 and 32 in order to familiarize yourself with typical gear for beaching a seaplane or patrol plane.

In the face of difficult conditions, both the wader crew and beach crew must be ENLARGED to make certain everything remains under control.

WING LINES are attached to the plane, for instance, and tended by men stationed ON THE BEACH, to overcome the natural tendency of the plane to weathercock. And if you're a member of the wader crew, you'll appreciate how much this lessens any difficulties you may be experiencing in handling the beaching gear.

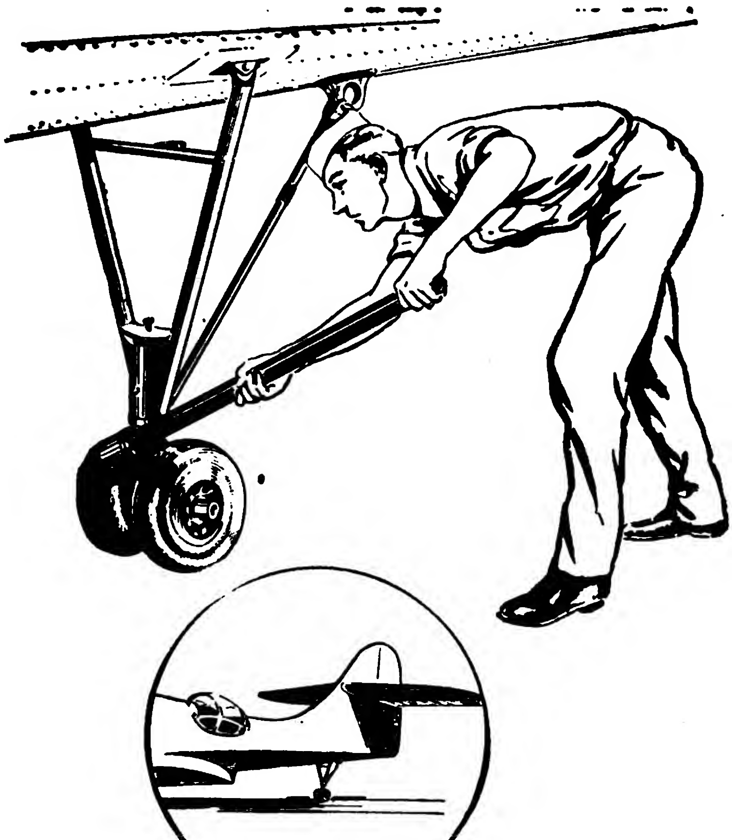


Figure 31.—Tail beaching gear for a PBY.

Once out of the water, a plane should be inspected carefully by the beachmaster until he's happy about the way it's sitting on the handling truck—or, if it's the variety that uses beaching gear, whether that gear has been attached properly.

Incidentally, DON'T start trying to shift beached planes around without the guidance of a responsible officer or petty officer, unless you're looking for a PECK OF TROUBLE or trying to gum up the Navy's air strength. It's pretty easy to have a COLLISION. When planes on trucks or beaching gear are in their proper position, they should be secured according to prevailing weather conditions. And if the plane you're working on has wings that are to be folded, special care will be needed in securing the plane float to the handling truck.

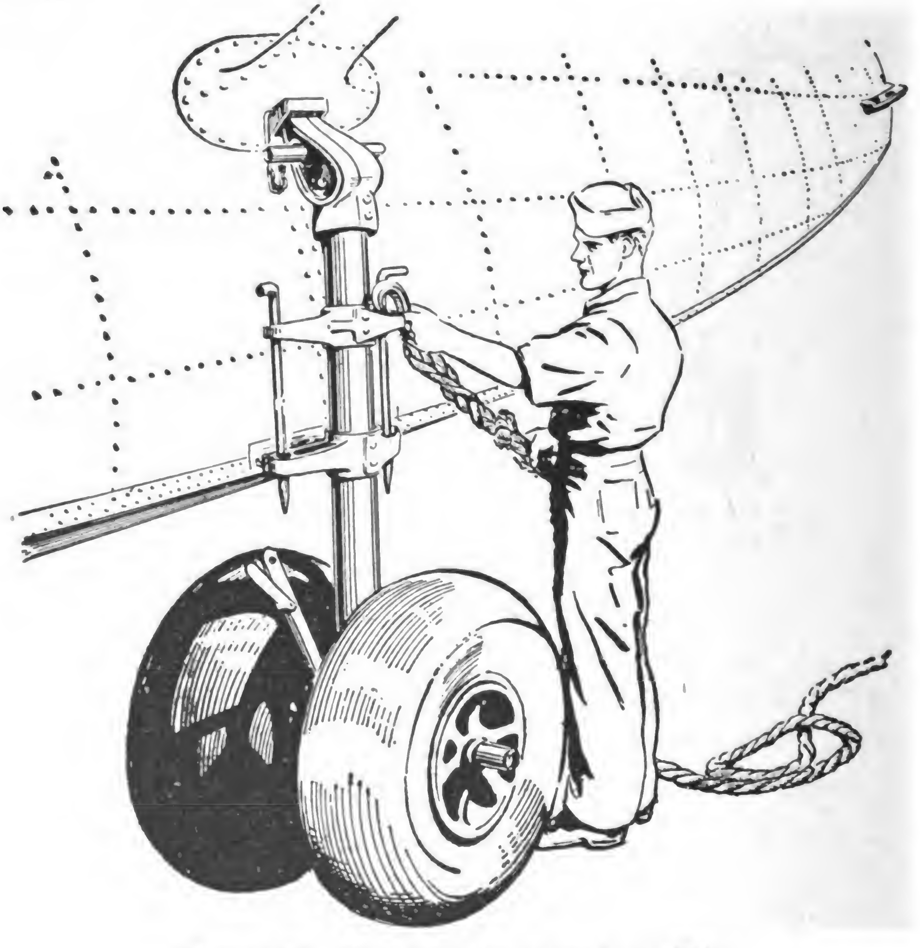


Figure 32.—Side beaching gear for a PBY.

SEAPLANES ON WARSHIPS

Handling and stowing seaplanes that OPERATE FROM CRUISERS OR BATTLESHIPS also differ from ship to ship. The available STORAGE FACILITIES, the OPERATING SPACE allotted to aviation activities, and the EQUIPMENT OF THE SHIP will necessitate departures from set procedures in each instance. You'll get the special "know how" about your ship's methods once you're aboard.

HOISTING OUT—or lowering the plane from ship to water—is the first job on your calendar. Whoever is in charge of lowering begins by STATIONING HIS MEN WHERE THEY'LL BE NEEDED. The WINCH MAN tests the HOISTING MACHINERY until he's satisfied it's in good order, then swings the boom over the plane which ordinarily is on the ship's catapult. The hook is engaged, and ANY SLACK in the plane-hoisting sling is taken up before the securing devices are cast off.

Everything ready? Then, with the crew in the plane all set for flying and other personnel at their stations for lowering away, it's time to hoist clear and lower the airplane INTO THE WATER. The boom swings outward to give the greatest possible clearance between plane and ship's side. The HOOK is quickly removed or stripped by the plane's crew at the INSTANT the plane is water borne. Wing and tail lines are released at one end and allowed to run through the hand-holes so the plane will be FREE TO TAXI CLEAR before its take-off.

Those men you see stationed at the rail with LONG POLES play a vital part in hoisting out operations. See the PADDED CRUTCH at the end of each pole? That's to FEND OFF A SWAYING plane during the lowering process. And a great amount of CARE must be taken in using such fenders so they won't injure delicate parts of the airplane structure. To further reduce swinging on the hook, it's a good idea to LEAD A LINE DIRECTLY TO THE HOOK ITSELF and have the line handled by one or more men on deck. This will help to overcome the sway of the suspended plane during the roll of the ship.

Back from its flight, the plane will be ready for HOISTING IN. Out the boom swings to the most favorable spot for HOOKING ON again—probably about the SAME location as that from which the plane was released after lowering. The pilot taxies on a course parallel with the ship's heading to a point where the hook can be engaged in its sling. The winch strains immediately, AVOIDING as much as possible any INITIAL SHOCK, and hoists the plane clear of the water. WING LINES are thrown from ship to plane and attached by the plane crew WITHOUT DELAY. Then the plane is hoisted on board.

On board, the plane is LOWERED ONTO ITS CATAPULT LAUNCHING CAR and SECURED without delay so that it will be safe from damage by the elements and ready for future use.

You can get an idea of how a plane should be secured on the catapult launching car by looking at figure 33. The plane is kept from moving forward by a RELEASE LEVER hinged to the catapult structure and bearing against the forward face of the TOE FITTING, by two SAFETY PINS operating from the catapult to engage SOCKETS IN THE LAUNCHING CAR, and by a metal TENSION BAR which engages LUGS ON BOTH THE CATAPULT AND LAUNCHING CAR. To prevent movement from side to side, there are two inverted J-hooks mounted on the launching car saddle. These engage the UPPER SURFACES OF FITTINGS on the FLOAT CHINES just behind the step of the float. Motion upward or to the rear is prevented by that same toe fitting you looked at a moment ago. The launching car is held to the CATAPULT TRACK by means of SLIPPERS.

If nobody's going to use the plane on the catapult for a while, further means of securing it should be adopted. LOCKING DEVICES must be put into use on plane controls, and battens lashed over the control surfaces. Frequently, STRAPS are placed OVER THE FLOAT and secured to both sides of the launching car. JURY STRUTS (temporary struts) should be secured to the catapult structure so as to engage FITTINGS ON THE WING, INBOARD OF THE WING TIP FLOAT STRUTS. ENGINE AND COCKPIT COVERS should be secured firmly in place and, when high winds are expected, you may need to place spoiler boards on the leading edges of the wings. A WATCH is stationed on all planes during HEAVY WEATHER.

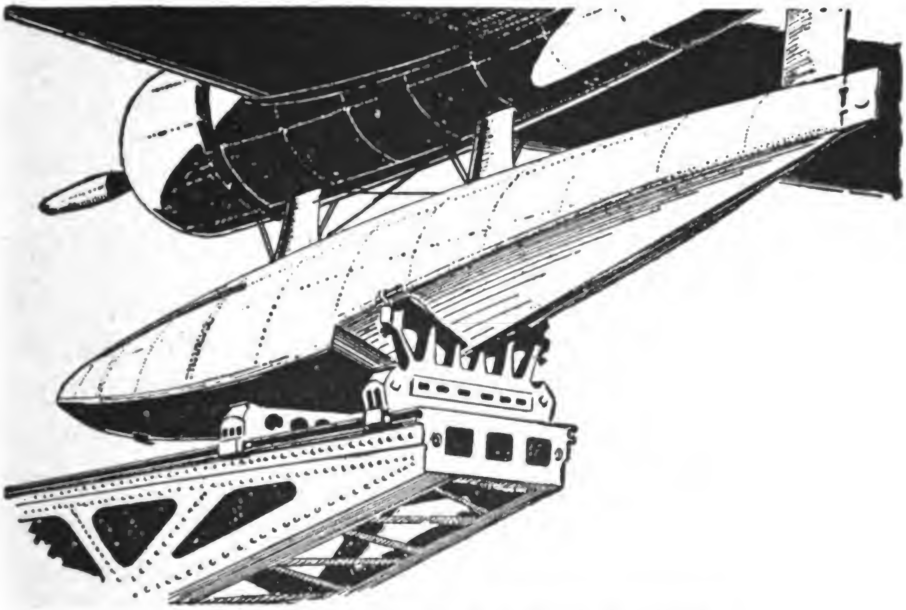


Figure 33.—Seaplane secured on a catapult.

Another point or two about planes on catapults before you pass along to other matters. An ENGINE SHOULD NEVER BE TUNED UP unless the PROPER AUTHORITY has been obtained and all PRECAUTIONS taken against fire and danger to the ship's personnel. Before starting the engine of a plane on a catapult, it is best to turn the catapult so that the AIR BLAST and OIL are directed over the side.

CHAPTER 10

ANCHORING AND MOORING

ANCHOR GEAR

Modern seaplanes and patrol boats are furnished with COLLAPSIBLE ANCHORS made of nonmagnetic, corrosion-resistant steel. Most such anchors are very much ALIKE IN APPEARANCE, but they will VARY IN SIZE according to the holding power required.

What is the anchor equipment for a small seaplane? There's the ANCHOR itself, an ample length of manila LINE attached to the anchor with SHACKLES, and such necessary plane attachments as the FLOAT CLEAT AND RING BOLT, strapped to the lower end of the FORWARD FLOAT STRUT. On a small plane you don't need a reel for the anchor line. If and when such a plane is converted for land use, the anchor gear is removed entirely, and the anchor stowage space is available for other purposes.

More and heavier anchor equipment is needed for bigger aircraft, such as the PBY patrol plane. You find a 30-POUND ANCHOR in a PBY, for instance, with an ANCHOR REEL, 150 feet of ¼-inch corrosion-resistant wire CABLE, a mooring and anchoring PENDANT equipped with a "lizard," and

PLANE ATTACHMENTS of the kind required for securing and operating the anchor gear. A WINCH for handling the anchor cable is provided with the reel. Other parts of the winch are the gearing, a brake, hand crank or electric motor—maybe both, sheaves to guide the anchor line, and a "level winding" device or the equivalent. There is plenty of space on the REEL to hold ALL THE ANCHOR CABLE, regardless of how adverse winding conditions may be, or what winding method you have to use on the spur of the moment.

There are GUARDS around the reel and gearing. They are put there to PREVENT INJURY to persons using the equipment. And the brake is placed in a spot where it can be applied without danger of the hand crank flying around and CONKING THE OPERATOR.

An ANCHOR CABLE CLAMP, called a "come along," will be found with the anchor gear. It is used in transferring the load from the anchor ring or mooring to the PENDANT, thus relieving the tension on the anchor winch. The pendant is strong enough to stand plenty of tension. By examining figure 34 you can readily identify these items of anchor gear. The "come along" clamp should also be used while "breaking out" the anchor to prevent excessive strain on the winch. Some winches are not designed to absorb heavy shocks.

Anchor stowage in seaplanes is very PLAIN because of the simplicity of the gear. In patrol planes it must of necessity to be more ELABORATE, as you can observe in figure 35 which shows the approved stowage of anchor gear for the PBY.

Suppose you're anchoring a seaplane.

The ANCHOR LINE is broken out of stowage and the end SHACKLED TO THE RING BOLT. Next from the compartment comes the ANCHOR. You unfold it by first pulling up the FLUKES and then the

SCANTLINGS until the catch engages. When the plane is just where it ought to be, LOWER THE ANCHOR AS THE PILOT CUTS THE ENGINE. Now run the line through the anchoring cleat and secure it. When it's time to weigh anchor, all you'll have to do is reverse the procedure, although you may need a little help from the engine in breaking the anchor loose from the bottom.

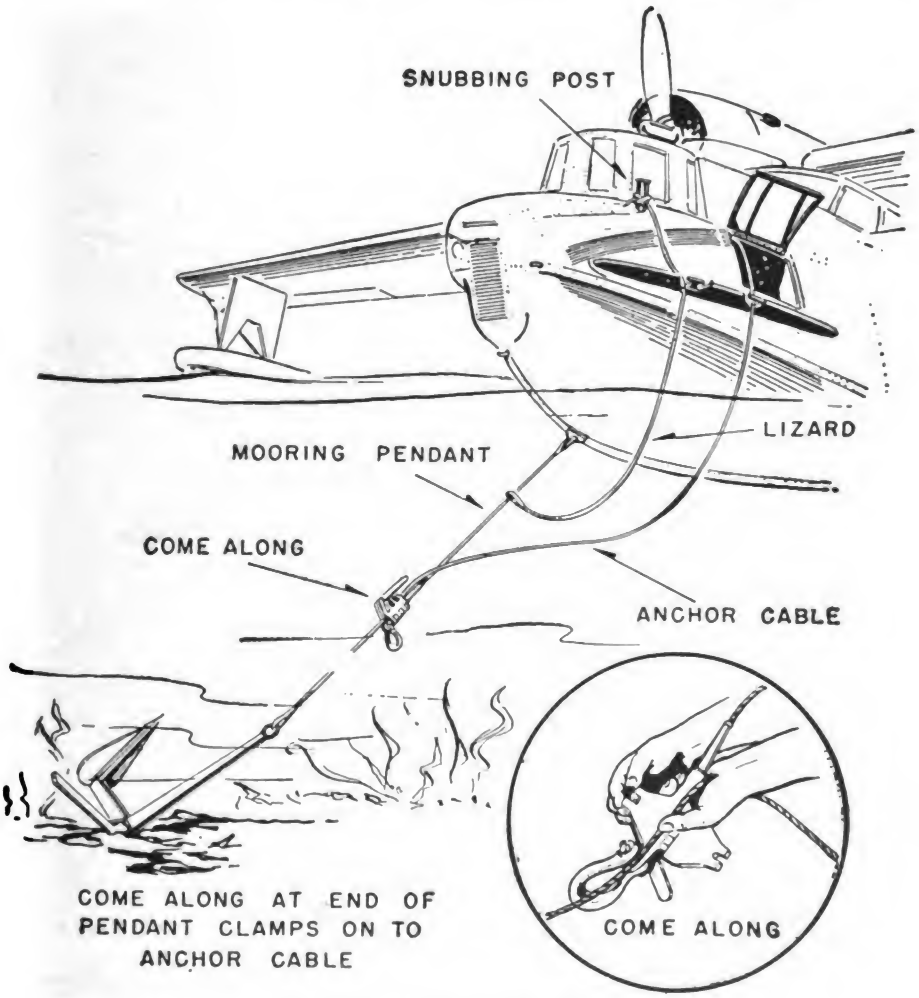


Figure 34.—Anchor gear for a PBY.

ANCHORING and GETTING UNDER WAY in patrol planes are considerably more detailed operations, and the procedure varies considerably according to the type of plane, its anchoring gear, and the way in which gear is stowed. Take a PBY, for instance, so you can follow through on operations as you approach the anchorage. Are you aboard? Keep referring to figure 34, and—

Obtain the WINCH CRANK.

See that the REEL is locked.

Stand on the MOORING PLATFORM. Remove the ANCHOR from the box and UNFOLD it.

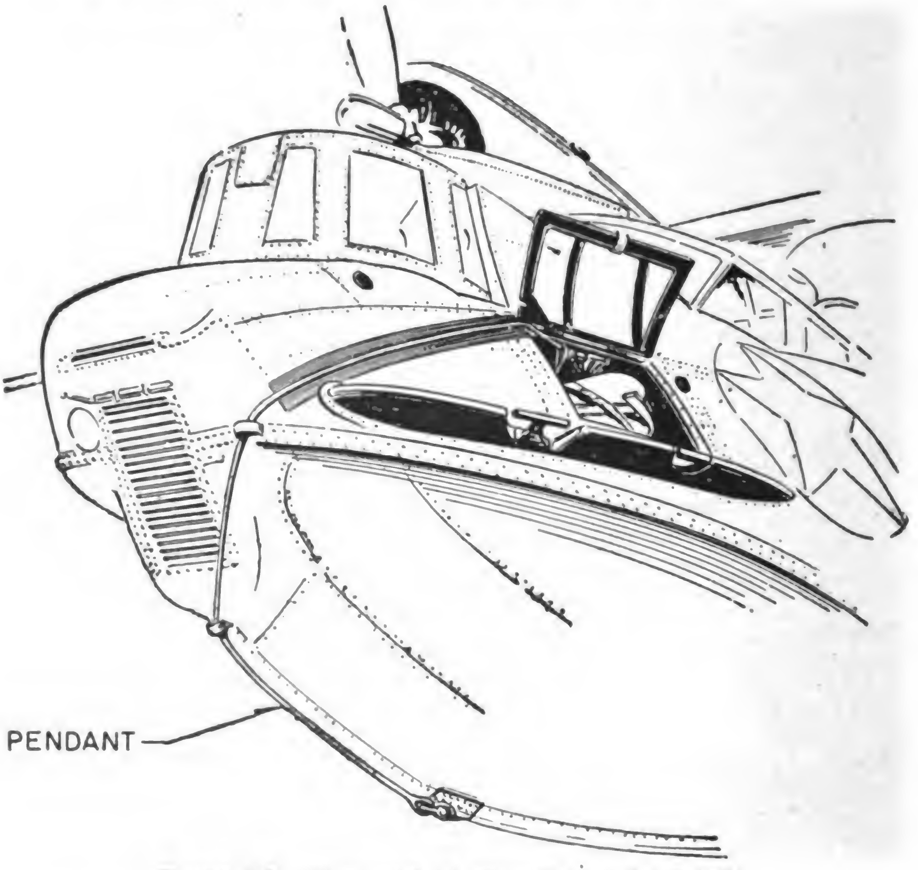


Figure 35.—Stowage of anchor gear for a PBY.

DROP THE ANCHOR over the side, threading the cable through the RUN provided on the mooring platform.

Using the BRAKE, allow cable to feed out SLOWLY to the desired length.

LOCK the reel, and ATTACH THE CLAMP on the mooring pendant to the anchor cable.

Allow cable to FEED OUT, while you're controlling the brake, until entire anchor pull is taken by the mooring pendant.

Leave enough SLACK to insure that no pull will be placed on the reel's lock mechanism.
LOCK the reel, and SECURE all loose gear.

If the anchor can not be broken loose with the WINCH, you can break it loose with the engine. Be sure the strain is taken up by the pendant—NOT by the reel. After the anchor is free of the bottom, the gear must be stowed. Take another look at figure 35, and—

UNLOCK the reel.
CRANK IN the cable until the clamp on mooring pendant attached to cable is accessible from the mooring platform.
LOCK the reel.
RELEASE the clamp on the cable.
UNLOCK the reel.
CRANK IN the cable until anchor hangs just below the mooring pendant.
LOCK the reel.
LIFT the anchor over the mooring platform, then fold and stow it.

DON'T try to lift the anchor out of the water and up over the side while the plane has WAY UPON HER through the water. Sure as shooting, the sharp point of the anchor will be THROWN IN AND TOWARD the hull, and you'll unintentionally become a full-fledged SABOTEUR. Now—

STOW the mooring pendant in the place provided for it in the compartment.
SECURE all gear.
LOCK the reel.

MOORING GEAR

When seaplanes and patrol boats are engaged on extended flight operations they are seldom anchored. Instead they are MOORED. One of the jobs performed by aircraft tenders is the planting of heavy moorings at locations expected to be occupied by the operating units. Hence anchoring is necessary only at INTERMEDIATE points.

Heavy moorings are sometimes anchored PERMANENTLY at a base. At other times they are planted TEMPORARILY in an anchorage by a tender acting in advance of the operating units. Moorings consist of an ANCHOR weighing about 500 pounds, a ⅝- or ¾-inch WIRE CABLE, a SPHERICAL BUOY, and a RIDING PENDANT made of about ⅝-inch wire to which is attached a length of MANILA LINE and a wooden MARKER FLOAT, or BUOY. Each end of the cable is provided with an eye splice. One end is shackled to the anchor, the other end to the buoy. Figure 36 shows you the gear.

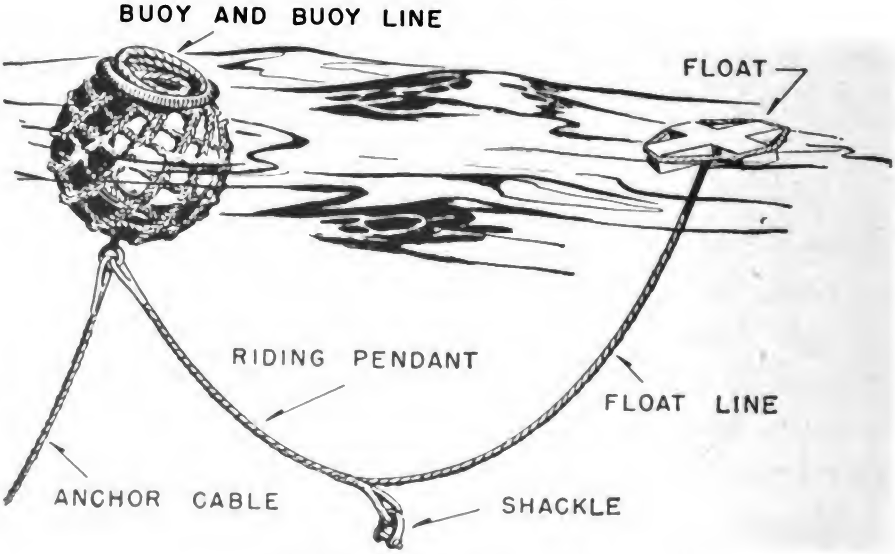


Figure 36.—Mooring gear.

The RIDING PENDANT is usually about 1 fathom (6 feet, if you weren't sure) in length and also has eye splices at either end. One end of the riding pendant is shackled to the buoy. The other end is used for shackling to the plane's mooring pendant, and is attached to the marker buoy by about 10 feet of manila line. You will find a

RING at the top of the mooring buoy. It is used for picking up the buoy and also is useful as a temporary fitting to which a line may be secured until the mooring pendant is firmly attached to the anchor pendant. Sometimes ADAPTERS, which will fit over the mooring buoy ring, are available. If so, they are for securing temporary lights to help avoid fumbling in after-dark mooring operations.

It is important to keep in mind that the LENGTH of cable by which a mooring buoy is anchored should vary according to the anchorage, normally being about THREE TIMES the depth of the water. Too short a cable results in poor holding power, as it does not allow for changes in tide level or for heavy seas, and sometimes permits the plane to ride UPON the buoy—a matter that can cause serious damage.

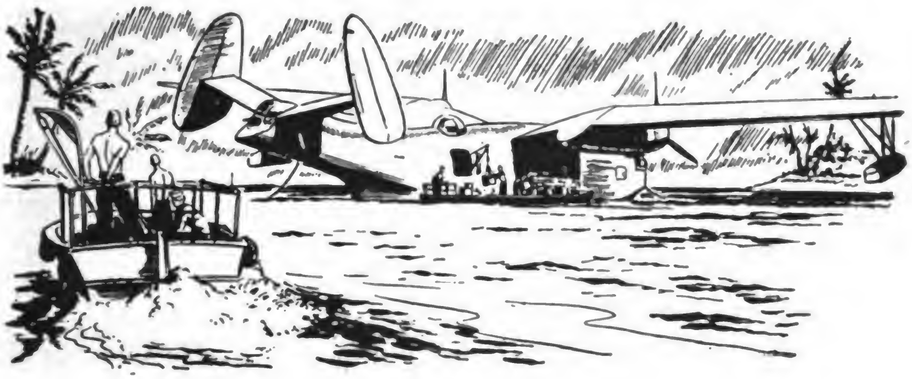
On SEAPLANES, a line attached and led in the same manner as an anchor line—but secured to the buoy instead of an anchor—serves as a mooring pendant. On PATROL PLANES, the anchoring pendant serves as the mooring pendant.

When you're aboard a patrol plane and approaching for mooring, the pilot brings your craft toward the buoy SLOWLY—from DOWNWIND—and maneuvers with controls and engines to bring the buoy close aboard the PORT BOW. Members of the crew—wearing life jackets—have all gear in readiness and are set to go to work from the mooring platform or rail. Someone should have an AUXILIARY manila line with HOOK attached, ready to pick up the buoy by means of the ring. When the line is passed through the ring and the plane temporarily secured, it is time to stop the engines.

The marker buoy is picked up next, so that the buoy pendant can be reached and shackled to the plane's mooring pendant. Then you can cast off the manila line from the buoy ring, because—YOU'RE MOORED.

Under extreme conditions you may also be called upon to secure the towing bridle to the buoy pendant. Another extra precautionary measure sometimes used when the weather's really bad is to drop the regular anchor in addition to mooring. If you're operating from a patrol plane, take care that the anchor cable is placed so that it won't foul the mooring gear if the plane swings in a shifting wind.

In unmooring a patrol plane, be sure to wear your LIFE JACKET if you're going to be working OUTSIDE the hull. First make ready all gear and tools. Then the auxiliary manila line should be passed through the buoy ring and both ends of the line secured. With the aid of the lizard, the mooring pendant is raised and unshackled from the buoy pendant. The airplane may then be permitted to drift back by allowing one part of the manila line to slip through the buoy ring. Keep a strain on the line as you drift. Get all your gear stowed while the engines are being started. When they're purring, the airplane may be taxied away from the buoy by freeing one end of the manila line and hauling in on the other end to clear it from the buoy ring.



CHAPTER 11

AVIATION SEAMANSHIP

HANDLING BOATS AROUND PLANES

AVIATION SEAMANSHIP relates to the WATER HANDLING OF SEAPLANES AND AMPHIBIANS—in all aspects—and to the OPERATION OF SURFACE CRAFT, large and small, in connection with such airplanes. Ordinarily there'll be a regular coxswain available for the job of handling small boats around waterborne aircraft, but you never can tell when EMERGENCIES are likely to arise, and YOU may be elected to take over. So it behooves you to absorb as much "savvy" of aviation seamanship as you can.

There are certain HABITS, common to the whole seaplane family, which you'll have to take into account whenever you're handling them—whether in independent operations or in operations involving the use of surface craft—such as towing, hoisting aboard ship, or lowering from ship to water. Here's a list of these FUNDAMENTAL CHARACTERISTICS of seaplanes—

On the water, with engine IDLING, a seaplane normally HEADS INTO the wind.

On the water, with engine STOPPED, a seaplane drifts quite rapidly before the wind and HEADS INTO (or very nearly into) the wind.

- A seaplane, when anchored or moored to a buoy with no current in the stream, rides HEADED INTO the wind.
- When anchored or moored to a buoy with current running, a seaplane will be CARRIED DOWNSTREAM by the current but will also tend to HEAD INTO the wind. The position which it assumes will depend on the combined effects of both wind and current.

Watch that boat, when approaching a seaplane. The construction of seaplanes, particularly of the wing and tail surfaces, has to be LIGHTWEIGHT. So they're liable to suffer severe damage if bumped against the ship's side or into contact with small boats. In your mind's eye, always look on seaplanes as if they had "HANDLE WITH CARE" signs plastered all over them.

In the normal course of operations, LIGHT-DRAFT boats which have a LOW FREEBOARD and are easy to maneuver should be used in going alongside seaplanes. The boats best suited for the purpose are 26-foot MOTOR WHALEBOATS and 24-foot MOTOR-LAUNCHES, but in a pinch you can use ANY type of boat, as long as it has good backing power.

WHY BOATS ARE NEEDED

There are a lot of reasons why you'll be using boats for duties in connection with seaplanes. For instance, there's the job of TOWING a plane, perhaps to a new location, or to a ship to be hoisted aboard, or away from the side of a ship. Boats are also used for placing crews aboard planes, or removing them to shore. Maybe you'll have to go alongside planes that have crashed. Or you may be detailed to help REFUEL a seaplane from a boat.

As coxswain of a power boat tending planes, you have to be thoroughly familiar with the MANEUVERING qualities of your craft. There's as much difference between types of boats as there is between a tin lizzie and a fire engine, when it comes to maneuverability. Small boats used around seaplanes should always be equipped with soft fenders or "puddings" around bow and gunwales. These are usually made of canvas stuffed with kapok, or of tubular rubber.

Figure 37.—Small boat approaching a seaplane. Inset—Method of approaching a drifting seaplane.

What's the best method for approaching and going alongside a seaplane if you're in a motor whaleboat or motor launch? The answer to that one depends upon the condition of WIND, SEA, and TIDE. There are some good general rules to follow, with an eye to these factors. You approach a DRIFTING seaplane from windward as in figure

37, so that it won't drift down on you. A plane drifts more rapidly than a boat, as it has a greater surface exposed to the wind. But a MOORED or ANCHORED seaplane should be approached AGAINST wind or current, depending upon which has the most influence. Always approach in such a way that your boat will tend to drift AWAY from the plane in case your engine stops.

You'll keep your record clean every time if you follow orders carefully and—

Avoid CONTACT between boat and seaplane. Seaplanes are delicate.

Use MINIMUM power on your boat engine. Don't approach drifting seaplanes from the stern.

Make sure that the men in your boat fend off by HAND—NOT with boathooks.

Stay clear of planes until swells from passing ships have SUBSIDED.

Avoid unnecessary DELAY when transferring personnel between boat and plane.

Never go alongside a seaplane which has its engines running unless ordered to do so by the pilot, and then KEEP CLEAR OF THE PROPELLERS.

If it is ever necessary for you to tend a seaplane with a large power boat that is difficult to maneuver, it is a good plan to anchor AHEAD of the plane and allow the boat to DROP BACK by veering the necessary amount of chain. If the seaplane is small, it is possible to anchor the boat and pull the seaplane up to the boat.

TOWING SEAPLANES

TOWING A SEAPLANE on the water presents some special problems, but they'll usually solve themselves if your remember those fundamental habits of water-borne aircraft that were pointed out earlier. Varying conditions of wind and sea, the available gear for the towing operation, and the type of towing craft will all affect the choice of tactics and methods for attacking the particular job.

Old-timers will tell you that towing operations usually fall into one of two classes—

The towing of SMALL, FLOAT-TYPE SEAPLANES by small boats for relatively SHORT distances.

The towing of PATROL-TYPE SEAPLANES by large or small surface craft for comparatively GREAT distances.

Why? Because all capital ships, cruisers, and carriers of our fleet are equipped to hoist aboard small types of seaplanes and to stow them properly. Small boats can handle the necessary towing, as the hauls are short. On the other hand, only a FEW aircraft tenders have facilities capable of hoisting LARGE patrol seaplanes aboard, and even then can do so only under VERY favorable conditions. What's the answer? LONG hauls whenever towing of patrol planes is necessary.

The operations of small seaplanes with the fleet are such that, if there is a forced landing and towing is required, there is almost always a near-by ship which is equipped to furnish a boat for towing the plane alongside. Patrol planes, however, operate over large sea areas, and ships equipped to take them aboard are SELDOM available.

TOWING GEAR

Ship-based seaplanes are commonly towed by means of line—or lines—secured around the FORWARD float struts and led through the cleat at the BOW of the float, as shown in figure 38. Most planes of this type do not carry their own permanently installed towing gear, so it must all be provided by the towing boat. This gear includes a 21-thread manila TOWLINE which is 20 fathoms long (120 feet), TWO WING LINES, also 20 fathoms long and equipped with heaving line, and CHAFING GEAR (for seaplanes not equipped with towing shackles at the base of forward float struts).

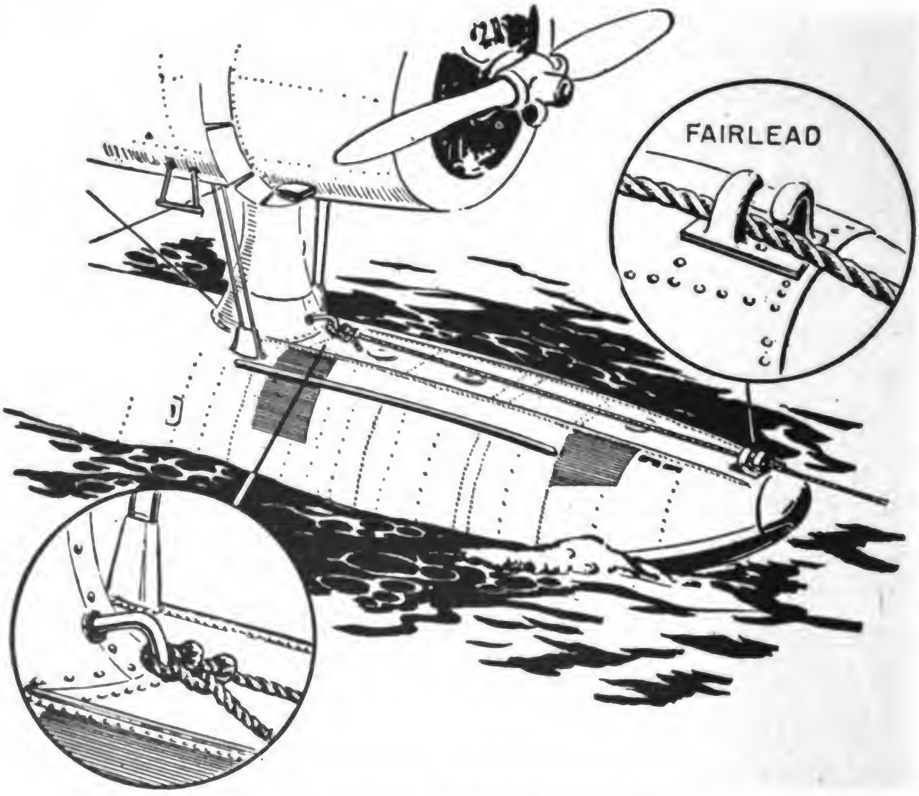


Figure 38.—Securing a towline to a seaplane.

A 20-fathom towline is long enough to allow an approach to a drifting seaplane—bows on—from windward, to pass the towline, and to turn and head into the wind before taking a strain. In LIGHT winds, sometimes it's better to approach the seaplane from abeam and turn into the wind just ahead of the plane, passing the towline as the turn is made. The approach in figure 37 is being made that way.

Whichever approach you make, the boat must be kept directly to WINDWARD of a DRIFTING plane and—as soon as the towline is passed—maneuvered to head into the wind straight AHEAD of the aircraft. If towing is to be done across wind, the seaplane should then be pulled up near enough to the boat to pass wing lines. Here's a tip to the wise—DON'T HESITATE TO USE WING LINES, as in figure 39. They are mighty useful in steering a plane that's in tow, and are especially important on the windward wing to prevent yawing when towing across wind. But don't put the strain of towing on the wing lines. They are not meant for such use.

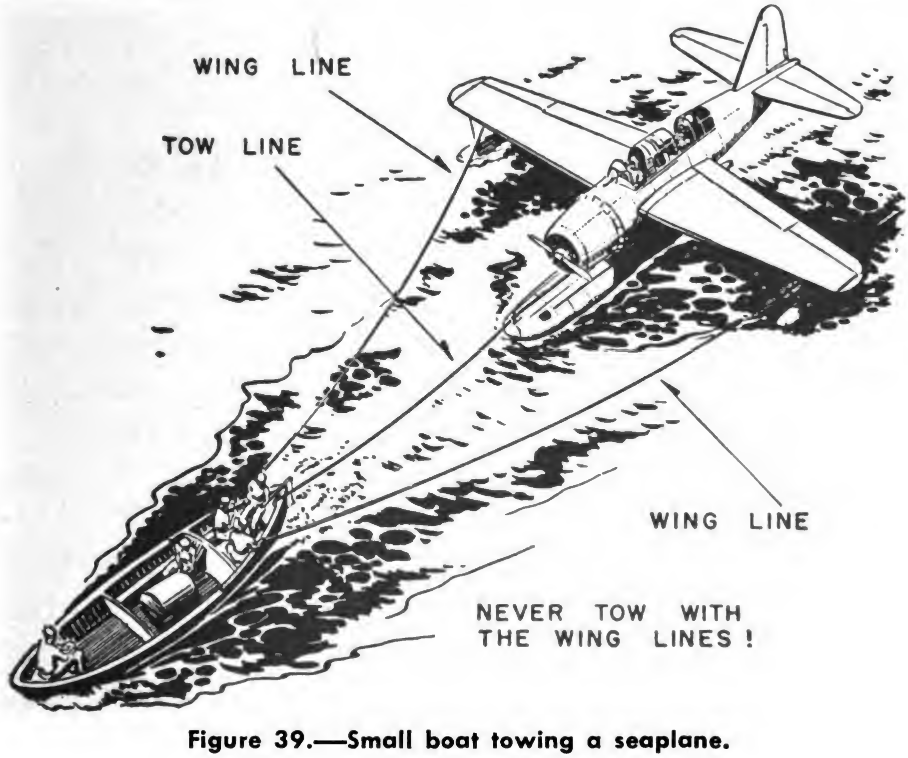


Figure 39.—Small boat towing a seaplane.

It is best if the ship to which a seaplane is being towed is also kept to WINDWARD. Such a position not only permits an up-wind tow, but also provides the protection of the LEE. When you reach the ship, pass the towline and wing lines up to the deck so the plane can be hauled under the hook.

TOWING PATROL PLANES

What about towing the patrol-type plane? When water conditions are smooth, these bigger craft may be towed by means of the anchoring and mooring pendant, with the aid of steadying lines. But if you have to tow a loaded plane a long distance—or through a rough sea—you'll be needing a TOWING BRIDLE.

All patrol planes are equipped to accommodate a towing bridle. Rings for the purpose are provided in the leading edge of monoplane wings. The rig you use will depend upon the circumstances, and the particular practices of your operating unit.

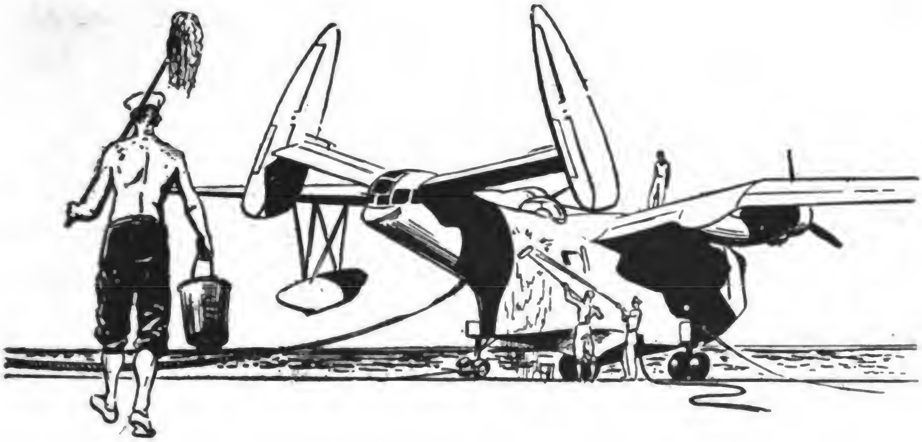
DISABLED PLANES

If a seaplane is DAMAGED OR DISABLED on the water, what's the first thing you'll do? Right. Look after the PERSONNEL aboard the plane. Make sure they're safe and not in immediate danger. Next, the RESCUE VESSEL should proceed to a spot alongside, where a line can be thrown to the plane. If that's impossible a boat must be lowered to tow the plane to the ship so that efforts can be made to hoist it from the water.

The HOISTING SLING, located above the upper wing of seaplanes, is almost always the best place for attaching the hook suspended from the boom on board ship. Damaged planes, however, don't behave the way you would like, most of the time. Often it's necessary to fix up a JURY RIG for hoisting.

The PROPELLER HUB, the ENGINE MOUNT, the ARRESTING HOOK or SLING EXTENSION (on carrier-based airplanes), or the JUNCTION OF BRACES in the fuselage (where the arresting hook is fastened when installed), are useful points for attaching a jury rig. If you can't use these strength members as attaching points, then STRAPS (wide ones) can be passed through a fuselage bay and led to the hook or a common junction point for hoisting. Chafing gear, and spreaders to hold the straps in place, should be employed to prevent further accidents or damage to the plane.

As the plane is raised slowly from the water, openings must be made in the fabric of wings and fuselage to release the water that has entered. The easiest way to make them? Slit the fabric with your jack-knife. If the hoisting gear still can't handle the load, you may have to punch a hole in the bottom of the hull or floats to let the water run out. But remember, that's only a LAST RESORT.



CHAPTER 12

CLEANING AND INSPECTING

WHY KEEP 'EM CLEAN?

A FLIGHT INSPECTION must be made EACH DAY before any flying is done in a service airplane. But before an inspection can be carried out properly the airplane must be thoroughly clean, INSIDE AND OUT. In case you're wondering why cleanliness is so important in airplanes, there are a number of answers. Any one of them is sufficient in itself to justify rigid cleaning rules.

It is easy to overlook something like a cracked landing gear fitting if it's covered with MUD or GREASE.

Vibration may cause cracks in the skin, loosen nuts, cause hinge fittings to wear and develop elongated bolt holes. DIRT HIDES THESE DANGER SIGNS if the airplane isn't cleaned properly and often.

The flying speed of an airplane—yes sir, the thing it needs most in combat—may be SERIOUSLY affected if a dirt film is allowed to collect on it's outer surface.

Dirt, trash, or loose gear—blowing or bouncing around inside the airplane is both annoying and DANGEROUS. A little dirt in the eyes of a pilot or crewmember at a critical time can cause all kinds of trouble.

Dirt collecting and allowed to remain on lubricated controls encourages CORROSION and WEAR.

The combination of dirt and grease on movable parts often results in making a "grinding compound" that causes a FAILURE if not caught in time.

WASHING DOWN

First, you can get going by WASHING DOWN a plane, as the boys are doing in figure 40. Usual practice is to WET THE OUTSIDE THOROUGHLY with a water hose. Don't turn on the water, though, until you've made certain that all doors, hatches and windows are closed. When you're using the hose, try to AVOID WETTING THE ENGINE. Engines are built to withstand heavy storms, but there is no point in soaking the electrical connections unnecessarily.

Use a ladder or scaffold to stand on, and begin washing on the TOP SURFACE of the wing. If oil and grease have been thrown back on the cowling and tail surfaces by the engine, soap and brush may not be enough to remove them. It may be necessary to use an approved CLEANING SOLUTION. Scrubbing with soap and brush will normally do the trick, however.

Be careful not to let any water enter the WING by getting in around strut or fitting openings. Water inside the wing will cause deterioration. When all surfaces have been scrubbed with soap (or cleaning solution) and thoroughly rinsed with clear water, the airplane should be WIPED DRY with a clean chamois or rags wrung out in clear water. Don't step on the cowling or wing skin while you're washing and wiping them. They're easily dented, and hard to repair. Airplane fabric should be wiped off daily and washed at least once a week. NEVER USE GASOLINE for cleaning doped or painted surfaces, or salt water for washing and rinsing.

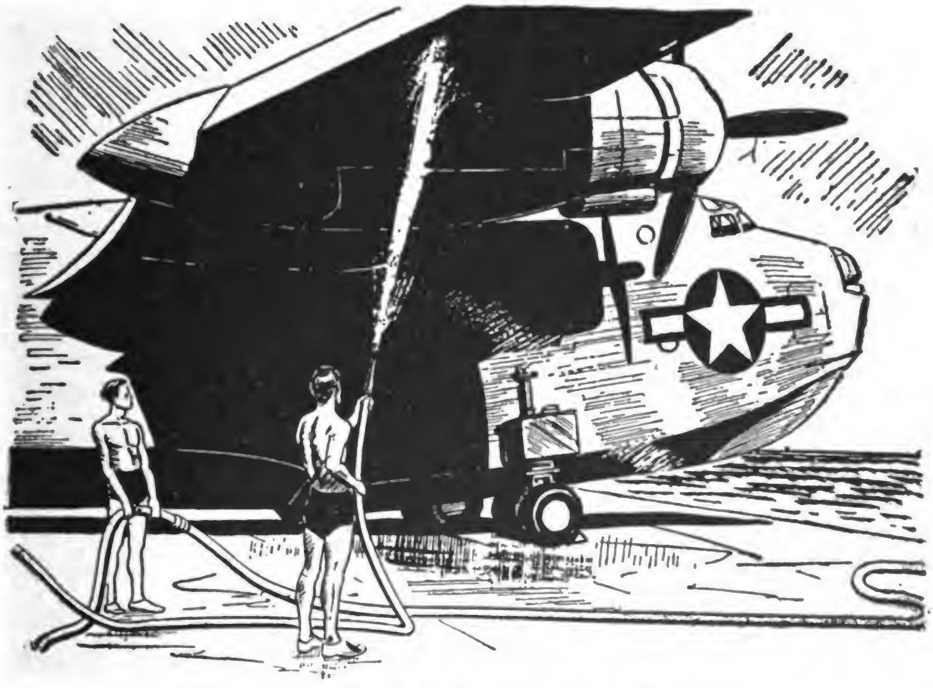


Figure 40.—Washing down a flying boat.

PREVENTING CORROSION

When an airplane is operating around salt water, metal parts tend to CORRODE rapidly. Such metal should be inspected frequently for signs of corrosion, particularly if not painted. Dirt and rust should be removed immediately, and the surfaces coated with OIL or a RUST PREVENTIVE.

On aluminum alloy surfaces, signs of corrosion will first appear in the form of a white powdery substance (aluminum hydroxide). You should watch for these signs carefully, particularly on rivets, seams, fitting, and propellers. If corrosion has started, take IMMEDIATE steps to check it. Wash the area, see that ALL traces of corrosion are removed, take care that you do not damage the metal while cleaning it, and have the area treated to prevent further corrosion. If priming and painting are required, you can refer to "Process Specifications" for full and latest details on WHAT and HOW.

CLEANING ENGINES AND PROPS

Now to clean up the ENGINE. It should be washed down with a spray, using fresh water or approved cleaning solution. Magnetos, starters, and generators should be covered. Clean around them with a bristle brush to keep the spray pressure from driving the cleaning solution inside the housings. Wash the TOP cylinder first, and avoid spraying electrical equipment. Then you can dry the engine, using CLEAN rags—NOT waste. How often should the engine be cleaned? That will depend on conditions under which the airplane operates. In other words—whenever necessary, remembering that the engine and it's accessories MUST be kept clean at all times.

Next comes the PROP. The life of a propeller depends largely on the care given it IMMEDIATELY after EACH flight. An aluminum alloy propeller, when used in salt air, will become coated with a light film of powdery aluminum hydroxide. In itself, this fine white powder does little harm and you can remove it easily by wiping the blade with a coarse cloth, followed by rubbing with oil. Old oil drained from aircraft engines is one of the best kinds for this. The free carbon in such oil acts as a mild abrasive, the traces of sulfuric acid present remove the hydroxide deposit, and the oil film left on the propeller blade keeps the salt air from it.

WATER SPRAY, striking a whirling propeller blade, does so with such force that small pits are often formed on the blade's leading edge. If you don't do anything about them these pits RAPIDLY grow bigger through corrosion. Blades subjected to salt water spray should be rubbed down with crocus cloth and oil after every flight. Otherwise the pits will get so big you'll have to remove them with a file. In turn, filing may necessitate rebalancing the blade—which is a considerably bigger job than you might guess.

Steel propeller blades have somewhat more resistance to abrasion and corrosion than aluminum alloy blades and, if rubbed down with oil after each flight, will retain a smooth surface for a longer time. On either steel or aluminum alloy blades, oil tends to oxidize in any cracks present, making them stand out as dark lines and thereby easing the job of inspection for defects.

Propeller HUBS should also be inspected regularly for cracks and other defects. You won't be able to find defects unless the hub surface is kept in its original bright condition. That's why paint is never used on hubs. If the plating is damaged or removed, be sure to keep the surface oiled.

CLEANING ENCLOSURES

Next job? Cleaning the COCKPIT ENCLOSURES, TURRETS, WINDOWS and other PLASTIC applications. And this is a chore to be handled carefully if ever there was one. Be gentle! Remember, the pilot, gunners, and other crew members depend upon being able to SEE through these "windows." Rough handling won't do!

The sheet plastic materials of which these parts are made react to too much buffing or polishing by

LOSING their transparency. You can't restore the original luster or successfully remove minor scratches by applying elbow grease. CAREFUL cleaning—in accordance with standard methods—will reduce to a minimum the necessity for polishing, so believe the book and follow the rules. Otherwise you'll have the pilot flying blind at high noon on a sunny day.

Before you start actual cleaning operations, FLUSH the plastic enclosures thoroughly with fresh water. On Naval airplanes, salt from sea water crystallizes and deposits on enclosure surfaces. Flushing with fresh water dissolves the salt and helps prevent scratches. Then go over the plastic with a water solution of MILD soap, using a CLEAN grit-free cloth, chamois, absorbent cotton or—best of all—your BARE HANDS. Rinse with fresh water, and dry with a damp chamois or some absorbent cotton—NOT with a dry cloth. A dry cloth may cause scratches, and it will build up an electrostatic charge that attracts dust particles to the surface.

Oily or greasy dirt may be removed from plastics with kerosene, naptha, hexane or—if you don't have these materials at hand—with UNLEADED GASOLINE. WARNING! DON'T USE aromatic fuel for this purpose. Absorbent cotton is best for applying solvents, you'll find. If there's a lot of dirt and grease on a plastic enclosure, you may have to follow up with a regular soap-and-water wash job to make the surface spic-and-span.

When you're nosing around, looking for a grease solvent that you can use on the plastic enclosures, don't grab the first thing you see. The substances mentioned above as being suitable have some dangerous cousins. NEVER, for instance, use acetone, benzene, lacquer thinner, toluene, ethyl acetate, ordinary kitchen cleaner or commercial window sprays. They will RUIN the plastic material or at least will MAR the surface.

As soon as you've cleaned the plastic surfaces, apply a coat of WAX to them. It will cover minor scratches, give the surface a good gloss, and HELP PREVENT further scratches. The following waxes have proved satisfactory for the purpose—

"3–M Automobile Wax."
"Simoniz Wax"—(not "Kleener").
"Wilco Plastic Polish."
"Johnson's Paste Wax."

Any static electric charge caused by the waxing can be removed with a damp, clean chamois.

INSPECTING

Each day, before any flight is made in a Naval airplane, a DAILY FLIGHT INSPECTION FORM (N. Aer. 3119, or "Yellow Sheet") must be filled out and SIGNED. The data on this form apply to all service-type airplanes, but many operating units use an additional sheet for recording details peculiar to the particular airplane they're using.

The plane captain, or whoever is officially detailed to make inspection, fills out these forms. He checks the form to be sure everything is shipshape before signing on the dotted line.

There are still more spaces to be filled in on the form before the day's over. A HISTORY OF THE FLIGHT is entered—including times of takeoff and landing, total time, purpose of flight, average rpm of the engine, fuel and oil pressures, and oil temperature. Also noted are the names of the first and second PILOTS, and of any PASSENGERS. A permanent record of this information is also made in the plane and engine logs.

After the flight, the pilot signifies, in writing, on this form that the airplane is either SATISFACTORY in all respects or that DEFECTS have been observed. If the latter, a remark concerning each defect is entered.

No doubt, you will be detailed to carry out an actual inspection. Here's a basic check list—and don't miss a point. A miss may mean a WRECKED AIRPLANE, and maybe LOSS OF LIFE.

—PROPELLER—

Inspect BLADES for pits, cracks, nicks, and proper oil film.
Inspect prop HUBS and ATTACHING PARTS for defects, tightness, and proper safetying.
Check VARIABLE PITCH PROPELLERS for adequate lubrication.
Check propeller SPINNER for security of attachment.

—ENGINE—

Inspect ENGINE COWLING—including ring cowl and flaps—for cracks and security.
Inspect EXHAUST STACKS for cracks and security.
Check SPARK PLUG TERMINAL ASSEMBLIES for cleanliness and tightness.
Inspect accessible IGNITION WIRING AND HARNESS for security of mounting.
Clean MAIN FUEL LINE STRAINERS.
Drain a small quantity of fuel from BOTTOM DRAIN and inspect for presence of water and foreign matter.
Check FUEL AND OIL SYSTEMS for leaks, tightness of tank caps, and to make certain that VENTS are clean of obstruction.
Check security of OIL DRAIN PLUGS.
Check FUEL and OIL supply (do not rely on gages).
Turn handle of disk-type OIL STRAINER (if installed) at least one revolution to clean it.

—LANDING GEAR—

Inspect TIRES for defects and proper inflation.

Check WHEELS for cracks and distortion. See that hub caps are secure.

Inspect SHOCK ABSORBER UNITS and BRAKE LINKAGE GEAR.

Check STRUT RETAINING BOLTS and fittings for security.

Inspect BRACE WIRES for tension and security.

Check the RETRACTABLE LANDING GEAR mechanism and lubricate as necessary.

Inspect MAIN FLOAT (or floats) or HULL for leaks, presence of water, and security of handhole covers and vents.

Check BEACHING GEAR tires, wheels, locking-pins, and attachment fittings.

—WINGS—

Inspect COVERING for damage, buckled ribs and end bows.

Look over the ATTACHMENT FITTINGS for security.

Check AILERON HINGES, PINS, HORNS and TABS for security of attachments, proper lubrication, and position.

Inspect and check operation of LANDING FLAPS or DIVING FLAPS. See that there are no hydraulic leaks.

See that all accessible CONTROL CABLES, TUBES and PULLEYS are secure and properly lubricated.

Check WING-TIP FLOATS for leaks, presence of water, and security of handhole covers and vents.

Remove all SURFACE CONTROL LOCKS before flight.

—TAIL—

Inspect COVERING for damage, buckled ribs, and bruised edges.

See that ATTACHMENT FITTINGS are secure.

Check STRUTS and BRACE WIRES for security of terminal connections.

Check the control SURFACE HINGES, PINS, HORNS and TABS for security of attachments, proper lubrication and position.

Inspect CONTROL CABLE, TUBES, and PULLEYS for security and proper lubrication.

Check TAIL SKID or WHEEL assembly for condition and lubrication, noting position of locking device.

Remove all SURFACE CONTROL LOCKS before flight.

—FUSELAGE—

Inspect all BAYS for loose articles.

Check the OXYGEN EQUIPMENT and service.

Inspect the CONTROL COLUMN assembly and accessible parts of control system for freedom of movement, lost motion, security of attachments, and proper lubrication.

See that RUDDER PEDAL assembly and CONTROL SYSTEM operate properly. Check for freedom of movement, lost motion, security of attachments, and proper lubrication.

Prior to carrier operation, check working condition of LANDING HOOK, and inspect its mechanism.

Test operation of NOSE SHUTTERS.

Inspect FLOTATION GEAR and FIRE EXTINGUISHER BOTTLE INDICATORS for fully charged condition.

See that all removable COWLING, FAIRING, and INSPECTION PLATES are secure.

Check proper functioning of LIGHTING SYSTEM.

Make certain all SAFETY BELTS are secure.

See that COCKPIT ENCLOSURES and the ADJUSTABLE SEAT mechanism function properly.

Check position of GENERATOR BATTERY-CHARGING SWITCH.

Make sure there is the proper quantity of fluid in the HYDRAULIC SYSTEM RESERVOIR.

—WARMING UP—

See that CHOCKS ARE UNDER WHEELS.

Check to be sure IGNITION SWITCHES are in the "off" position.

Pull PROP through by hand for at least three complete revolutions.

Warm up and check proper functioning of ENGINE, or engines.

Test engines on EACH FUEL TANK, and place on designated tank for take-off.

Check ENGINE CONTROLS for proper functioning and to detect any lost motion.

See that VARIABLE PITCH PROPELLER operates properly.

During warm up, open the engine's COWL SKIRT FLAPS.

Check position of CARBURETOR AIR CONTROL.

Make certain that CARBURETOR MIXTURE CONTROL functions properly.

Check operation of VACUUM PUMP (if installed) at a speed sufficient to operate instruments.

IDENTIFYING PIPE LINES

Although there are regular mazes of PIPE LINES running through the insides of modern airplanes and their engines, you won't have any difficulty in telling them apart if you get thoroughly familiar with the SYSTEM used for IDENTIFYING them. It's not done with mirrors and wires, and there's nothing baffling about it. Each pipe has it own particular kind of "dog tag" in the form of COLORED BANDS painted around it. Various COMBINATIONS OF COLOR have been universally agreed upon to DIFFERENTIATE ONE PIPING SYSTEM FROM ANOTHER.

The color bands are one-half inch wide. They are PAINTED NEAR EACH END OF A PIPE, and also at INTERMEDIATE POINTS where they'll be helpful in following the pipe through the system. A little study of figure 41 will familiarize you with the whole setup.

PERIODIC INSPECTIONS

In addition to daily flight inspections, REGULAR CHECKUPS on Naval airplanes are required at DEFINITE INTERVALS. You will obtain "PERIODIC

AIRCRAFT INSPECTION FORMS" from the Bureau of Aeronautics, but you'll find there are features on certain airplanes that are NOT covered by the forms and sometimes it's necessary to ADD to the list of points to be inspected. In some other instances you'll want to MODIFY the forms to meet the requirements of a particular case.

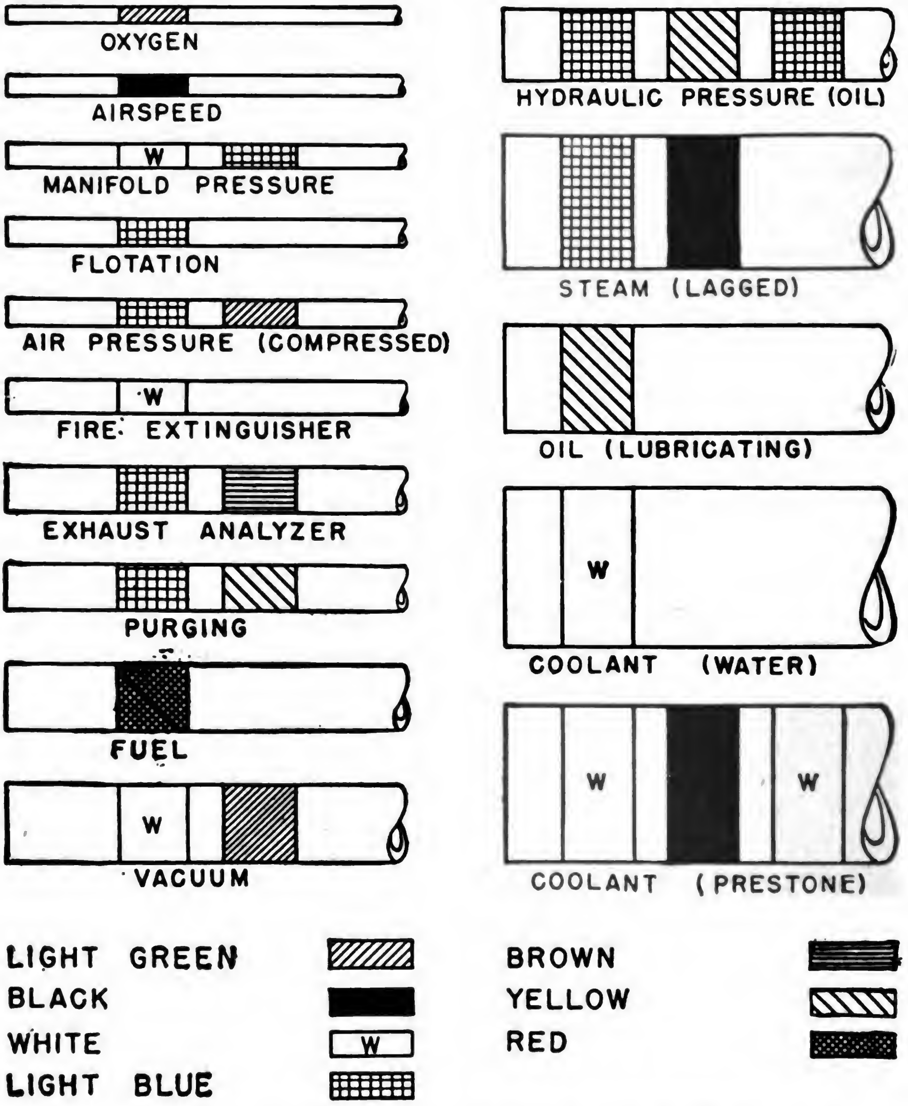


Figure 41.—Markings of aircraft piping systems.

It will be necessary to have further inspection forms prepared and printed for checks and inspections, which are required at intervals NOT

COVERED BY THE BUREAU FORMS—such as for the 60-hour and 120-hour inspection. If you are having these forms prepared, be sure to include the items covered by the Bureau forms as well as the items requiring inspection at these special intervals.

Under some circumstances, such as when the climate or service conditions are adverse or unusual, certain parts of airplane equipment may require inspection MORE FREQUENTLY THAN SPECIFIED by the Bureau of Aeronautics. If you're working under such conditions, additional forms should be prepared and ready for use.

Every airplane must be supplied with TAKE-OFF and LANDING CHECK-OFF lists for the pilot's use. These lists should be posted in the cockpit and maintained in an easily readable condition. They include all the points to be checked—and the acts to be performed—by the pilot in landing and taking off.

ROUTINE CHECKS

The pilot will note any defects he discovers during flight. The plane captain also makes an inspection, and any defects he or the pilot have discovered MUST BE CORRECTED before the next scheduled flight of the plane. If there isn't enough time to make the airplane shipshape, the plane captain's duty is to make a FULL REPORT to the flight officer who is responsible for carrying out operations scheduled by the squadron commander. Even though nobody finds or reports any defects, there are still a number of routine inspections to be made from time to time.

After each flight you should check over all parts which have been treated with protective coatings of GREASE or WAX. If any corrosion is found, or the protective coating has deteriorated, take care of it—pronto.

Fuel tanks which don't have sumps and sump drains should be DRAINED AND CLEANED once every 30 days.

All PARACHUTES must be unpacked and inspected at least ONCE a month. That's orders! New SELF-INFLATABLE LIFE JACKETS should be tested thoroughly at the end of their FIRST month in service, and at SIX-MONTH intervals thereafter.

Wheel-brake mechanisms need careful inspection throughout—every SIX weeks or less. In fact, to prevent possible deterioration, ALL accessible parts of the airplane should be inspected periodically. The squadron commander decides how often, but these checkups should all be conducted at least ONCE every six weeks—oftener if possible.

All fixed or portable FIRE EXTINGUISHERS (carbon dioxide type) must be tested every SIX months.

SAFETY BELTS—and remember, the accent is on SAFETY—must get careful visual inspection every TWO months or less for signs of deterioration and other possible flaws. TWICE a year they are put through a "static load" test to check for any indications of weakness in the webbing or the release.

PILOT'S SAFETY BELTS must stand up under a 500-pound test load. GUNNER-TYPE BELTS have to be able to pass a 400-pound pull. And SIDE STRAPS of gunners' belts must not fail under a load of 250 pounds. Be sure the RELEASE BUCKLE is still in free-and-easy working order after the tests are finished. There's no percentage in wrecking good gear while your checking it.

SELF-INFLATABLE LIFE JACKETS have gas-filled cylinders (carbon dioxide) which blow them up.

It's necessary to inspect the jackets FOUR or FIVE times a year to make certain there's no corrosion of the cylinder walls which might let the gas escape. Coat the cylinder and its container with light oil to protect them from such corrosion. IT MIGHT BE YOU that'll be wearing that life jacket in a pinch, so be guided accordingly.

On all INFLATABLE LIFE RAFTS the cylinder valve seals have to be inspected QUARTERLY. Replace the cylinder IF the seal is found to be broken. Rafts of this kind are given complete inspections and tests BEFORE being placed in service and SEMIANNUALLY thereafter. When in storage, ONCE-A-YEAR inspection is adequate. Here's the method you'll use for testing rafts—

WEIGH THE CYLINDER COMPLETE. Put in a new one if it weighs one-half ounce less than the total weight stenciled on the side.

INFLATE THE RAFT to see if the inflation system is working correctly.

Remove the CYLINDER AND PLUGS from the manifold. TEST ALL MANIFOLD CONNECTIONS for airtightness by applying soapy water to them.

Inspect all EXPOSED METAL PARTS for evidence of corrosion, and examine the body of the raft for deterioration.

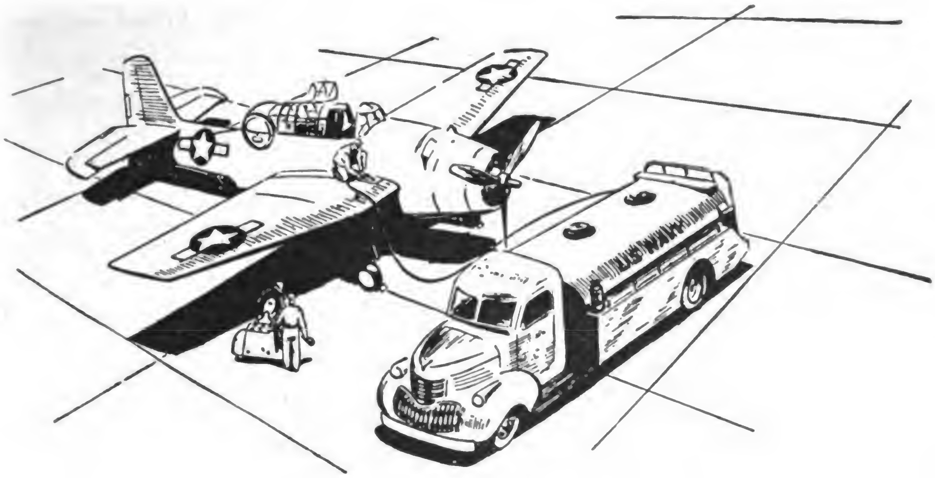
See that all the LOOSE EQUIPMENT IS PRESENT, COMPLETE, and in GOOD condition. Try the HAND PUMP to see that it's in working order.

Let the raft STAND INFLATED for 24 hours. There shouldn't be any undue deflation in that time.

Deflate the raft and REATTACH THE CHARGED CYLINDER. Treat the threaded plugs of the manifold with anti-sieze compound, and screw all connections tight.

POWDER THE RAFT thoroughly WITH TALC, and fold carefully so as to avoid chafing. Be certain that the inflating valve is IMMEDIATELY accessible.

Put a TAG on the raft with date of inspection on it. Then REPLACE the raft in its carrying case.



CHAPTER 13

FUELING AND STARTING

FUELING ASHORE

Keeping the gasoline and oil tanks of an airplane filled up is more important than you might realize at first thought. The fact is that MOISTURE FROM THE AIR will condense on the exposed interior surfaces of PARTIALLY-FILLED TANKS. Before long there will be WATER in the fuel system, and you will be in a fix. DON'T LET IT HAPPEN.

IMMEDIATELY after any flight, the fuel and oil supply of an airplane should be replenished. Refueling an airplane is a bigger job than taking the family sedan down to the filling station, however. Be sure you have received COMPLETE AND PROPER INSTRUCTIONS before you tackle it.

First of all, the airplane should be in a SAFE PLACE where there's NO FIRE HAZARD. Be POSITIVE that the switch is "OFF" and that the wheels are chocked carefully. The fuel trucks must be driven carefully into position, and a portable fire extinguisher should be placed near the airplane. Assemble all the necessary equipment for your job and see that every piece of it is cleaned thoroughly. Rinse the funnel with fresh gasoline. Clean the hose nozzle before using it, and keep it from touching the ground or otherwise picking up dirt.

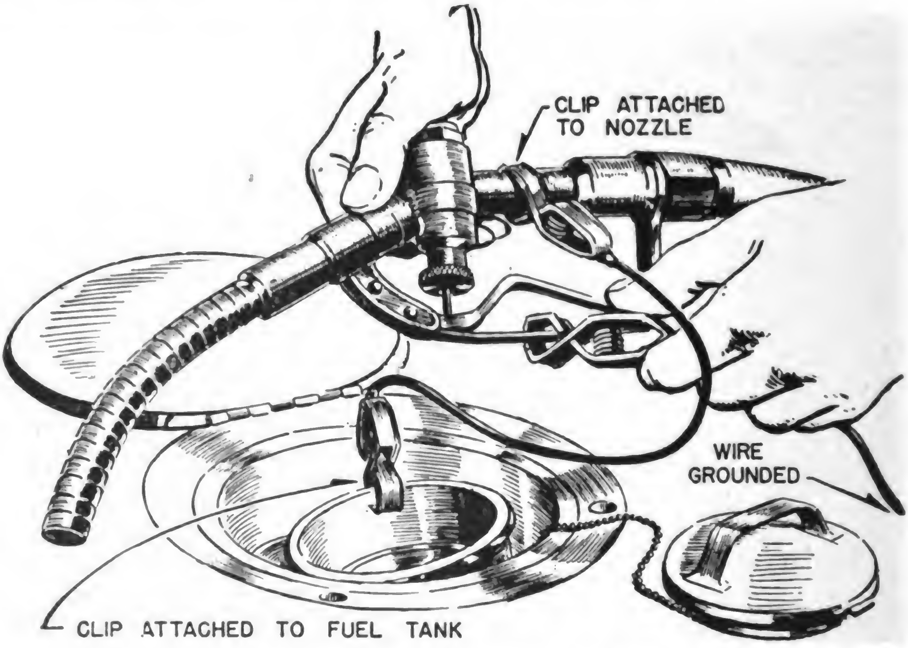


Figure 42.—Grounding nozzle and fuel tank.

Gasoline flowing through a hose builds up a CHARGE OF STATIC ELECTRICITY. When you withdraw a hose nozzle from the tank of an airplane, this charge can easily create a spark that will set the gasoline AFIRE, if you don't take proper precautions in advance. BEFORE you start refueling, the hose nozzle and the funnel MUST BE GROUNDED—that is, electrically connected to the earth to remove the charge.

Usually, you'll find that Naval refueling hoses have a GROUND WIRE which automatically makes connection with the earth through a conducting hose. If so, connect that wire to some METAL part of the airplane, such as the tank or engine.

If you're not using a hose that is so equipped, however, you can easily rig a suitable grounding system. A short wire with clips at each end should be obtained. You attach one clip to the nozzle and the other clip to the fuel tank of the airplane, as in figure 42. Then attach another wire to the nozzle or to the airplane, and connect the free end of this wire with the earth. If you're drawing fuel from an underground tank, make an electrical connection between the nozzle and the storage tank.

Danger from static electricity is a lot greater JUST BEFORE—AND DURING—an electrical storm, so avoid doing any refueling at such times except when ABSOLUTELY necessary. If it MUST be done, ground the airplane by running a wire or chain from the engine mounting, or some other metal part of the fuselage, to the earth BEFORE any other operations are started.

One of the big BUGABOOS in refueling is the possibility of getting WATER into the fuel tanks. It's worse than getting salt in the sugar bowl! If there's the slightest chance that water has crept into the gasoline, it must be STRAINED.

Fortunately for you, most refueling trucks and underground storage systems have WATER SEPARATORS which automatically filter the gasoline before delivering it to the airplane tank. These separators should be checked regularly and drained of any accumulated dirt and water. When clean and operating properly they are a big help.

You may, however, have to use a strainer funnel in filling an airplane fuel tank. There are several types made which have patented strainer equipment. Some of these are good, others are not. You'll have to test their effectiveness separately before using any of them for filling an airplane tank.

When an approved patented strainer funnel or regular separator isn't on hand, you can IMPROVISE an excellent strainer by placing a chamois skin loosely over the mouth of a funnel and tying it in position. Chamois skin used for straining must be washed with soap and water to remove the sediment which will tend to clog its pores. Then it should be AIR DRIED and RINSED thoroughly in clean gasoline before being used.

POOL-TABLE FELT over your funnel also makes a good strainer. You'll find that it strains fuel more quickly than chamois, but will have to be changed more frequently as water accumulates, because the water will eventually pass through.

Gasoline that has been stored in 5– or 10–gallon cans must ALWAYS be strained before it can be used in an airplane. Such fuel invariably contains water and sediment as the result of condensation and rust.

DOUBLE OR NOTHING on this question! How would you refuel an airplane in the open during a RAINSTORM? No! You wouldn't wait till it stopped raining. You'd place a waterproof cover over the filler neck of the tank, and work underneath it.

Never remove the filler cap from a fuel tank until everything else is ready. If you're using a funnel, place it in the filler neck so that the weight of the funnel—and its load of gasoline when the fuel is flowing—is not on the neck. It may easily be bent. The tank itself might even buckle or crack.

When you're finished with the actual refueling of all tanks, measure the amount of gasoline in each tank carefully and record it exactly. Use a CLEAN measuring stick, and DON'T RELY ON GAGES. Inspect all gas tank vents to see that they are open. Check to see that the chain on the filler cap is in good order. Replace the gas tank cap and be certain IT IS SECURE. Then pick up all rags and gear used during refueling and return them to the places in which they belong.

Here are some valuable tips on gasoline and how to handle it around airplanes—

Mixtures of gasoline and air in certain proportions are highly EXPLOSIVE. The slightest spark will ignite them.

Gasoline vapor may cause SICKNESS, or even BE FATAL to persons breathing it. Be cautious.

Aviation gasoline may cause serious injury if spilled on your skin. By all means KEEP IT FROM GETTING IN YOUR EYES OR HAIR.

Learn HOW to prevent and extinguish gasoline fires BEFORE YOU HANDLE FUEL.

Be EXTREMELY CAREFUL IN HANDLING TOOLS in the vicinity of fuel lines.

Check gasoline piping and tanks daily for LEAKS, and report findings immediately.

NEVER mix gasoline with oil for use in running an airplane engine. Oil should never be introduced into an airplane fuel system.

Long, unsupported fuel and oil lines in an airplane are likely to VIBRATE loose. The free length of such lines should be cut down as much as possible.

When there is a chance of anything rubbing against a fuel or oil line, FRICTION TAPE or some equivalent insulation must be used.

Carburetor DRIP-PAN DRAINS must ALWAYS be in place, and the discharge from drains must clear the airplane structure.

Chamois leather will separate water from gasoline for a certain length of time only. Water-saturated chamois WILL DISCHARGE WATER from the under side as fast as the top will absorb it.

Chamois leather should be kept dried out when not in use. DISCARD IT after it becomes hardened and cracked.

Always strain fuel in the SAME DIRECTION through chamois.

Wet chamois MUST NOT BE STOWED in an airplane, as it may become a source of gasoline fumes.

Take SPECIAL PRECAUTIONS to prevent fire if it is necessary to refuel an airplane at night.

Airplanes must not be serviced unless all engines are STOPPED, except in flight.

Inflammable liquids are NEVER to be stored in hangars.

Airplane engines are NOT to be run in hangars, unless absolutely necessary.

REFUELING AFLOAT

So far, you've been dealing with the refueling of landplanes, or seaplanes out of water. The job of fueling SEAPLANES AFLOAT is quite a different thing. In general, this can be done in one of two ways—by means of a SMALL BOAT equipped with fuel tanks, or by bringing the plane ALONGSIDE A SEAPLANE TENDER.

Refueling a floating seaplane by means of a small boat brings into use your knowledge on handling small boats around planes. Several kinds of small boats may be used for fueling seaplanes afloat. There's a modern type of 42-foot boat, for instance, that is built expressly for the purpose. More than likely, though, you'll have to use a whaleboat that is equipped with a small BOWSER (fuel tank) and a HAND PUMP.

Getting your boat into position for fueling the seaplane is the first part of the job. The details of reaching position properly will, of course, depend on wind and weather conditions, and will vary with the kind of plane being fueled. The PBM, for instance, has its fuel tanks in the HULL whereas the PBY tanks are in the WINGS and must be fueled from the top.

Naturally, there are a number of positions from which your small boat can fuel a floating seaplane efficiently, and they can't all be considered here. But a discussion of the general principles of refueling from a FEW TYPICAL POSITIONS will furnish you with the basic background for handling the job.

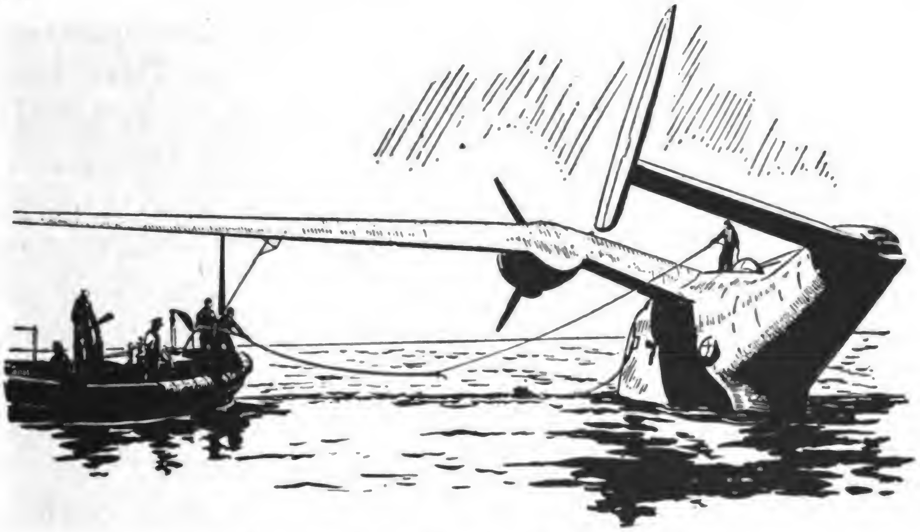


Figure 43.—Passing refueling hose to a seaplane.

Suppose, then, that you're proposing to refuel the PBM—which has its tanks in the hull—from the PORT QUARTER. Don't try to approach with your boat until someone in the plane crew SIGNALS you that the plane is moored. When you've been assured that all's well, bring the boat up AHEAD of the plane and SLIGHTLY TO PORT OF CENTER. Drop anchor about one boat length ahead of the plane.

When the anchor is fast, pay out the anchor line and back the boat down to a position opposite the port stern quarter. Be sure to KEEP CLEAR OF THE SEAPLANE WHILE YOU'RE BACKING INTO POSITION. As soon as the boat is where you want it, pass a line to the plane crew man on the tail of the seaplane to keep the boat from swinging away. If it tends to swing in instead, by all means keep it from hitting. Airplanes are FRAGILE!

Everything should now be ready for passing the gas hose over to the plane. Toss a heaving line to the plane crew, having first attached the hose to YOUR end of the line, as in figure 43. The plane crew then hauls the hose over, taking it in through the after hatch, leading it through the hull and out again through the hatch near the fuel tank. This is done so the plane crew man who is fueling won't have to hold the whole weight of the hose.

Think a moment, now, before you start fueling. Don't forget your precautions against FIRE HAZARD. The plane crew man must "ground" the nose nozzle by trailing a wire from it to the water, or attaching a wire to the nozzle and the side of the plane. The boat crew should stand by with FIRE EXTINGUISHERS—ready for any emergency.

When the fueling is finished, you can cast off the line to the plane and haul in on the anchor line until your boat is clear. As soon as the anchor is weighed, be ready to pull away. It still wouldn't do to let the boat and plane collide.

Another position from which the PBM can be fueled is at the BOW. The bowser boat should be anchored several lengths AHEAD of the plane, and the anchor line paid out until the boat is just forward of the hull. The hose is taken in—by means of a heaving line—through the forward hatch, led through the hull and passed out as before through the hatch near the gas tank.

There are also many positions from which you can refuel a floating PBY. These patrol planes, you remember, have their fuel tanks in the WINGS. Anchor your bowser boat several lengths ahead of the plane, and pay out the anchor line until the boat is JUST FORWARD of the hull. Pass a heaving line to a man on the wing, and the plane crew will haul the hose over the leading edge of the wing to the tanks.

At ADVANCED BASES refueling of seaplanes is usually done from SEAPLANE TENDERS, as shown in figure 44. Depending on the size and type of tender, three methods of fueling are generally employed—FROM THE STERN OF A SMALL TENDER, AT THE END OF A BOOM, or at the STERN OF A LARGE TENDER.

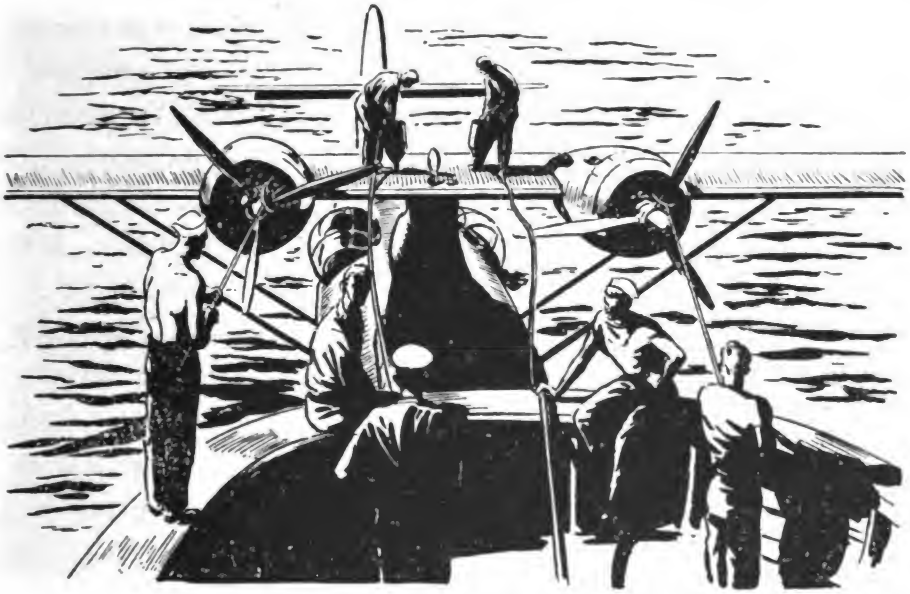


Figure 44.—Refueling a seaplane from a tender.

It is easiest to fuel a seaplane at the STERN FUELING STATION of a small tender. At this station the seaplane is always clear of the ship—which has a tendency to yaw. A long line, FITTED WITH FLOATS, is taken out astern of the tender and picked up by the plane crew. They then haul the plane up to the stern of the tender. Wing lines may be passed to prevent yawing, and other lines passed to haul over the gas hose. WARNING! DON'T LET THE PLANE TOUCH THE SHIP. Use fending poles to keep it off.

FUELING AT THE END OF A BOOM takes training and experience. Tenders have a habit of yawing at the wrong moment when moored or anchored.

The plane crew must keep on its toes to fend off in case the tender swings toward the plane. If you're refueling by this method, a boom is rigged outboard from the tender and the fuel hose is passed along the boom from the fueling station. The plane TIES UP at the end of the boom, and the hose is passed down to the plane crew.

The DECK of a large tender is so far above the water that you had better not bring a seaplane close to the stern for refueling. The plane should taxi in and pick up the end of a floated line—just as when approaching a small tender. But it should not be hauled in too far. Rather, you should secure the plane a short distance astern, so that it can't swing into the ship under any conditions of wind or current. A floated hose is then taken out from the ship by a man in a small boat.

Now, to repeat TWO PRECAUTIONS you've heard before. No matter how, when, or where you're refueling a seaplane afloat, remember that IT IS FRAGILE. And don't forget the EVER-PRESENT FIRE HAZARD. If you're careless, you'll be decorated with a WOODEN CROSS—instead of a NAVY CROSS.

FILLING OIL TANKS

Here are a few words on the subject of OIL. The capacity of airplane oil tanks is clearly marked in conspicuous places on them. You should fill them to this capacity—AND NO MORE. That additional space is for the oil to EXPAND when it gets hot. If you've added too much oil, the tank may overflow in operation.

NEWLY INSTALLED ENGINES, whether just freshly overhauled or brand-new, should have their oil drained and be refilled at the end of the FIRST FIVE HOURS of flight. Thereafter, the interval between oil changes will vary with the type of engine.

Some engines require oil changes after every 60 hours of flight time. Others need draining and refilling after 120 hours of flying. And some models need no change between overhauls, as a general rule. Be sure you know the oil requirements of the engine YOU'RE servicing.

Be sure that NO RAGS OR DIRT get into the tanks to clog up the lines or obstruct the flow of oil when you're refilling or adding lubricant. A clogged oil line can down an airplane as quickly as a broken fuel line.

STARTING

When a pilot gets set for a take-off, he has every right to expect that his ENGINES ARE AS FIT AS A BOXING CHAMPION AT THE OPENING BELL. Anything short of perfection on your end of the line ISN'T GOOD ENOUGH. A slip-up on your part can easily endanger the lives of the entire crew. Their fate is in your hands. There's more to readying an airplane than handling, cleaning and inspecting it. The engines must be in tip-top shape, and running smoothly before the pilot takes over. STARTING THEM, WARMING THEM UP, AND TESTING THEM THOROUGHLY may be part of YOUR job—an interesting and vital part.

Unless you are fully familiar with an engine, DON'T TRY TO START IT for a warm-up and test without consulting a responsible superior for full information on the proper procedure. Improper starting, warming up, and testing of a modern, high-performance engine can result in SERIOUS DAMAGE. Manufacturer's directions should always be followed explicitly. Guesswork will get you a large hunk of grief.

KNOW YOUR ENGINE! One set of rules for starting will apply only to A PARTICULAR ENGINE, and even then there will be variations, depending upon the kind of accessory equipment installed with it. Here, for instance, starting, warming-up, and ground testing a Pratt & Whitney R–2800 engine will be considered. Since the position of the mixture control in starting depends upon the type of carburetor and other equipment installed with a particular engine, the procedures discussed will apply in all details ONLY to a Pratt & Whitney R–2800 using a Stromberg injection carburetor. However, a careful study of what follows will show you the care with which you must approach all engines in starting and warming up.

In cold weather the oil in an engine should be PREHEATED before you attempt starting, unless an oil dilution system is used. In the latter case, the engine oil should have been diluted with fuel PREVIOUS to stopping the engine after its last run. If the weather is EXTREMELY cold, you may have to PREHEAT THE ENGINE, too, before it will start.

Be positive that the IGNITION SWITCH is turned to "OFF." Turn the engine over four or five revolutions by PULLING THE PROPELLER THROUGH BY HAND. That will clear out any oil or gasoline which might have collected in the lower cylinders while the engine was inactive. It's a good plan to remove the LOWER spark plugs before turning the engine over in this way, if you have reason to think the cylinders might be loaded with gasoline—particularly if the exhaust tail-pipe is raised so as to prevent drainage out of the exhaust ports.

OPEN THE COWL FLAPS. During all ground operations, the adjustable cowl flaps should be fully opened—and LEFT that way.

Set the CARBURETOR HEAT CONTROL in "cold" position, and the PROPELLER CONTROL at "low pitch."

The BLOWER RATIO SELECTOR VALVE should be set in the "low" position for all ground operations, unless you're expressly checking it for proper positioning or functioning, or testing the operation of the supercharger drive mechanism in general.

Place the MIXTURE CONTROL in the "idle cut-off" position. Set the THROTTLE according to the kind of starter you'll be using. If it's a DIRECT CRANKING ELECTRIC STARTER, the throttle setting should be between one-tenth and one-fourth open. With an INERTIA or CARTRIDGE STARTER, open the throttle at least one-fourth or perhaps a little farther, as the engine will be turned over initially at a higher speed. CAUTION! As soon as the engine actually starts to run, cut down the throttle opening so as to limit engine rpm to between 600 and 800.

Turn ALL VALVES in the engine fuel line to "ON" and, with the auxiliary or hand wobble pump, fill the fuel lines and carburetor with fuel, but don't build up more than 2 or 3 pounds per square inch (psi) pressure. If the engine hasn't been run for several days, a period of two minutes or more may be required to permit air and vapor to escape (or "vent") from the carburetor. Poor starting may be a sign of INCOMPLETE VENTING. If so, just hold your horses! The trouble will clear up.

You'll generally have to PRIME an engine to get it started easily. The PRIMING PUMP, or PRIMER, draws liquid gasoline from the fuel supply system and forces it into several of the cylinders or to the intake manifold of the engine. The amount of priming needed for quick starting will depend on the type of engine, its size, the weather and temperature conditions prevailing, and the priming equipment installed. Gasoline coming from the carburetor does not vaporize as quickly when the engine is cold. Hence, if a primer was not used, you'd have to do a lot more propeller cranking to draw gas from the carburetor, through the induction system, and into the cylinders.

Too MUCH PRIMING will load the cylinders with raw gasoline. So be careful not to overdo it. Loaded cylinders mean difficult starting, and excess gasoline will tend to wash the oil off the cylinder walls, with consequent danger of scoring or of "piston seizure" because of dilution of the lubricating oil. If, ACCIDENTALLY, YOU DO prime cylinders excessively, you should APPLY FRESH OIL TO THE CYLINDER WALLS before starting the engine.

Piston rings and cylinder walls are liable to become rusty if the engine is allowed to stand for a day or so after unsuccessful attempts to start it. FRESH OIL APPLICATIONS in the cylinders are again the answer. If you really overdo the use of the priming pump or valve, fuel may drain back through the intake pipes of the PRIMED cylinders and collect in the intake pipes of the BOTTOM cylinders, without showing any signs of fuel leakage from the blower drain valve. This valve drains ONLY that fuel introduced at the CARBURETOR NOZZLE.

In starting a cold engine, UNDERPRIMING is more often the cause of difficulties than slight overpriming. You can usually recognize underpriming by the BACKFIRING through the intake system—and that presents some hazards you'll want to avoid. As would be expected, cold-weather starting requires a GREATER AMOUNT OF PRIMING and a SLIGHTLY LARGER THROTTLE OPENING than starting in warm or moderate weather. To start a hot engine you probably will have to do no priming at all.

Priming is done either with a HAND PRIMER PUMP or by means of an electrically operated PRIMER VALVE. With either type of equipment, first be sure the mixture control is in "idle cut-off" position. Then, with the hand wobble or electric auxiliary pump, bring the fuel pressure up to 2 or 3 psi. In case your engine is equipped with the hand-type primer pump, don't build up more than 4 psi pressure with the fuel pump while the hand primer is OPEN, or it may become HYDRAULICALLY LOCKED and you won't be able to push in the primer pump plunger. In fact, you'll have to take the WHOLE primer pump apart to release the mechanism.

If you're using an electrically operated primer valve instead of a hand primer pump, the fuel pressure should be built up to about 8 psi. Then you open the primer valve for as long as is needed to prime the engine adequately. This can be anywhere between 5 and 30 seconds, and depends on the make of primer as well as the engine temperature. Experience is the BEST teacher. In general, remember, if the engine is warm from previous running, or if the outside temperature is 60° F. (15° C.) or above, priming probably won't be necessary.

Once any necessary priming has been done, the engine should be ready for starting. Is your THROTTLE open the right amount? Have you set the MIXTURE CONTROL in "idle cut-off" position? Are you keeping the FUEL PRESSURE at about 8 psi? Well and good. If you're using a direct-cranking electric starter and the engine's fairly warm, wait until it has been spun about ONE REVOLUTION before turning the ignition switch to "BOTH ON" position, in order to avoid kick-back. The engine may start immediately, and you'll move the mixture control to "AUTOMATIC RICH" while continuing to operate the wobble pump (or electric auxiliary pump) until the engine is running smoothly. Adjust the throttle to hold engine speed as low as possible for 30 seconds, and watch for an indication of OIL PRESSURE on the gauge. If oil pressure doesn't register almost immediately, you'd better stop and investigate.

What's that? YOUR engine DIDN'T start right off the bat? Well, if you're sure you turned on the ignition switch, and did everything just the way you were supposed to, then just try again. Only, THIS time move the mixture control out of "idle cut-off" and over to "automatic rich" for about three seconds after you've switched the ignition to "on." If that doesn't do it, adjust the mixture control back to "idle cut-off" and continue turning the engine with the starter, keeping the fuel pressure at 8 psi. One to three repetitions of this procedure will USUALLY start her.

When an oil pressure indication has appeared on the gauge, adjust the throttle to about 1,000 rpm.

OVERLOADING of a WARM engine with gasoline will show up by a discharge of fuel from the drain valve, located in the lower part of the engine blower. If this symptom appears, keep the mixture control in "idle cut-off" position, discontinue using the auxiliary fuel pump, open the throttle wide, and turn the engine over with the starter to clear out the excess gas. The MOST FREQUENT CAUSE of cylinders loading with gasoline is FAILURE TO LEAVE THE MIXTURE CONTROL IN "IDLE CUT-OFF" POSITION. So keep that in mind.

There are, of course, OTHER REASONS why your engine may not start right away. If there's no drainage of fuel from the blower drain valve, the difficulty is probably NOT due to overloading. Maybe the engine hasn't obtained sufficient fuel from the carburetor because you forgot to keep up the pressure by using the wobble pump, or didn't richen the mixture for a long enough period. Try again, and keep your EYES and HANDS on the controls this time.

If the engine STILL won't start, chances are you're having IGNITION TROUBLE. Perhaps the booster isn't functioning. Continued operation can OVERHEAT THE COILS and make the booster quit. At any rate, you'd better have a LOOK-SEE and find the trouble.

A cold engine will always have to be primed. An outside temperature lower than 60° F. (15° C.) is "cold" to an engine, even if it isn't to you. The cooler the weather, the more priming you'll have to do to get started. A discharge of fuel from the engine blower drain isn't necessarily an indication of overloading in a cold engine. It may mean there's liquid gasoline in the exhaust—probably from primed cylinders. What do you do about it? The SAME as you would do to clear an overloaded WARM engine.

The direct-cranking electric starter will turn the engine at a SLOWER SPEED IN COLD WEATHER, so you may have to open the throttle wider than usual under such starting conditions to make sure the cylinders are getting an adequate fuel charge. Then, once the engine starts and begins to pick up speed, you can draw back the throttle to keep the rpm down to between 600 and 800.

INERTIA AND CARTRIDGE STARTERS

You'll be following a slightly MODIFIED procedure if you are starting the engine with an INERTIA-TYPE STARTER or a CARTRIDGE STARTER. These changes in method are made necessary by the fact that such starters turn the engine over initially at a MUCH HIGHER SPEED than other types. It's important to leave the mixture control in "idle cut-off" until the engine fires.

Otherwise, if the engine fails to start immediately, large quantities of fuel may be discharged into the engine, draining from the blower section and CREATING A FIRE HAZARD.

It's impractical to use the mixture control to obtain partial priming, as you would with direct cranking starters. It's best to depend on the HAND PRIMER or PRIMING VALVE when you feel the engine is not getting enough fuel for starting. But as soon as the engine fires—and BEFORE THE PRIMING FUEL IS USED UP—move the mixture control quickly to the "automatic rich" position.

WARMING UP

Remember, you're still working with that R-2800 engine you started with. Once the engine starts, you're ready for the WARM-UP. After the first half minute, the engine speed is slowly increased to about 1,000 rpm. LEAVE THE COWL FLAPS OPEN. Closing them, even in extremely cold weather, is likely to burn the ignition system insulation, particularly at the spark plug elbows.

OIL COOLER CONTROLS should be in the "hot" position to aid in warming up. The oil pressure relief valve is fitted with a temperature control that forces the oil—when cold—through the engine under high pressure. With very cold oil, the pressure may go up to more than 400 psi but it is AUTOMATICALLY REDUCED when an "oil inlet" temperature of around 104° F. (40° C.) is reached.

AVOID PROLONGED IDLING of the engine at speeds below 800 rpm or you'll probably find yourself with a batch of FOULED SPARK PLUGS. An occasional short run to clear out the engine—at an idling speed of 400 to 500 rpm—won't do any harm, however. Keep the engine speed at 1,000 rpm and by the time the oil temperature starts to rise, the engine will be warm enough. Then you'll be ready for a GROUND TEST.

When the OIL INLET TEMPERATURE gets above 104° F. (40° C.), the throttle may be opened to about 70 percent rated horsepower. Cylinder head temperatures should have reached at least 248° F. (120° C.) by now. Move the magneto switch from "both" to "left," and then to "right" in order to check engine operation on each breaker assembly of the dual magneto. You make these checks by noting the LOSS IN RPM when the switch is moved.

In switching from "both" position to either "left" or "right," the normal drop-off is between 50 and 75 rpm. But when you switch from "left" to "right" or vice-versa, the shift in rpm varies with the type of propeller and the original engine speed. Make this check in as SHORT a time as is practicable. Continued running on one switch point with the engine at high speed may cause serious KNOCKING.

You'll probably notice strong VIBRATION of the engine if one or more cylinders are missing fire because of improperly-functioning spark plugs. On the other hand, at low engine speeds with the magneto switch on "both," "left," or "right," freedom from vibration is a mighty good indication that the engine is operating correctly, particularly with respect to the ignition system.

Once in a great while you may run up against uneven engine operation during the regular magneto check, even after the engine has been run so long that you'd think the spark plugs were cleared out. In such a case, you can make a quick check of the dual magneto (at "33 inches Hg" on the manifold pressure gage) to find out what the trouble may be. Such an operation with the magneto switch in either "left" or "right" positions at this high power output, however, must be held to the SHORTEST POSSIBLE TIME, or you'll SERIOUSLY DAMAGE THE ENGINE.

Next, open the throttle until the engine is at 2,000 rpm at "low pitch." OIL PRESSURE (measured at the "pressure gage take-off" on either the upper left or right side of the engine rear section) should be between 75 and 80 psi at 2,000 rpm with the oil inlet temperature at 140° F. (60° C.) The pressure will VARY with their rpm and temperature, so don't be alarmed if it drops to as low as 25 psi, with the engine idling, or jumps to over 100 psi with cool oil at take-off speed.

Check the FUEL PRESSURE which should be between 15 and 17 psi (relative to carburetor air pressure) at 2,000 rpm. At low idling speed the fuel pressure may be as low as 8 or 10 psi, and still be satisfactory if it COMES UP PROPERLY AT HIGHER SPEEDS.

To help PREVENT SLUDGE ACCUMULATION and to check on the OPERATION OF THE TWO-SPEED BLOWER, shift the blower ratio selector valve according to the following directions before each flight and before stopping the engine after long flights.

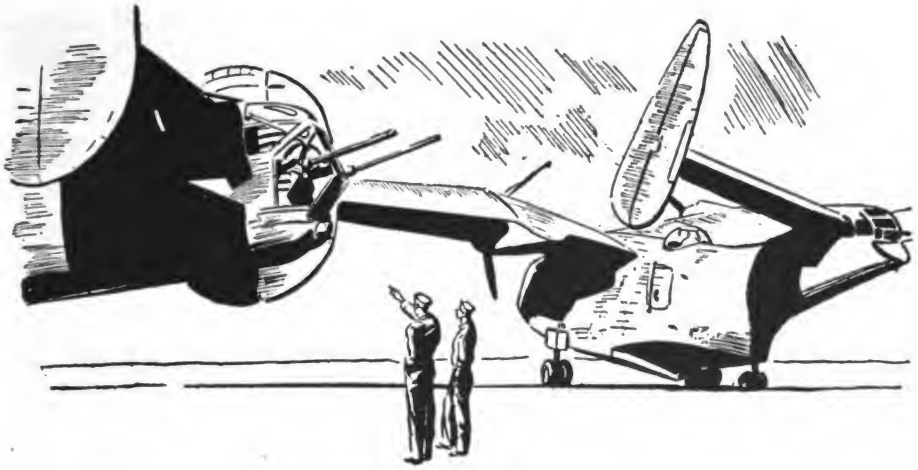
After the OIL INLET TEMPERATURE is 104° F. (40° C.) or higher, speed up the engine to 1,200–1,400 rpm, with propeller control in "low pitch," so as to obtain the 40 psi minimum oil pressure required for blower clutch operation. Move the blower ratio selector valve to the "high" position. The oil pressure should show a MOMENTARY DROP at this point.

Open the throttle to the prescribed cruising speed (but not more than 2,000 rpm) and lock it. Then shift immediately to "low" blower ratio. Watch the manifold pressure gage for a drop in pressure when you shift from "high" to "low" blower. This drop indicates that the control system is working properly, and prevents the pilot from taking off with the valve in "high" position by mistake. Finally, reduce the engine speed to 1,000 rpm or less after you've made this check.

If the test wasn't satisfactory, run the engine at around 1,000 rpm for two minutes BEFORE repeating the procedure. Prolonged fluctuation or loss of manifold pressure when shifting from "low" to "high" blower ratio indicates POOR CLUTCH ENGAGEMENT. Return the control to "low" and try the shift again. This time be certain to make the shift WITHOUT HESITATION, so as to avoid dragging or slipping the clutches. MAKE SURE the selector control is in "low" position when ground tests have been completed.

The engine cooling system won't keep cylinder heads and barrels—or ignition harness—cool while running continuously above a specified rpm on the ground. So, while making ground tests, avoid running the engine at high speeds as much as possible and NEVER LET CYLINDER HEAD TEMPERATURE GO HIGHER THAN THAT SPECIFICALLY ALLOWED. Engines vary in allowable ground rpm, manifold pressure, oil temperature, oil pressure, head temperature, etc., so KNOW the engine you're working with BEFORE you operate it.

And here's an old warning all over again: The ADJUSTABLE COWL FLAPS (or "gill") should be FULLY OPEN during all ground operations—warm-up, ground test, taxiing—and at least PARTLY OPEN for take-off and climb.



CHAPTER 14

ARMAMENT

MACHINE GUNS

In the early days of military aviation, airplanes were looked upon primarily as a means of obtaining information about the enemy. Then, according to legend, a World War I aviator had a brainstorm one day and FIRED HIS PISTOL at an enemy flier. After that everybody realized, all of a sudden, that here was a brand new weapon—THE ARMED AIRPLANE—and an aircraft armament race began. It's still going on full tilt.

During World War I the .30 CALIBER MACHINE GUN became the accepted standard for airplane armament. It did an excellent job, offensively and defensively, when you consider the task it had to perform in those days. It was inevitable, though, that the experts would work out ways to protect airplanes against .30 caliber gunfire. Better engines, for instance, made it possible to equip airplanes with ARMOR that would stop .30 caliber bullets and safeguard pilots without sacrificing too much speed in carrying the added weight of the armor.

Throughout all military history heavier armor has always been answered by heavier guns. So it has been with the airplane. Enemy craft, equipped with armor which would turn away .30 caliber ammunition, now could escape. A more effective gun became necessary, and a .50 CALIBER MACHINE GUN, already proved and in production for the ground forces, was soon adapted for aircraft use.

At first the ".50" was used only for fixed gun installations in FIGHTER airplanes, where it was found to be very effective. Within a short time, the .50 caliber gun was also put to work in BOMBER type airplanes, flexible mounts being provided for them. In some few cases, small bombers were also fitted with FIXED guns. On a bomber, however, you can't defend yourself completely with fixed guns, because they must be aimed at the target by maneuvering the airplane. Bombers just won't maneuver that easily. On the other hand, unless very firmly mounted, FREE guns installed in bombers are inaccurate at best, because free gunners are upon unsure footing when such airplanes are maneuvering or are flying in bumpy air.

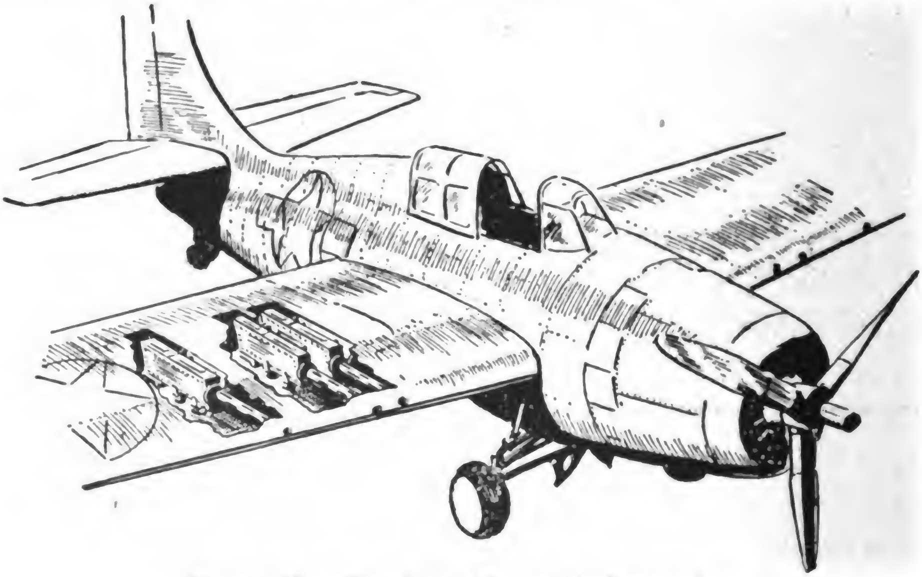


Figure 45.—Fixed guns in an airplane wing.

The best answer to the problem of bomber armament was found in the POWER-OPERATED TURRET, a piece of equipment which holds the guns steady during all maneuvers and in rough air. Moreover, the turret enables the gunners to bring their guns to bear at angles not previously possible in an airplane with hand-operated guns.

FIXED GUNS are rigidly mounted so as to fire in a direction practically parallel with the line of flight. Some fixed guns are synchronized to fire between the blades of the propeller. Others are mounted within the wing, as you see in figure 45, so that their line of fire clears the propeller blades. Such guns are operated by the pilot, who directs their fire by maneuvering the airplane. FLEXIBLE MACHINE GUNS are mounted in a way that permits them to be aimed at a target regardless of the direction in which the airplane is flying. Turret mountings combine the firmness of the fixed guns with the freedom of movement of the flexible guns. Actual battle experience has proved that turret guns are very effective, particularly against enemy aircraft which are not so equipped.

You will find flexible machine guns, other than turret-mounted guns, on certain types of airplanes, however. They are still very useful under certain conditions. One of these types is the TUNNEL GUN, which fires downward through a tunnel or opening in the fuselage. Although its freedom of movement is restricted, it provides effective fire in areas that are beyond the firing zones of the other guns on the airplane. The BRACKET-MOUNTED GUN is another type. It is fired through an opening in the side of the fuselage. It serves the same purpose as the tunnel gun. A bracket gun appears in figure 46.

It is necessary to use ADAPTERS in installing either fixed or flexible guns in an airplane. These adapters are furnished as accessories. FIXED GUN-MOUNT ADAPTERS are quite simple, consisting of a REAR MOUNTING POST ASSEMBLY and a TRUNNION-BOLT ASSEMBLY. The mounting post incorporates a quick-detachable feature that permits the gear to be removed and reinstalled in a minimum amount of time. FLEXIBLE GUN-MOUNT ADAPTERS are somewhat more complicated, since they must permit the gunner to train, elevate, and depress the gun as required.

Practically all machine gun installations on FIGHTERS today are of the .50 caliber type, in fixed mounts. SCOUT BOMBERS usually carry BOTH fixed and flexible guns, as do SCOUT-OBSERVATION airplanes and TORPEDO BOMBERS. Turrets are also installed on many of the latest torpedo-bomber models and patrol bombers.

Packing more sockeroo than anything previously carried in the way of armament is the 20-MM. AUTOMATIC GUN. This gun was developed as the next logical step in increasing the airplane's firepower. More and more of the new airplanes have them installed in the form of fixed wing mounts. Because of the nature of its firing mechanism, this gun cannot be adapted for use as a synchronized gun—that is, to fire between the propeller blades.

TURRETS

Turrets, which you see on many of the larger aircraft, are the small round, glassed-in "greenhouses" in which the gunner sits. You can see a turret in figure 46. In general, there are four main locations for turrets on various airplanes. The UPPER TURRET, is located in the upper part of the fuselage to guard against attack from above. The LOWER TURRET is in the lower part of the fuselage to ward off punches "below the belt." The REAR or TAIL TURRET protects the airplane against stern attacks. The NOSE or BOW TURRET guards the airplane's forward area.

Although turrets add to an airplane's weight, they make it possible to reduce the size of the crew carried. The result of this is that there's no need to reduce the useful load, or to weaken an airplane's fire power because of the turrets. With hand-operated guns, one operator is required for each weapon, while in turrets one gunner can control the fire of several guns. Moreover, firing from a turret is more accurate, since the gunner doesn't have the problem of trying to keep a hand-held gun steady in the slipstream during flight.

Figure 46.—Flexible guns: turret mounted (left); bracket mounted (right).

The power-driven mechanism of a turret turns the turret horizontally and also elevates the guns vertically. In some turrets the guns all fire together. In other types they may be fired separately OR together, as the gunner desires. The amount of movement a turret can make—and therefore the field of fire of its guns—depends upon the type of airplane in which the turret is mounted, and its position in the airplane. Almost all turrets nowadays are fixed up with INTERRUPTER devices which make it IMPOSSIBLE for the gunner to fire into HIS OWN airplane.

SIGHTS

Any gunner will tell you that one way to keep from growing old is to handle an airplane machine gun as if it were a hose pipe, and hope for a hit. The fire from such a gun isn't worth a Japanese nickel unless it's accurately aimed, and the hose-pipe method will let the enemy gunner get the drop on you EVERY time.

Good gunners must know how to use their GUNSIGHTS. Mechanically, your aerial gunsights are the best in the world, but they will only be 100 per cent effective if you know how to use them properly.

The function of a gunsight is to aid the gunner in aiming his weapon so that the bullets will hit the target. Aerial gunsights are more complicated than those found on rifles and similar weapons. A projectile or bullet fired from a gun in an airplane does not travel in a straight line to the target. Instead, the forces encountered by the bullet in the air make it take a curved path—known as the TRAJECTORY. So special gunsights are needed to aid the gunner in determining where to point his guns so he'll hit the target.

The ordinary aerial gunsight consists of a RING PEEP and a BEAD. This arrangement is a lot like the sights of a rifle, except for the ring encircling the peep, which helps the gunner estimate the speed, range, and direction of the target. Errors are quite likely to creep in when you're using such MECHANICAL sights, however, and OPTICAL sights have been devised to eliminate these errors. Sometimes both types of sights are mounted on an aerial gun, so that the more rugged mechanical sight will be ready for use in case the fragile optical sight goes out of commission.

There are a number of different kinds of optical sights used on the Navy's aerial guns, such as OPTICAL ILLUMINATED SIGHTS, AUTOMATIC COMPUTING SIGHTS (which include an optical system, a range finder, and an automatic computing mechanism), and TELESCOPIC SIGHTS. Each has some advantages for particular purposes, and all offer better results than mechanical sights. All gunsights on airplanes are classified as either FIXED, or FLEXIBLE, according to the type of gun with which they're mounted.

HARMONIZATION AND BORESIGHTING

As explained above, the aerial gunsight aids the gunner in correcting for the forces which affect the bullet. The most accurate gunsight, however, will fail in its purpose if it and the gun (or guns) are not properly adjusted in relationship to each other.

Such adjustments are called HARMONIZATION. When the guns and sights are harmonized—and the sights are used properly—the bullets will strike in the proper position on the target, as indicated by the sight.

In aerial gunnery there are certain factors which limit the effective lethal range of the guns. This doesn't mean that the bullets will do no damage beyond that range, but that the number of bullets concentrated in a given area on the target will be too few to justify firing. For this reason, guns and sights are harmonized for a specific range. To do this it is necessary to set up a PATTERN at the desired distance, and harmonize the guns and sights on this pattern so that the bullets will intersect the line of sight at the specified range.

As this range may be as much as 1,200 feet, circumstances may not permit use of the full distance for boresighting. In such case the same results can be obtained by sighting the guns and sight at a specially prepared pattern placed, say, at a distance of 300 feet.

The successful harmonization of guns and sight on the pattern depends largely upon the ability of the man who is assigned to BORESIGHT the guns. Boresighting is essentially the job of sighting through the bore (or barrel) of a gun and making the required adjustments to achieve harmonization.

AMMUNITION

The ammunition for aerial machine guns is issued in the form of fixed rounds, ready for firing, the complete round being loaded into the gun as a unit.

The principal types used are—

- BALL—for use against personnel and light material targets.
- TRACER—for observation of fire.
- ARMOR-PIERCING—for use against armored objects, airplanes, vehicles, etc.
- INCENDIARY—for igniting inflammable materials.

All types and models of .30- and .50-caliber ammunition have bullets with gilding metal (copper colored) jackets. The various types are identified by the following colors on the bullet tips—

Ball—plain, no marking.
Tracer—a painted red tip.
Armor-Piercing—a painted black tip.
Incendiary—a painted light blue tip.

Dummy ammunition, which is used for testing the action of guns after repair, looks much like service ammunition, except that the case is perforated with three circular holes. In some cases, dummy cartridges are also plated a silver color to permit easier identification. You have to take reasonable care to prevent mixing service and dummy ammunition when belting ammunition for combat use. Dummies won't kill Japs!

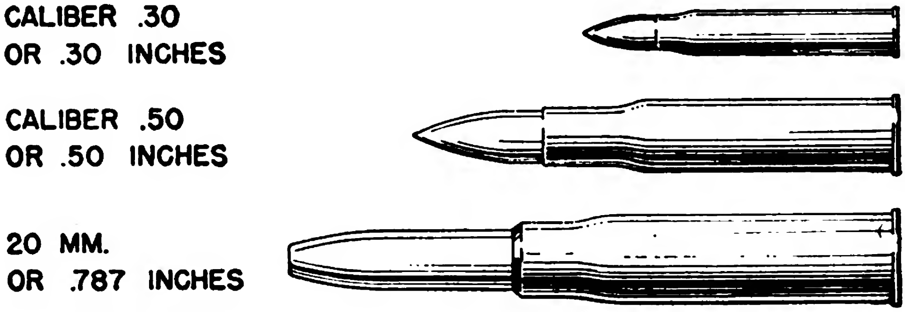


Figure 47.—Ammunition for aerial guns shown smaller than actual size.

Ammunition for aerial machine guns comes packed in metal-lined wooden cases. On the labels of all cartons, on all packing containers, and on cards sealed inside the metal lining of each ammunition box, the contents are identified as to QUANTITY, TYPE, CALIBER, MODEL, and LOT NUMBER. Ammunition boxes also have special identifying markings in the form of colored bands. As these color bands do NOT agree with the markings of the ammunition itself, care must be exercised, in breaking out ammunition, until the meanings of the various color bands are thoroughly understood. Figure 47 shows the three principal types of aerial machine gun ammunition.

The BOMB is the second of the two major offensive weapons of Naval aircraft. Bombing is accomplished by HORIZONTAL BOMBING, DIVE BOMBING, SKIP BOMBING, and TORPEDO BOMBING. Each method requires special techniques, skills and equipment, and has its own special advantages and disadvantages.

HORIZONTAL BOMBING is done from HIGH, or moderately high, altitudes with the assistance of an elaborate BOMBSIGHT which makes corrections in the bomber's aim. Some of the factors which have to be taken into account are speed of the airplane, altitude, wind speed and direction, and the exact position of the airplane in space with regard to the target.

One of the advantages of horizontal bombing is that LARGE-CALIBER BOMBS can be dropped most effectively from HIGH altitudes. The speed of such bombs at the moment they hit the target is greater than in other types of bombing, so they have greater penetration. Since airplanes engaged in horizontal bombing fly at high levels, the effectiveness of antiaircraft fire is reduced to a minimum.

There are some disadvantages, however. A straight approach to the target is necessary just before bombs are released. During this period, the bombing airplane is more vulnerable to defending fighters and antiaircraft fire. Clouds are another problem, as they may interfere with the bomber's view of the target. In addition, the time required for a bomb to fall from high altitudes permits maneuverable targets to avoid bombs after they have been released.

DIVE BOMBING has been practiced by the Navy's air forces for many years. This method involves

AIMING THE AIRPLANE at the target while in a STEEP DIVE, and releasing the bombs at a comparatively low altitude. Successful dive bombing depends largely upon the skill of the pilot, as you can well imagine. In favor of dive bombing are the surprise element in attack, increased accuracy because of the low release point, less chance for the target to maneuver during the drop of the bomb, and the speed of the bombing airplane which makes it a difficult target for antiaircraft.

On the other hand, bombs dropped at low altitudes by dive bombers may not obtain as much penetrating speed as desired. And there is sometimes danger of the explosive blast reacting on the bombing airplane and other aircraft following it in a dive.

The procedure known as SKIP BOMBING (or "masthead" bombing) has been developed during the present war. It requires the use of a simple BOMBSIGHT, and finds the attacking airplane pilot attempting to pierce the SIDE of the enemy vessel with his bomb—either by DIRECT HIT or by a RICOCHET from the surface of the water. Skip bombing has as its strong points increased accuracy, the probability that the bomb will burst inside the enemy vessel's hull, maximum speed of the attacking airplane can be used, and the fact that small, fast airplanes can be employed for this type of bombing.

The attacker is, however, more vulnerable to antiaircraft fire, and must usually be accompanied by other airplanes to help knock out enemy batteries. Accurate FUSE TIMING on the bomb is also essential. And, in ricochet attacks, there is the possibility that the bomb may leap completely over the target.

The AERIAL TORPEDO is a very effective weapon if the torpedo plane can avoid antiaircraft fire and be defended against attack by enemy aircraft. The torpedo itself is a PRECISION INSTRUMENT, and its damaging effect is great. The pilot of a torpedo plane must drop his torpedo in such a manner that a COLLISION COURSE with the target results. An aircraft torpedo runs at a speed of 35 to 40 knots, and, if properly adjusted, will stay on course, as it is not affected by surface wind or sea conditions.

Among the reasons for the effectiveness of aircraft torpedoes are that the airplane is in fully-controlled flight when the torpedo is dropped, and the big explosive charge of a torpedo does its damage below the target vessel's water line.

Torpedo planes are nevertheless highly exposed to enemy antiaircraft and fighters unless heavily protected by escorting airplanes. They must get within 1,000 yards of the target before releasing their missiles, and keep a straight course at low altitude.

CHAPTER 15

EMERGENCY EQUIPMENT

PARACHUTES

Everybody who goes up in a Navy airplane is provided with a PARACHUTE. This vital device has saved literally thousands of lives and is just about the Number One Item on your list of emergency equipment. A parachute ready for use consists of FIVE major parts. First is the CANOPY—a huge white cup-shaped bag of silk. Long cords, called SHROUD LINES or suspension lines, connect the canopy to the HARNESS. The harness is a series of straps that support you when you are in the air.

Attached to this harness is a canvas PACK, into which the entire parachute is carefully folded. The pack is opened by means of the rip cord which, when pulled, releases the flaps of the pack. The fifth part of the parachute is a small PILOT CHUTE that opens as soon as the rip cord is pulled and helps to draw the main chute from the pack.

Each of the five main parts of the parachute must do its share if the parachute is to work properly, as each is a link in the chain on which your life depends. In manufacturing a parachute the strength of each part is determined carefully, and all units are tested under much greater strains than are usually expected when the parachute is operated. How strong must a parachute's parts be? Really RUGGED! The strain on a parachute at the moment it opens is terrific. It is equivalent to jamming the brakes on a car speeding over 100 miles per hour!

SEAT PACK and BACK PACK parachutes have the rip cord located on the left thigh, so you can reach across your body with your right hand to pull the cord. On FRONT PACK parachutes, the rip cord is at the right side. Most parachutes used by the Navy are packed in a seat pack. You sit on them as cushions, and thus are freed from any weight or bulk. But gunners and photographers in airplane crews use front suspension packs in many cases. In small airplanes the pilot frequently wears only a harness, with the parachute pack close at hand, ready to be clipped to in an emergency.

Parachutes are used for other purposes besides emergency jumps. Life rafts and shipwreck kits (of medical supplies and food) can be dropped by parachute to survivors of sea battles or accidents, where rescue landings are not possible. The aerial mailman uses parachutes to deliver letters and packages—at sea and at way stations that have no landing facilities.

LIFE JACKETS

Another indispensable item is the PNEUMATIC LIFE JACKET. Constructed of rubberized fabric, it is shaped much like a vest. It contains two separate AIR CHAMBERS, each of which is capable of supporting a man in the water. Inflation of the jacket is accomplished by means of a small cylinder of CARBON DIOXIDE GAS. All you do is open a valve to make the jacket inflate. TUBES are also attached to each chamber so the jacket can be blown up by mouth, in a pinch. All aircraft pilots and air crews are required to wear life jackets—called "Mae Wests"—in flights over water.

LIFE RAFTS

Very similar in operation to life jackets, but on a larger scale, are the PNEUMATIC LIFE RAFTS carried in airplanes. One is illustrated in figure 48. Made of rubber-covered fabric, they are also inflated by carbon dioxide from a flask attached to the raft. FOUR SIZES of life rafts are built—for one, two, four, or seven men.

A number of types of life rafts have been developed, each of which is designed to provide adequate lifesaving protection under various circumstances. All Naval airplanes operating over water are equipped with enough life rafts to take care of EVERYBODY on the plane.

Landplanes attached to aircraft carriers are not capable of landing on the water and remaining afloat. Under combat conditions, forced landings are an ever-present possibility, and rafts must be available for immediate use after the airplane has touched the surface of the water. AUTOMATIC RAFTS have been developed for such emergencies, requiring no action by the jumper. When the airplane strikes the water, the action of the salt water closes an electric SWITCH which releases a raft COMPARTMENT DOOR and inflates the raft, forcing it out of the compartment.

The most common kind of raft in use is the DROPPABLE TYPE. It is designed so that—when dropped from an airplane—it will be fully inflated by the time it reaches the water. Inflation of this type of raft is accomplished by means of a pull on a T-shaped HANDLE attached to the outside of its CARRYING CASE and connected to a carbon dioxide cylinder.

When parachuting over water, you frequently may not have much chance to do anything but jump. For such situations a PARACHUTE LIFE RAFT has been developed. This is secured to you at all times, and is available after you have jumped and landed in the water. It's similar to the one-man raft, but slightly smaller.

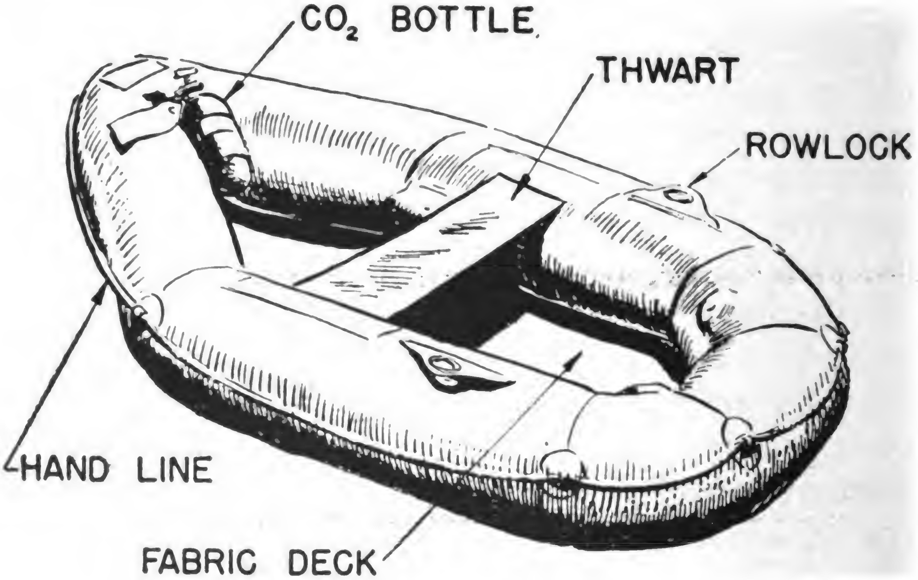


Figure 48.—Pneumatic life raft.

Certain items of OTHER emergency equipment are provided with each raft to sustain the occupants while they're afloat. They include food, water, a first-aid kit, signaling devices, sail, fishing kit, collapsible oars, and a compass. New additions are made to this gear from time to time as experience dictates.

The color of all exposed raft surfaces is ORANGE-YELLOW. Tests have proved that this color is the easiest to see against a water background, looking either from a ship at sea or an airplane in the air.

SAFETY BELTS

Air crews have come to look upon the SAFETY BELT as a piece of equipment fully as basic as shoes or a jacket. It is a wide, thick, fabric WEBBING which secures you across the thighs and is capable of withstanding a pull of 1,600 pounds. The safety belt is fastened to the base of the seat in which you are sitting, and keeps you from being thrown forward or out of the airplane in all but the most severe crashes.

There is a quick-action RELEASE BUCKLE on the safety belt. It trips from left to right with little effort, and releases instantly. Thus, if you must jump for safety, no precious moments are lost in disentangling yourself.

FIRE EXTINGUISHERS

Almost all Navy airplanes have FIRE-EXTINGUISHING EQUIPMENT built into them. AUTOMATIC FIRE EXTINGUISHERS, for putting out fires in the power plant sections of an airplane, are operated by pulling a handle located in the COCKPIT. Such action releases a spray of extinguishing gas or liquid into the engine compartment. One or more HAND-OPERATED FIRE EXTINGUISHERS are also provided in airplanes for putting out fires occurring outside the engine compartment. They're usually operated by pumping a handle at the top. But be sure you know the directions for using the equipment in your airplane BEFORE you have to use it. Don't wait until there's a fire to read the directions.

OXYGEN EQUIPMENT

The requirements of World War II have put new emphasis on many phases of aviation. Perhaps no phase has received more attention than high altitude flying, and the problems attending it.

Many of these problems involve the functioning of the airplane itself in the rarefied upper air. But the human element has also demanded a lion's share of attention.

Airplane engines can be—and have been—redesigned for high altitude flying by the addition of supercharger systems. Superchargers force additional quantities of air into airplane engines so sufficient oxygen will be available for fuel combustion. Unfortunately, you can't very well rig up pilots and air crews with a supercharger to provide them with the oxygen they need under similar circumstances. Instead, they use **OXYGEN EQUIPMENT.**

In general, this equipment consists of an **OXYGEN MASK** (of which there are a number of types, some covering the whole face, others just the nose and mouth), an oxygen supply tube, and a tank or bottle of oxygen under pressure, plus the necessary valves, meters and like equipment that allows the flyer to control the oxygen flow. Many airplanes have the basic oxygen equipment **BUILT IN.** Portable equipment is used widely, however.

There are a number of variations in portable oxygen gear. Small, compact outfits that fit into your pocket are supplied for use during high-altitude parachute jumps, for instance. These are called **BAIL-OUT OXYGEN BOTTLES.**

Another type of oxygen supply device is the **REBREATHER**, used most frequently for sustained flights in rarefied air. The rebreather permits you to breathe the same air over and over again, replenishing the oxygen as your lungs consume it.

DE-ICERS

At certain altitudes and under special weather conditions, airplanes have an unfortunate habit of getting themselves coated with ice. This is a very serious matter, and ice formations have carried numerous airplane crews to death. Ice is particularly dangerous when it forms on the leading edges of airplane wings. To combat it, very effective devices called DE-ICERS were developed.

De-icers of many kinds have been tried on airplane wings, but the most effective type has been the PNEUMATIC DE-ICER, like that in figure 49. It consists of a hollow tube of soft, flexible rubber, attached horizontally to the wings along the leading edge. Its operation is simple and is controlled by the pilot. Air is alternately pumped into and exhausted from the de-icer tube (or "shoe"), causing any ice deposits on its surface to crack off and blow away.

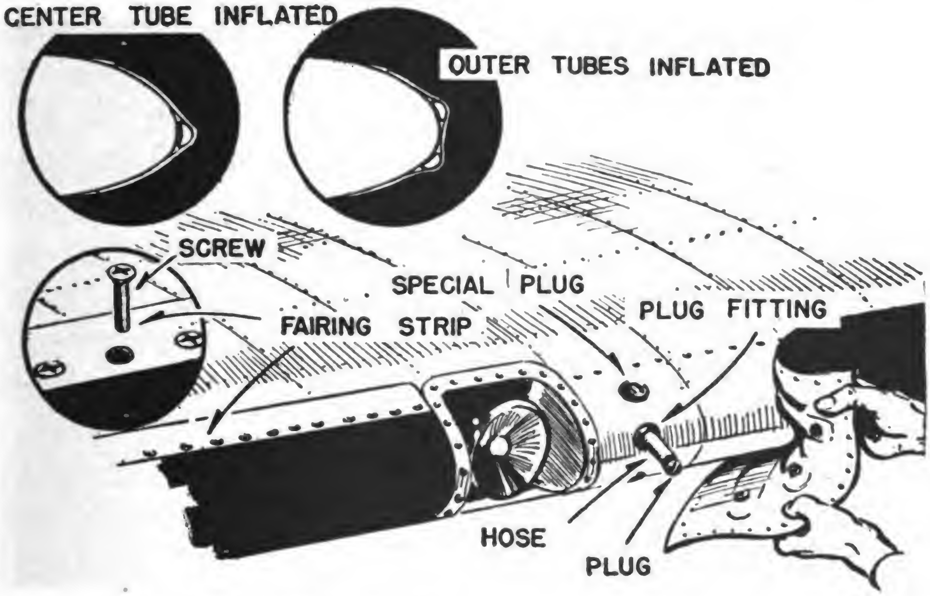


Figure 49.—De-icers on an airplane wing.

SIGNALING EQUIPMENT

There are plenty of ways you can get in touch with ships, bases, and other men in other airplanes. At the present moment, though, you are concerned principally with EMERGENCY SIGNALS. Many occasions arise, of course, in which regular

COMMUNICATION channels are called upon to carry emergency distress messages, but here you're talking about signals used ONLY when the PINCH comes—the EXTRA SOS devices provided in Naval airplanes for visually getting across the point that you're in trouble.

Most of these distress signals are in the form of fireworks—more politely called PYROTECHNICS. The most important of them are PARACHUTE FLARES, SMOKE BOMBS and GRENADES, DRIFT SIGNALS, and PYROTECHNIC CARTRIDGES. Pyrotechnics are used primarily when there is either lack of time or of other communication facilities. You have to be EXTREMELY CAREFUL in using them, not only because fireworks are tricky and dangerous, but because they are quite likely to give as much information to the enemy as to your friends.

PARACHUTE FLARES consist of an illuminating candle attached to a parachute. They're used to light up a target, or an area for a forced landing. Offhand you might question whether such uses constitute signaling. But think it over. Actually such a flare is bringing information to YOU, and thereby helping you over a real obstacle.

To attract attention of would-be rescuers after you've made a forced landing, you might use a SMOKE GRENADE—if it's daylight and a rescue party or friendly airplane is in sight. Smoke grenades are secured to a three-foot stick so they can be held in position where they won't endanger the aircraft.

DRIFT SIGNALS give off both flame and smoke, and therefore can be used either at night or during the day. They are designed primarily to aid a pilot flying over water in determining the drift of his airplane, but are extremely useful for marking the location of contact with any object to which the pilot wishes to call the attention of others. In an emergency, when no flares or landing lights are available, a drift signal may be used to locate the surface for a night landing.

The PYROTECHNIC PISTOL is the standard means of identifying your airplane to others in an emergency. The "stars" from its cartridges can be seen at any time of the day or night, but care should be taken not to use it except when radio or signal lights are out of commission—or are banned. The pistol is mounted so as to fire out through an opening in the fuselage in most airplanes. Red, yellow, and green "stars" are produced by the various pyrotechnic cartridges used with the pistol. Each means something different—SO FIND OUT THE MEANINGS.

One or more cans of sea marking compound (a yellow-green dye) are packed with most life rafts. This compound, when poured on the surface of water, spreads out to make the area around a raft clearly visible to ships and airplanes that may be passing. FRIENDLY CRAFT, YOU HOPE!

How Well Do You Know—

INTRODUCTION TO AIRPLANES

QUIZ

CHAPTER 1

FLIGHT

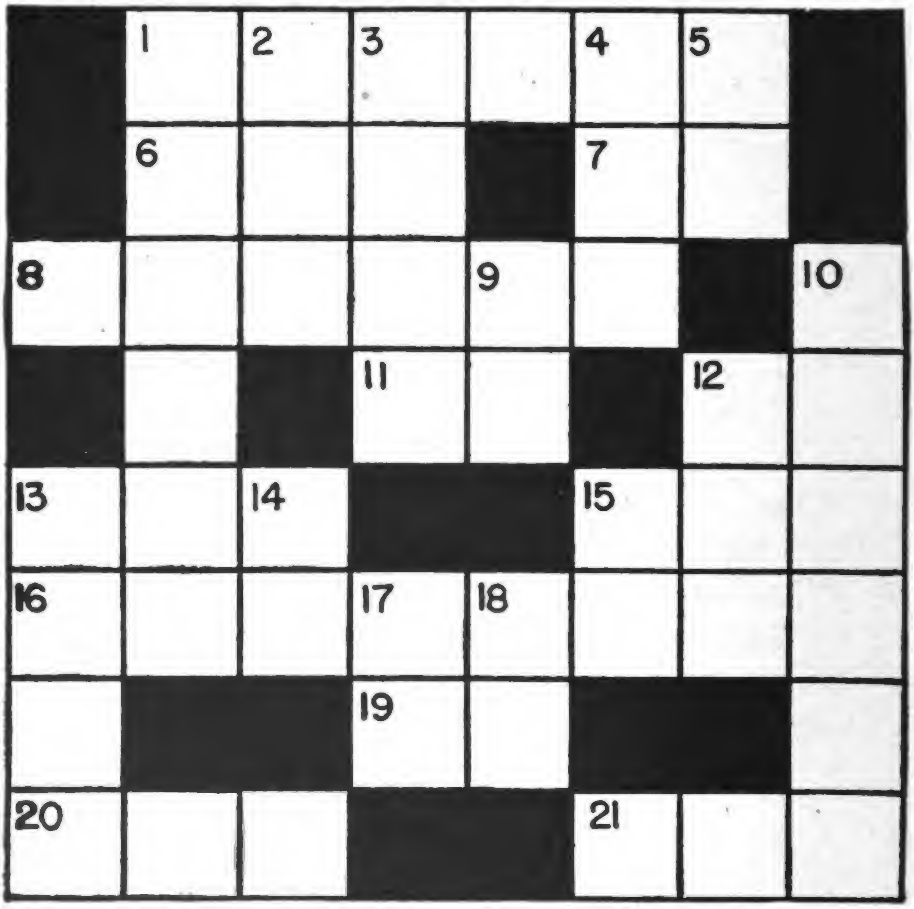
1. (*a*) What is the fundamental difference between a "tractor" airplane and a "pusher"?
   (*b*) What are the other five principal characteristics by which airplanes are generally classified?
   (*c*) Name two types of airplanes that do not fall within any of these classifications.

CHAPTER 2

WHY AIRPLANES FLY

1. Explain why helicopters can take off vertically, and why autogiros cannot.
2. Why do pilots generally try to take-off into the wind?
3. (*a*) What is the effect of air density on the lifting power of an airplane wing?
   (*b*) Is the air more dense at high or low altitudes? Why?

4. Try the crossword puzzle—it's a handy way of fixing some important information in your memory.



ACROSS

1. Distance (plural) between leading and trailing edge.
6. ________ foil sections look like slices out of a wing.
7. Observation scout (abbreviation).
8. One kind of pressure exerted by the wind on the bottom surface of a wing.
11. What you'd answer if someone asked you whether fluid moving through a venturi tube exerts its greatest pressure at the narrowest point.
12. There's a big Seabee camp in this State.
13. What sailors see.
15. "Give 'er the ________!"
16. The rear edge of an airplane wing is the ________ edge.
19. Initials of an airplane manufacturing company. It makes the "Texan."

20. Forward end of float.
21. Down five enemy airplanes and you're one of these.

DOWN

1. Curvature of an airplane wing surface.
2. Hirohito's Imperial Palace (abbreviation).
3. A North African port where the French fleet was shelled.
4. A key word in the ARM's vocabulary.
5. Steamship (abbreviation).
9. Commanding officer (abbreviation).
10. The Helldiver is a -------- -engine airplane.
12. Flight directly over a bombing target.
13. Slang for stabilizer.
14. Initials of the angle formed by wing chord line and relative wind.
15. Not "Tailor-made".
17. When they give you a nickname, you're ---------.
18. Initials of a famous giant lighter-than-air craft (pre-war) destroyed in a storm at sea.

CHAPTER 3

STRUCTURES

1. Other things being equal, will an airplane with slotted wings reach the burble point at a higher or lower angle of attack than an airplane which does not have slotted wings?
2. In the empennage—
   (*a*) What are the four main control surfaces? Indicate whether each is horizontal (H) or vertical (V).
   (*b*) Is right-left motion of the airplane controlled by horizontal or vertical surfaces?
3. (*a*) What part of the airplane wing is manipulated to bank the airplane?
   (*b*) How is it manipulated, and how does it cause the airplane to bank?

4. (*a*) Name the main structural parts of the wing which carry the load in flight, in the order in which the load would be transmitted to them.
   (*b*) Which of these provides the main strength of the wing?
   (*c*) Which give the wing its shape?
5. (*a*) Which of the surfaces mentioned in Question No. 2 need to be "balanced"? Why?
   (*b*) How are they balanced?
6. Indicate in which type of landing gear each of the following may be found.
   (*a*) Sponson.
   (*b*) Shock absorber unit.
   (*c*) Tail skid assembly.
   (*d*) Sea wing.
7. What is the function of each of the following parts in landing gear?
   (*a*) Spreader bar.
   (*b*) Deck clamp.
   (*c*) Mooring cleat.
   (*d*) Handhole.
   (*e*) Step.
   (*f*) Rubbing strip.
   (*g*) Sea wings.
8. What is the meaning of each of the following, in relation to landing gear?
   (*a*) Tread.
   (*b*) Chine.
   (*c*) LWL.
   (*d*) Frames.
   (*e*) Stringers.
   (*f*) Stiffeners.
9. Why must the skin (or covering) of a monocoque-type fuselage be stronger than that of a truss-type fuselage?

CHAPTER 4

INSTRUMENTS

1. What instrument would you look at to find out—
   (*a*) How fast the airplane was climbing?
   (*b*) How high it had already climbed?
   (*c*) Whether it was skidding?
   (*d*) Whether the wind was blowing it off its course?
   (*e*) The rpm of the power plant?
2. What does the Automatic Pilot do?

CHAPTER 5

ENGINES

1. (*a*) Through what opening does fuel enter the cylinder?
   (*b*) What happens to it within the cylinder?
   (*c*) What effect does this have on the piston?
2. (*a*) What moving part of the engine is connected to the propeller and causes it to turn?
   (*b*) How many strokes of a piston complete a cycle in the typical airplane engine?
   (*c*) How many complete revolutions does the moving part of the engine referred to in (a) make during one such cycle?
3. What are two factors by which an airplane engine's efficiency may be measured?
4. (*a*) What type of engine has its cylinders arranged in a circle around the crankshaft?
   (*b*) What type of engine is easiest to streamline?

CHAPTER 6

ENGINE SYSTEMS

1. What type of cylinder arrangement is found in most Naval aircraft engines?
2. Name an aircraft engine system in which each of the following parts may be found, and describe the function of the part briefly.
   (*a*) Mechanical pump.

(*b*) Carburetor.
(*c*) Magneto.
(*d*) Baffles.
(*e*) Counterbalance.
(*f*) Selector valve.

3. What is the function of the idle cut-off?
4. What is the principal difference between the functions of the external and internal lubrication systems?
5. (*a*) In the air-fuel mixture delivered to the aircraft engine, an increase in the proportion of gasoline to air results in a mixture which is said to be more --------.
   (*b*) What instrument would you adjust when operating conditions make it necessary for you to change the proportion as in (*a*)?
6. (*a*) Why must an aircraft engine take in a greater volume of air for effective combustion at high altitudes than at lower altitudes?
   (b) What part of the fuel system is designed to insure the engine's receiving the proper volume of air-fuel mixture at higher altitudes?

CHAPTER 7

PROPELLERS

1. (*a*) What is the basic similarity between an airplane wing and a propeller blade?
   (*b*) What is the principal way in which a propeller's lift action differs from that of the wings?
2. (*a*) What are the two principal types of stress which the propeller must withstand?
   (b) Where are they greatest?
3. (*a*) What is meant by the "effective pitch" of a propeller?
   (*b*) What is meant by "slip"?
   (*c*) Which type of propeller is adjustable to more pitch settings, the two-position controllable-pitch propeller or constant-speed propeller?

CHAPTER 8

NAVAL AVIATION

1. For each of the following aircraft designation symbols, indicate the function of the airplane designated, and whether this is the first, second, (etc.) model. For (*a*), (*d*), (*f*), (*g*), and (*h*), name the company which manufactures the plane.

Symbol	Function	Model	Manufacturer's Name
(*a*) OS2U			
(*b*) N2T			
(*c*) R5C			
(*d*) N3N			
(*e*) HOS			
(*f*) PV			
(*g*) F6F			
(*h*) PBO			

2. Each of the four groups of characteristics listed below is broadly descriptive of one class of airplane. Give the designation symbols of each class.
   (*a*) Maneuverable; fast; armored cockpit; high service-ceiling.
   (*b*) Tough; rugged construction; low speed.
   (*c*) Long range; "The eyes of the Navy."
   (*d*) Powerful engine(s); high service-ceiling; long range; large crew; medium speed.

CHAPTER 9

HANDLING

1. (*a*) What is the primary requisite of a good location for securing a landplane in the open?

   (*b*) When staked out, why should the airplane be headed into rather than tailed into the wind?

2. What further protection should you give the control surfaces when securing in the open?
3. (*a*) If you were detailed to serve on a handling crew moving an airplane on a carrier, what are three positions (relative to the airplane) to which you might be assigned?

   (*b*) Where should the Plane Captain be if the airplane were being moved on the flight or hangar deck, and why?
4. (*a*) What is the minimum allowable clearance between airplanes parked on the flight deck?

   (*b*) What precaution must be taken, before parking the airplane, to prevent it from rolling with the ship?
5. How is a seaplane prevented from weathercocking while it is being beached?
6. (*a*) What is the term applied to the job of lowering a seaplane from a warship to the water?

   (*b*) Who tests the machinery to be used in this job, and leads off by swinging the boom over the seaplane?
7. How should a catapult with a seaplane on it be turned before the seaplane's engine is started?

CHAPTER 10

ANCHORING AND MOORING

1. In the anchor equipment for a small seaplane—
   (*a*) What is one major use for a shackle?
   (*b*) What are the principal airplane attachments?
   (*c*) Is a reel provided?
2. (*a*) What is the chief function of the anchor cable clamp?

   (*b*) What is another name for it?
3. (*a*) When ready to weigh anchor on a patrol plane, what provides the pull to break the anchor loose?

   (*b*) What part of the anchor gear should take the strain of breaking loose?

4. (*a*) Why is it dangerous to use too short a cable for anchoring a mooring buoy?
   (*b*) What is a safe length?
5. Describe the way a pilot should bring his patrol plane in for mooring, with respect to speed, wind direction, and final position of buoy.

CHAPTER 11

AVIATION SEAMANSHIP

1. What position relative to the wind or current would you expect a seaplane to take under these circumstances?
   (*a*) On the water, with engine stopped.
   (*b*) Moored to a buoy, with current running.
   (*c*) On the water, with engine idling.
2. What are five kinds of jobs concerned with seaplanes, for which boats are used frequently?
3. (*a*) From what direction should a motor whaleboat or motor launch approach a seaplane under the circumstances described in (*a*) of Question No. 1?
   (*b*) How about (*b*) of Question No. 1?
   (*c*) What is the general rule for such boats approaching planes?
   (*d*) What is a general rule for larger, less maneuverable boats?
4. What limitation on the use of wing lines must be kept in mind when using them for steering a seaplane that is in tow?
5. How can the protection of a lee be obtained for a seaplane that is being towed to a ship?
6. (*a*) What is a "jury" rig?
   (*b*) What are four points on a seaplane that are useful for attaching a jury rig?

CHAPTER 12

CLEANING AND INSPECTING

1. How does an airplane with a well-cleaned outer surface have an advantage in combat over a similar plane with dirt on its outer surface?
2. (*a*) What parts of the engine should not be wet unnecessarily in cleaning?
   (*b*) How should they be cleaned?
3. (*a*) What will happen to such plastic applications as the cockpit enclosures, turrets, and windows if you polish them too vigorously?
   (*b*) What treatment should you give them before you clean them?
   (*c*) What cleaning solution should you use?
   (*d*) What should you use to apply the cleaning solution?
   (*e*) Why should a dry cloth not be used to dry these plastics?
   (*f*) What treatment should these plastics get immediately after cleaning?
4. (*a*) On what form are the results of the daily inspection of each airplane recorded?
   (*b*) Who signs this report?
   (*c*) How soon should defects be corrected?
   (*d*) What procedure should be followed if they cannot be corrected within that time?
5. (*a*) What type of identification marking differentiates piping systems?
   (*b*) Where should you look for the markings?
6. (*a*) How often must parachutes be inspected?
   (*b*) How about self-inflatable life jackets?

CHAPTER 13

FUELING AND STARTING

1. Why should an airplane's fuel supply be replenished immediately after any flight?

2. (*a*) Why should hose nozzle and funnel be grounded before you start refueling?
   (*b*) If the hose is not equipped with a ground wire, how would you rig a grounding system?
3. How should a funnel be placed in the filler neck of a fuel tank?
4. Name six things you must do after replenishing a landplane's fuel, before you may consider the refueling job done.
5. Mention two personal hazards, other than fire, against which persons handling aviation gasoline must protect themselves.
6. What characteristic of oil makes it extremely important that an airplane's oil tank be filled to no more than its specified capacity?

CHAPTER 14

ARMAMENT

1. (*a*) What is the basic difference between fixed and flexible gun installations?
   (*b*) What difficulty involved in the use of machine guns in bomber airplanes was solved by the development of the power-operated turret, and how does the turret solve it?
2. In what positions may turrets be found on airplanes?
3. What is the function of the interrupter device?
4. What is the principal difference between an ordinary aerial mechanical gunsight and the gunsight on a rifle?
5. (*a*) Match the three types of aerial machine gun ammunition in the left-hand column on p. 222 with the uses, listed at the right, for which each is suitable.
   (*b*) Name the two principal types not listed, and give the use of each.

Ammunition	**Principal Uses**
Dummy	Against personnel and matériel.
Ball cartridge	Testing action of guns after repair.
Incendiary	Igniting inflammable materials.

6. How are various types of aircraft ammunition distinguished?

CHAPTER 15

EMERGENCY EQUIPMENT

1. What are the five major parts of a parachute?
2. What kind of life raft is used most commonly?
3. What is the easiest color to see against a water background?
4. (*a*) How much pull is a safety belt required to withstand?
   (*b*) How do you release the belt?
5. (*a*) What part of the airplane does the automatic fire extinguisher protect?
   (*b*) From what part of the plane is this extinguisher operated?
   (*c*) What equipment is provided for extinguishing fires in sections not protected by the automatic extinguisher?
6. Why should you be extremely careful in handling and using pyrotechnics?

ANSWERS TO QUIZ

CHAPTER 1

FLIGHT

1. (*a*) Location of propellers.
   (*b*) Number of wings.
   Location of wings.
   Number of engines.
   Landing gear.
   Purpose.
   (*c*) Autogiro and helicopter.

CHAPTER 2

WHY AIRPLANES FLY

1. Both autogiros and helicopters obtain their lift from wings which, by their rotation, create the necessary relative wind. The helicopter's wings are rotated by engine-power, thus setting up their own relative wind. The autogiro must make a running take-off to set its wings in rotation.
2. To take advantage of the additional lift created by the motion of the wind across the airplane's wings.
3. (*a*) Other things being equal, an airplane wing has more lift in dense than in more rarefied air.
   (*b*) Low altitudes; because there is then more air above it, exerting pressure and compressing it into a smaller space, hence making it more dense.

4.

■	^{1}C	^{2}H	^{3}O	R	^{4}D	^{5}S	■
■	^{6}A	I	R	■	^{7}O	S	■
^{8}I	M	P	A	^{9}C	T	■	^{10}S
■	B	■	^{11}N	O	■	^{12}R	I
^{13}S	E	^{14}A	■	■	^{15}G	U	N
^{16}T	R	A	^{17}I	^{18}L	I	N	G
A	■	■	^{19}N	A	■	■	L
^{20}B	O	W	■	■	^{21}A	C	E

(Abbreviations)

ACROSS

19. North American (NA).

DOWN

14. Angle of attack (AA).
18. Los Angeles (LA).

CHAPTER 3

STRUCTURES

1. Higher.
2. (*a*) Fin (V).
   Rudder (V).
   Stabilizer (H).
   Elevator (H).
   (*b*) Vertical.
3. (*a*) Aileron.
   (*b*) By moving the control stick in the direction toward which the airplane is to bank, causing the aileron of that wing to move up, decreasing the wing's effective camber as well as the impact pressure, and consequently decreasing that wing's lifting power. The effect on the other aileron and wing is just the opposite.
4. (*a*) Covering, ribs, spars.
   (*b*) Spars.
   (*c*) Ribs.
5. (*a*) The movable surfaces—rudder and elevators. To keep them from fluttering during flight.
   (*b*) Statically, by locating a weight forward of the hinge; or aerodynamically, by locating the hinge back from the control surface's leading edge.

6. (*a*) Hull.
   (*b*) Wheel.
   (*c*) Wheel.
   (*d*) Hull.
7. (*a*) Brace between floats of a twin-float seaplane.
   (*b*) Attach deck to sides.
   (*c*) Attachment of lines for mooring or tying.
   (*d*) Permit inspection, pumping out water, or repairs to interior.
   (*e*) Break float from grasp of water.
   (*f*) Protect keel.
   (*g*) Steady plane in water, and add to planing surface of hull bottom during take-off.
8. (*a*) Horizontal distance between the centers of two floats.
   (*b*) Ridge where bottom meets side.
   (*c*) Dividing line between under-water and above-water parts of float when seaplane is carrying normal load.
   (*d*) Curved members attached at right angles to lengthwise braces, to give float its curved cross-sectional shape.
   (*e*) Fore-and-aft strips supporting skin between frames.
   (*f*) Structural reinforcement braces inside or outside float.
9. Because in a monocoque fuselage many of the loads and stresses of flight are borne by the skin itself, whereas in the truss-type they are borne by the truss frame beneath the skin.

CHAPTER 4

INSTRUMENTS

1. (*a*) Rate of Climb indicator.
   (*b*) Altimeter.
   (*c*) Bank and Turn indicator.
   (*d*) Drift indicator.
   (*e*) Tachometer.
2. It "flies" the airplane on a steady, straightaway course, temporarily relieving the pilot for other chores.

CHAPTER 5

ENGINES

1. (*a*) Inlet (intake) valve.
   (*b*) It is compressed, ignited and burned.
   (*c*) It pushes the piston away from the cylinder head.
2. (*a*) Crankshaft.
   (*b*) Four.
   (*c*) Two.
3. Weight and horsepower.
4. (*a*) Radial.
   (*b*) In-line.

CHAPTER 6

ENGINE SYSTEMS

1. Radial.

Engine system	**Function**
2. (*a*) Fuel	Supply fuel from tank to carburetor under pressure.
(*b*) Fuel	Convert liquid gas into small particles, and mix them with air.
(*c*) Ignition	Provide a strong surge of current to the spark plugs.
(*d*) Cooling	Direct cooling air to rear rows of radially arranged cylinders.
(*e*) Mechanical	Counteract weight of crank throw, so that crankshaft will turn without jerking.
(*f*) Fuel	Tap fuel tanks.

3. It stops the flow of fuel from the carburetor to the engine, thus eliminating the possibility that hot cylinder heads might keep the engine running after the ignition switch is shut off.
4. The purpose of the external system is primarily to convey the oil between tank and engine. The internal system conveys oil to specific parts within the engine.

5\. (*a*) Rich.

(*b*) Mixture control.

6\. (*a*) Because the weight of a given volume of air at high altitudes is less than it is at lower altitudes.

(*b*) Supercharger.

CHAPTER 7

PROPELLERS

1\. (*a*) They are both made up of a series of airfoils.

(*b*) The lift action of a propeller tends to pull or push the airplane, in a forward direction, whereas the wings tend to lift it vertically.

2\. (*a*) Centrifugal force and thrust.

(*b*) Near the hub.

3\. (*a*) The distance the propeller moves ahead through the air during one revolution.

(*b*) The difference between effective pitch and geometric pitch. (Geometric pitch is the distance the propeller would move ahead during one revolution if the air were a solid medium.)

(*c*) Constant-speed propeller.

CHAPTER 8

NAVAL AVIATION

	Function	Model	Manufacturer's Name
1. (*a*)	Observation Scout	Second	Chance-Vought
(*b*)	Trainer	Second	
(*c*)	Transport (multi-engine)	Fifth	
(*d*)	Trainer	Third	Naval Aircraft Factory.
(*e*)	(Helicopter) Observation	First	
(*f*)	Patrol	First	Vega.
(*g*)	Fighter	Sixth	Grumman.
(*h*)	Patrol Bomber	First	Lockheed.

2\. (*a*) VF.

(*b*) VN.

(*c*) VOS.

(*d*) VPB.

CHAPTER 9

HANDLING

1. (*a*) Protection from the wind.
   (*b*) So that the wind will hit the plane's control surfaces in the normal direction, minimizing the danger of warping or damaging them.
2. They should be lashed, with battens, in neutral position.
3. (*a*) Right wing, left wing, tail.
   (*b*) In the cockpit; to tend the brakes.
4. (*a*) 8 inches.
   (*b*) Tail-wheel must be locked.
5. Wing lines are attached to the plane and tended by the beach crew.
6. (*a*) Hoisting out.
   (*b*) Winch man.
7. So that air blast and oil from the seaplane's engine will be directed over the side.

CHAPTER 10

ANCHORING AND MOORING

1. (*a*) To attach manila line to anchor.
   (*b*) Float cleat and ring bolt.
   (*c*) No.
2. (*a*) To transfer the load from the anchor ring or mooring to the pendant, thus relieving the tension on the anchor winch.
   (*b*) "Come along".
3. (*a*) The winch or the engine.
   (*b*) Pendant.
4. (*a*) Too short a cable means poor holding power, as it does not allow for changes in tide level or for heavy seas. Serious damage may result if the plane is permitted to ride upon the buoy.
   (*b*) About three times the depth of the water at the anchorage.

5. The pilot should bring the plane toward the buoy slowly, from down wind, until the buoy is alongside the port bow.

CHAPTER 11

AVIATION SEAMANSHIP

1. (*a*) Drifting rapidly before, and tending to head into, the wind.
   (*b*) Position would depend on the combined effects of wind and current. Plane would tend to head into the wind and to be carried downstream by the current.
   (*c*) Headed into the wind.
2. Towing.
   Placing crews aboard.
   Removing crews.
   Going alongside crashed planes.
   Refueling.
3. (*a*) From windward.
   (*b*) Against wind or current, whichever is more powerful.
   (*c*) This type of boat should always approach in such a way that if its engine stopped, it would tend to drift away from the plane.
   (*d*) Anchor ahead of the plane and allow the boat to drop back by veering the necessary amount of chain; or, if the plane is small, anchor the boat and pull the plane up to it.
4. They should not bear the strain of towing.
5. By keeping the ship to windward.
6. (*a*) A temporary rig.
   (*b*) Propeller hub.
   Engine mount.
   Arresting hook or sling extension (on carrier-based planes).
   Junction of braces in fuselage.

CHAPTER 12

CLEANING AND INSPECTING

1. Dirt on an airplane's outer surface may seriously impair its flying speed.
2. (*a*) Electrical equipment: magnetos, starters, generators.
   (*b*) With bristle brush.
3. (*a*) They will lose their transparency.
   (*b*) Flush them with fresh water.
   (*c*) Water solution of mild soap.
   (*d*) Bare hands or clean, grit-free cloth; chamois; absorbent cotton.
   (*e*) It may cause scratches, and it will build up an electrostatic charge that attracts dust particles to the plastic surface.
   (*f*) A protective coat of wax.
4. (*a*) Daily Flight Inspection Form (N. Aer. 3119, or "Yellow Sheet").
   (*b*) Plane Captain, or whoever is officially detailed to make the inspection.
   (*c*) Before the next scheduled flight of the airplane.
   (*d*) Plane Captain, or whoever is officially detailed to make the inspection, must make a full report to the flight officer responsible for carrying out operations scheduled by the Squadron Commander.
5. (*a*) Colored bands painted around the pipes.
   (*b*) Near either end of a pipe, and at intermediate points where it would otherwise be difficult to follow the pipe through the system.
6. (*a*) At least once a month.
   (*b*) Should be tested thoroughly at end of first month's service, and at six-month intervals thereafter.

CHAPTER 13

FUELING AND STARTING

1. Because partially filled tanks have exposed interior surfaces on which moisture from the air will condense, resulting in water in the fuel system.

2. (*a*) To lead off the static electric charge built up by gasoline flowing through the hose, and prevent it from causing sparks which might set the gasoline afire when the hose nozzle is withdrawn from the airplane tank.
   (*b*) The ends of a short wire having clips at each end should be attached to the nozzle and to the airplane tank; one end of another wire should be attached to the nozzle or the airplane, and this wire's other end connected with the earth.
3. So that the weight of the funnel—and its load of gasoline—is not on the fuel tank's neck.
4. Measure the amount of gasoline in each tank with a clean measuring stick.
   Record the measurement exactly.
   See that all gas tank vents are open.
   See that the chain on the filler cap is in good order.
   Replace the gas tank cap securely.
   Pick up all rags and gear used, and return them to their proper places.
5. Breathing gasoline vapor (fumes).
   Getting gasoline in eyes, on hair or skin.
6. Hot oil expands.

CHAPTER 14

ARMAMENT

1. (*a*) Fixed guns are rigidly mounted so as to fire in a direction practically parallel with the line of flight; their fire is therefore directed by maneuvering the airplane.
   Flexible guns can be aimed at a target regardless of the direction in which the airplane is flying.
   (*b*) Fixed mounting is unsatisfactory because a bomber's maneuverability is limited; flexible mounting is unsatisfactory because rough air or maneuvering of the airplane hampers the accurate aiming of guns not firmly mounted. The turret mounting combines the scope of the flexible gun with the accuracy of the fixed gun.

2. Upper and lower parts of fuselage.
   Rear (tail).
   Nose (bow).
3. It prevents the gunner from firing into his own airplane.
4. A ring encircling the peep on an aerial mechanical gunsight aids in deflection shooting by helping the gunner to estimate the speed, range, and direction of his target. An ordinary rifle has no ring or peep.
5.

	Ammunition	Principal uses
(*a*)	Dummy	Testing action of guns after repair.
	Ball cartridge	Against personnel and matériel.
	Incendiary	Igniting inflammable materials.
(*b*)	Tracer	Observation of fires.
	Armor piercing	Against armored objects, airplanes, vehicles, etc.

6. By the color of bullet tips.

CHAPTER 15

EMERGENCY EQUIPMENT

1. Canopy.
   Shroud lines.
   Harness.
   Pack.
   Pilot chute.
2. Droppable type.
3. Orange-yellow.
4. (*a*) 1,600 pounds.
   (*b*) Trip the release buckle from left to right.
5. (*a*) Engine compartment.
   (*b*) Cockpit.
   (*c*) Hand-operated fire extinguishers.
6. Because they are incendiary, and because they may be visible to the enemy.

○