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TECHNICAL MANUAL

AIRPLANE STRUCTURES

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AIRPLANE STRUCTURES

Prepared under direction of the Chief of the Air Corps

SECTION I

GENERAL

1. General.—The subject of aircraft structures is an exceptionally broad one and no attempt is made in this manual to cover the entire field. It is, however, intended to present sufficient subject matter that the student will be familiar enough with structural details of service airplanes used by the Air Corps to be able to perform properly the inspec-

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tion and maintenance of this equipment. In addition, it was found necessary to include certain information, for example, Air Corps designations, insignia, approved methods of handling, cleaning and lubricating airplanes, etc., which is not generally classified under aircraft structures, but is so closely allied with the main subject matter that it can be presented logically in this manual.

2. Air Corps designation of airplanes.—*a.* The various types of airplanes used by the Air Corps are determined by their particular tactical and operative employment, for example, bombardment, combat, training, etc. The model of any particular type is governed by specific characteristics of the airplane and identifies the manufacturer. Furthermore, there may be a series of a particular model which provides for minor modifications resulting from engineering improvements but not necessitating a change in the specific characteristics, tactical use, or manufacture of the airplane. When airplanes perform more than one function, the primary one determines the type designation.

b. The types, models, and series of airplanes used by the Air Corps are designated by a combination of letters and figures. These designations consist of—

(1) Letter or letters indicating type.
(2) Number indicating model.
(3) Letter suffix indicating the series of the model.

Present types of Army Air Corps airplanes and their respective designations are given in the following table, several of which are shown in figures 1 to 7, inclusive.

Types	Designation
Attack	A
Autogiro	G
Bombardment	B
Cargo (transport)	C
Combat (basic)	BC
Fighter (multiplace)	FM
Observation	O
Observation amphibian, corps and division	OA
Amphibian, Army reconnaissance	OA
Amphibian	OAU
Photographic	F
Pursuit	P
Rotary wing	R
Training (advanced)	AT
Training (basic)	BT
Training (primary)	PT

FIGURE 1.—Cargo airplane.

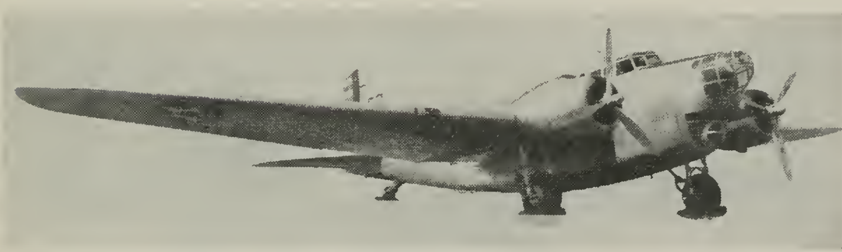


FIGURE 2.—Bombardment airplane.

FIGURE 3.—Pursuit airplane.

FIGURE 4.—Observation airplane.

FIGURE 5.—Basic training airplane.

FIGURE 6.—Attack (light bombardment) airplane.

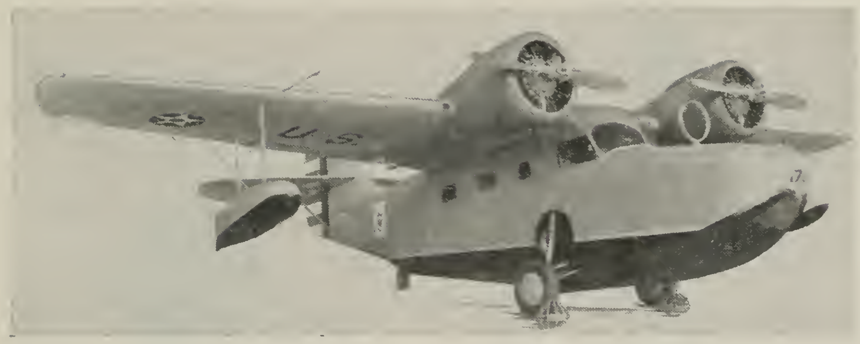


FIGURE 7.—Observation (amphibian).

c. Airplanes of experimental, service test, limited procurement, and obsolete status are prefixed as follows:

(1) Experimental, X.

(2) Service test and limited procurement, Y.

(3) Obsolete, Z.

3. Principal structural units.—*a.* The principal structural units of an airplane consist of fuselage, nacelle, engine mount, wings, stabilizers, control surfaces, and landing gear. Figure 8 shows the location of these units on a single-engine airplane and in some cases the details of their structure.

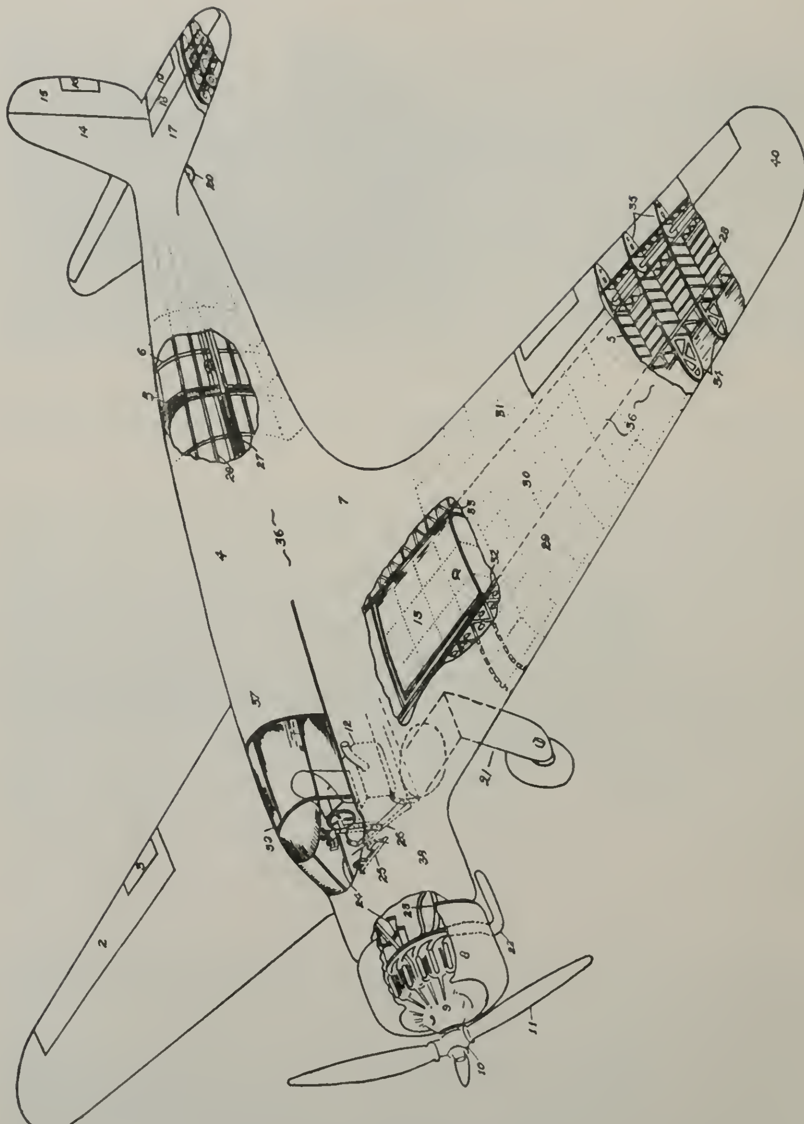
b. The fuselage is the main structure (or body) of the airplane to which the wings and tail units are attached. In the case of single-engine airplanes it houses the crew, passengers, cargo, power plant, etc. On multiengine airplanes however the power plants are mounted on nacelles which are separate units similar in design and construction to the fuselage and attached to the wing structure.

c. Engine mounts are used to attach the power plant to the airplane. On most single-engine airplanes they are mounted on the front end or nose of the fuselage, and on multiengine airplanes they are attached to, or incorporated with, the nacelle structure.

d. The wings constitute the main lifting and supporting surface of the airplane in flight and are designated as right and left. The right and left sides of an airplane are relative to the right and left hand of the pilot seated in the cockpit.

e. Stabilizers are airfoils whose primary purpose is to increase stability of the airplane. They are mounted at the rear end of the fuselage and consist of the vertical fin or fins and the horizontal stabilizer.

f. Control surfaces are movable airfoils by means of which the airplane is controlled in flight. They are hinged auxiliary surfaces and



1. Wing.
2. Aileron.
3. Aileron tab.
4. Fuselage.
5. Frame or bulkhead.
6. Intermediate frame.
7. Fairing.
8. Engine cowl.
9. Engine.
10. Propeller hub.
11. Propeller blade.
12. Oil tank.
13. Fuel tank.
14. Vertical fin.
15. Rudder.
16. Rudder tab.
17. Stabilizer.
18. Elevator.
19. Elevator tab.
20. Tail wheel.
21. Retractable landing gear.
22. Exhaust collector ring.
23. Fuel and oil lines.
24. Engine controls.
25. Rudder control.
26. Elevator and aileron control.
27. Longeron.
28. Stringer.
29. Leading edge.
30. Interspar section.
31. Trailing edge.
32. Front spar.
33. Rear spar.
34. Nose ribs.
35. Aileron ribs.
36. Metal skin.
37. Cabin.
38. Accessory cowl.
39. Pilot's enclosure.
40. Wing tip.

FIGURE 8.—Principal structural units of single-engine airplane.

consist of ailerons, elevators, rudders, tabs, and flaps. The control mechanism is the means by which the control surfaces are actuated.

g. Landing gears are the structures which support the airplane while on the ground or water. They incorporate shock-absorbing devices to reduce the shock of landing and taxying and are often retractable in flight. They may be any one of several general types, for example, float, ski, wheel, or a combination float and wheel, or ski and wheel.

4. Definitions and nomenclature.—*a*. The axes and motions of the airplane are described relative to the center of gravity which is

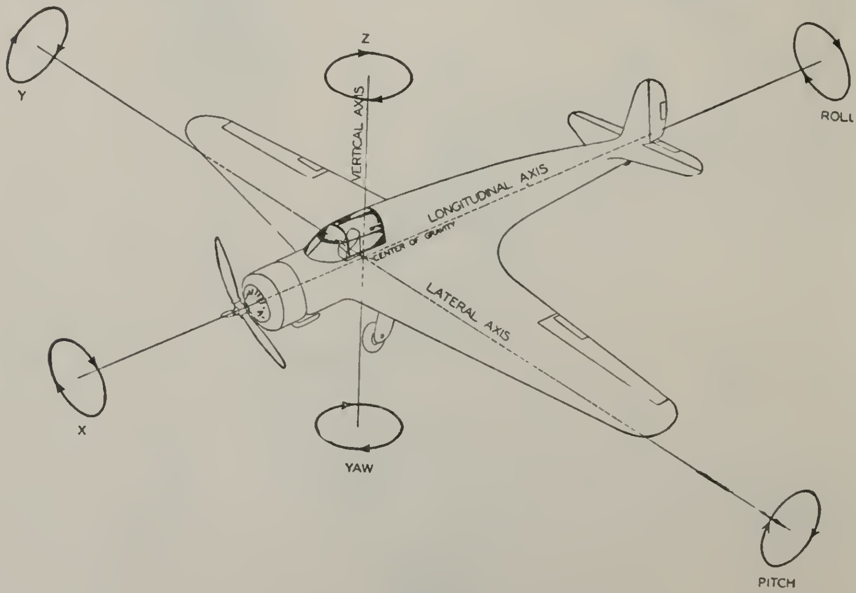


FIGURE 9.—Axis and fundamental motions of airplane.

the point at which total weight of the airplane is assumed to be concentrated.

(1) *Axes*.—The three principal axes of the airplane shown in figure 9 are—

(*a*) Longitudinal (X) axis which is a line parallel to the fuselage axis or thrust line.

(*b*) Lateral (Y) axis which is a horizontal line through the center of gravity perpendicular to the longitudinal axis.

(*c*) Vertical (Z) axis which is a line through the center of gravity perpendicular to the other two axes.

(2) *Motions*.—The three fundamental motions of an airplane as shown in figure 9 are pitching, rolling or banking, and yawing.

(*a*) Pitching is the angular motion about the lateral axis.

(*b*) Rolling or banking is the angular motion about the longitudinal axis.

(*c*) Yawing is the angular motion about the vertical axis.

b. The following definitions of aeronautical terms and nomenclature of airplane parts are presented to serve as a reference for the student and only those items have been included which are necessary for a proper understanding of the material used in this manual.

Accelerometer.—Instrument that measures accelerations of an aircraft in a defined direction.

Aerodynamics.—Branch of dynamics that treats of motion of air and other gaseous fluids and of forces acting on solids in motion relative to such fluids.

Aeronautics.—Science and art of flight.

Aileron.—A hinged or movable portion of an airplane wing, primary function of which is to impress a rolling motion on the airplane. It is usually part of the trailing edge of a wing.

External.—Separate airfoil mounted clear of wing surfaces but usually attached to them and deflected for lateral control.

Frise.—Aileron having nose portion projecting ahead of hinge axis, the lower surface being in line with the lower surface of the wing. When trailing edge of aileron is raised, the nose portion protrudes below lower surface of the wing, increasing drag.

Slotted.—Aileron having a nose and axis arrangement somewhat similar to a Frise aileron but having a smooth air passage between nose portion of aileron and wing for the purpose of maintaining a smooth air flow over upper surface of the aileron when its trailing edge is deflected downward.

Upper surface.—Split flap forming rear upper surface of a wing, deflected for lateral control.

Aircraft.—Any weight-carrying device designed to be supported by the air either by buoyancy or by dynamic action.

Airfoil.—Any surface such as wing, aileron, or rudder, designed to obtain reaction from the air through which it moves.

Airfoil section.—Cross section of an airfoil parallel to the plane of symmetry or to a specified reference plane.

Airplane.—Mechanically driven fixed-wing aircraft, heavier than air, which is supported by dynamic reaction of air against its wings.

Air speed.—Speed of an aircraft relative to the air.

Air speed head.—Instrument which in combination with a gage is used to measure the speed of aircraft relative to the air. It usually consists of a pitot static tube or a pitot venturi tube.

Altimeter.—Instrument that measures elevation of an aircraft above a given datum plane.

Altitude:

Absolute.—Height of an aircraft above the earth.

Pressure.—Altitude corresponding to a given pressure in a standard atmosphere.

Amphibian.—Airplane designed to rise from and alight on either land or water.

Angle:

Dihedral.—Acute angle between a line perpendicular to the plane of symmetry and the projection of the wing axis on a plane perpendicular to the longitudinal axis of the airplane. If the wing axis is not approximately a straight line, the angle is measured from the projection of a line joining the intersection of the wing axis with the plane of symmetry and the aerodynamic center of the half-wing on either side of the plane of symmetry.

Drift.—Horizontal angle between the longitudinal axis of an aircraft and its path relative to the ground.

Flight path.—Angle between the flight path of the aircraft and the horizontal.

Gliding.—Angle between the flight path during a glide and a horizontal axis fixed relative to the air.

Landing.—Acute angle between the wing chord and the horizontal when airplane is resting on level ground in its normal position; also called "ground angle."

Minimum gliding.—Acute angle between the horizontal and the most nearly horizontal path along which an airplane can descend steadily in still air when the propeller is producing no thrust.

Rudder.—Acute angle between the rudder and the plane of symmetry of the aircraft. It is positive when the trailing edge has moved to the left with reference to the normal position of the pilot.

Angle of attack.—Acute angle between a reference line in a body and the line of relative wind direction projected on a plane containing the reference line and parallel to the plane of symmetry.

Critical.—Angle of attack at which flow about an airfoil changes abruptly as shown by corresponding abrupt changes in lift and drag.

Angle of incidence.—Acute angle between plane of the wing chord and the longitudinal axis of the airplane. The angle is positive when leading edge is higher than trailing edge.

Artificial horizon.—A device that indicates attitude of an aircraft with respect to the true horizon. A substitute for a natural horizon such as a liquid level, pendulum, or gyroscope, incorporated in a navigating instrument.

Atmosphere:

Altimeter calibration standard.—Standard atmosphere used in calibrating aeronautic instruments. The standard now in use in the United States is completely defined in National Advisory Committee for Aeronautics Report No. 246.

Standard.—Arbitrary atmosphere used in comparing performance of aircraft. Standard atmosphere in use in the United States at present represents very nearly average conditions found at latitude 40° and is completely defined in National Advisory Committee for Aeronautics Report No. 218.

Attitude.—Position of an aircraft as determined by inclination of its axes to some frame of reference. If not otherwise specified, this frame of reference is fixed to the earth.

Attitude of flight.—Inclination of the three principal airplane axes to the relative wind.

Automatic pilot.—Automatic control mechanism for keeping an aircraft in level flight and on a set course. Sometimes called "gyro pilot," "mechanical pilot," or "robot pilot."

Bank.—Position of an airplane when its lateral axis is inclined to the horizontal. A right bank is the position with the lateral axis inclined downward to the right.

Bank.—To incline an airplane laterally, that is, to rotate it about its longitudinal axis.

Blade element.—A portion of a propeller blade contained between the surfaces of two cylinders coaxial with the propeller cutting the propeller blades.

Blade face.—Surface of a propeller blade that corresponds to the lower surface of an airfoil. Sometimes called "thrust face" or "driving face."

Blade section.—Cross section of a propeller blade made at any point by a plane parallel to the axis of rotation of the propeller and tangent at the centroid of the section to an arc drawn with axis of rotation as its center.

Blade width ratio.—The ratio of chord of a propeller blade section to diameter of propeller.

Mean blade width ratio.—Ratio of mean blade width to diameter of propeller.

Blast gate (supercharger).—Device for controlling pressure in nozzle box of a turbo supercharger by discharging into free atmosphere a portion of the exhaust gases that would otherwise pass through the turbine wheel.

Boost.—To supply an engine with more air or mixture than it normally would induct at sea level.

Boost control, automatic.—Automatic regulator of boost pressure.

Bump.—Sudden acceleration of an aircraft caused by a region of unstable atmosphere characterized by marked local vertical components in air currents.

Cabane.—Arrangement of struts used for bracing on an aircraft.

Cable control.—Line of wire or stranded cable leading from control levers to control surfaces or interconnecting control surfaces.

Camber.—Rise of curve of airfoil section, usually expressed as ratio of departure of the curve from a straight line joining extremities of the curve to the length of this straight line. "Upper camber" refers to the upper surface; "lower camber" to the lower surface; and "mean camber" to the mean line of the section. Camber is positive when departure is upward, and negative when it is downward.

Ceiling.—Height of lower level of a bank of clouds above the ground.

Absolute.—Maximum height above sea level at which a given airplane would be able to maintain horizontal flight under standard air conditions.

Service.—Height above sea level under standard air conditions at which a given airplane is unable to climb faster than a small specified rate (100 feet per minute in the United States and England). This specified rate may differ in different countries.

Cellule (or cell).—In an airplane, the entire structure of the wings and wing trussing of the whole airplane on one side of fuselage, or between fuselages or nacelles where there are more than one.

Center section.—Central panel of a wing; in the case of a continuous wing or any wing having no central panel, the limits of center section are arbitrarily defined by location of points of attachment to cabane struts or fuselage.

Chord.—Arbitrary datum line from which ordinates and angles of an airfoil are measured. It is usually the straight line tangent to the lower surface at two points, the straight line joining the ends of the mean line, or the straight line between the leading and trailing edges.

Cockpit.—Open space in an airplane for accommodation of pilots or passengers. When completely enclosed, such a space usually is called a cabin.

Compass, card (or card magnetic).—Magnetic compass in which magnets are attached to a pivoted card on which directions are marked.

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

Control column.—Lever having a rotatable wheel mounted at its upper end for operating longitudinal and lateral control surfaces of an airplane. This type of control is called "wheel control."

Control servo.—Control devised to reinforce pilot's effort by an aerodynamic or mechanical relay.

Controllability.—Quality of an aircraft that determines ease of operating its controls and/or effectiveness of displacement of controls in producing change in its attitude in flight.

Controls.—General term applied to means provided to enable pilot to control speed, direction of flight, attitude, power, etc., of an aircraft.

Control stick.—Vertical lever by means of which longitudinal and lateral control surfaces of an airplane are operated. The elevator is operated by a fore and aft movement of the stick; the ailerons by a side-to-side movement.

Control surface.—Movable airfoil designed to be rotated or otherwise moved by pilot in order to change attitude of aircraft.

Cowling.—Removable covering.

Cockpit.—Cowling placed around a cockpit.

Engine.—Removable covering placed around all or part of an airplane engine.

Decalage.—Difference between the angular settings of the wings of a biplane or multiplane. The decalage is measured by the acute angle between the chords in a plane parallel to the plane of symmetry. The decalage is considered positive if the upper wing is set at the larger angle.

Directional gyro.—Gyroscopic instrument for indicating direction, containing a free gyroscope which holds its position in azimuth and thus indicates angular deviation from the course.

Displacement, engine.—Total volume swept by the pistons of all the cylinders during one complete stroke of each piston.

Dive.—Steep descent, with or without power, in which the air speed is greater than the maximum speed in horizontal flight.

Dope.—Liquid material applied to the fabric surfaces of airplanes to increase their strength, to produce tautness by shrinking, and to act as a filler for maintaining airtightness.

Drag.—Component of the total air force on a body parallel to the relative wind.

Induced.—That part of drag induced by lift.

Parasite.—That portion of drag of an aircraft exclusive of induced drag of wings.

Drag strut.—Fore and aft compression member of the internal bracing system of an aircraft.

Elevator.—Movable auxiliary airfoil, the function of which is to impress a pitching moment on the aircraft. It is usually hinged to the stabilizer.

Emergency flotation gear.—Device attached to a landplane to provide buoyancy in case of an emergency landing on water.

Engine:

Compression ignition.—Type in which fuel is sprayed into the cylinder and ignited by heat of compression of air charge.

Double row radial.—Engine having two rows of cylinders arranged radially around a common crankshaft. Corresponding front and rear cylinders may or may not be in line.

Left hand.—Engine whose propeller shaft to an observer facing propeller from engine end of shaft, rotates in a counterclockwise direction.

Right hand.—Engine whose propeller shaft, to an observer facing propeller from engine end of shaft, rotates in a clockwise direction.

Supercharged.—Engine with a compressor for increasing air or mixture charge taken into cylinder beyond that inducted normally at the existing atmospheric pressure.

Dry weight.—Weight of an engine exclusive of fuel, oil, and liquid coolant.

Weight per horsepower.—Dry weight of an engine divided by rated horsepower.

Exhaust collector ring.—Circular duct into which exhaust gases from the cylinders of a radial engine are discharged.

Factor of safety.—Ratio of the ultimate load to any applied load. This term usually refers to the probable minimum factor of safety which is the ratio of ultimate load to probable maximum applied load.

Fairing.—Auxiliary member or structure whose primary function is to reduce the drag of part to which it is fitted.

Fin.—Fixed or adjustable airfoil attached to an aircraft approximately parallel to plane of symmetry to afford directional stability; for example, tail fin, skid fin, etc.

Fitting.—Generic term for any small part used in structure. If without qualification, a metal part is usually understood.

Flap.—Hinged or pivoted airfoil forming the portion of an airfoil, used to vary the effective camber.

Split.—Hinged plate forming rear upper or lower portion of an airfoil. Lower portion may be deflected downward to give increased lift and drag; upper portion may be raised over a portion of wing for the purpose of lateral control (example, upper surface aileron).

Flare:

Parachute.—Pyrotechnic device attached to a parachute and designed to illuminate a large area when released from an aircraft at an altitude.

Signal.—Pyrotechnic signaling device of distinctive color and characteristics.

Flight path.—Flight path of the center of gravity of an aircraft with reference to the earth, or with reference to a frame fixed relative to the air.

Float.—Completely enclosed watertight structure attached to an aircraft to give it buoyancy and stability when in contact with water.

Inboard stabilizing.—Stabilizing float placed relatively close to the main float or hull.

Outboard (*or wing tip*) *stabilizing.*—Stabilizing float placed relatively far out from main float or hull, usually at or very near the tip of the wing.

Single.—Single central float fitted under a seaplane and usually requiring two stabilizing floats to give adequate stability and complete the float system.

Stabilizing (*or side*).—Float used in addition to a single float or hull and intended to provide lateral stability while seaplane or flying boat is at rest on water.

Flow:

Streamline.—Fluid flow in which the streamlines, except those very near a body and in a narrow wake, do not change with time.

Turbulent.—Any part of a fluid flow in which velocity at a given point varies more or less rapidly in magnitude and direction with time.

Flutter.—Oscillation of definite period but unstable character set up in any part of an aircraft by a momentary disturbance, and maintained by a combination of aerodynamic, inertial, and elastic characteristics of the member itself (example, buffeting.)

Fuselage.—Body of approximately streamline form to which wings and tail unit of an airplane are attached.

Gap.—Distance separating two adjacent wings of a multiplane.

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

Ground loop.—Uncontrollable violent turn of an airplane while taxying or during the landing or take-off run.

Gyro horizon.—Gyroscopic instrument that indicates lateral and longitudinal attitude of the airplane by simulating the natural horizon.

Horn.—Short lever attached to a control surface of an aircraft to which the operating wire or rod is connected.

Horsepower of engine, rated.—Average horsepower developed by a given type of engine at the rated speed when operating at full throttle, or at a specified altitude or manifold pressure.

Impact pressure.—Pressure acting at the forward stagnation point of a body such as a pitot tube placed in an air current. Impact pressure may be measured from an arbitrary datum pressure.

Inclinometer.—Instrument that measures the attitude of an aircraft with respect to the horizontal.

Induction system, rotary.—Carburetor induction system used on radial engines in which a rotary fan assists in distributing the fuel charge to the cylinders.

Inflow.—Flow of air into a propeller.

Instability, spiral.—Type of instability inherent in certain airplanes which becomes evident when airplane assumes too great a bank and sideslips; bank continues to increase and radius of turn to decrease.

Instrument flying.—Art of controlling an aircraft solely by use of instruments; sometimes called "blind flying."

Landing.—Act of terminating flight in which the aircraft is made to descend, lose flying speed, establish contact with the ground, and finally come to rest.

Glide.—Landing in which a steady glide is maintained to the landing surface without the usual leveling off before contact.

Normal (or three-point).—Landing in which a path tangential to landing surface and loss in flying speed are attained approximately at instant of contact.

Pancake.—Landing in which leveling off process is carried out several feet above the ground, as a result of which the airplane settles rapidly on a steep flight path in a normal attitude.

Landing area, effective.—That portion of landing area with approaches clear within allowable safe climbing and gliding angle available for take-off and landing of aircraft.

Landing field.—Any area of land designed for take-off and landing of aircraft. It may or may not be part of an airport.

Landing gear.—Understructure which supports weight of an aircraft when in contact with land or water and which usually contains a mechanism for reducing shock of landing. Also called "undercarriage."

Retractable.—Type of landing gear which may be withdrawn into body or wings of an airplane while it is in flight in order to reduce parasite drag.

Landing strip.—Narrow and comparatively long area forming part of land-plane airport or of intermediate or auxiliary field which is suitable for the landing and take-off under ordinary weather conditions.

Leading edge.—Foremost edge of an airfoil or propeller blade.

Level off.—To make the flight path of an airplane horizontal after a climb, glide, or dive.

Lift, dynamic.—Component of the total aerodynamic force on a body perpendicular to the relative wind.

Lift-drag ratio.—Ratio of lift to drag of any body.

Light:

Anchor.—Light or group of clear lights carried on an aircraft to indicate its position at night while at anchor.

Approach.—Light, usually green, designed to indicate a favorable direction of approach for landing.

Blinker.—Flashing light giving more than 20 flashes per minute.

Boundary.—Any one of the lights designed to indicate limits of landing area of airport or landing field.

Course.—Light projected along course of an airway so as to be visible chiefly from points on or near the airway.

Fixed.—Light which is constant in luminous intensity with respect to both time and direction.

Flashing.—Light which is intermittent as viewed from a single direction.

Identification.—Group of lights, clear and colored, carried on rear part of an airplane for identification at night.

Landing direction.—Light designed to indicate either by itself or in conjunction with other lights the direction in which landings are to be made.

Landing.—Light carried by an aircraft to illuminate the ground while landing.

Obstruction.—Red light designed to indicate position and height of an object hazardous to operation of aircraft.

Position.—Any one of a group of lights, red, green, and clear, used aboard an aircraft to indicate its position and direction of motion.

Load:

Full.—Weight empty plus useful load; also called gross weight.

Pay.—That part of useful load from which revenue is derived. that is, passengers and freight.

Useful.—Crew and passengers, oil and fuel, ballast other than emergency, ordnance, and portable equipment.

Loading:

Power.—Gross weight of airplane divided by the rated horsepower of the engine computed for air of standard density, unless otherwise stated.

Wing.—Gross weight of airplane divided by the wing area.

Longeron.—Principal longitudinal member of framing of airplane fuselage or nacelle, usually continuous across a number of points of support.

Loop.—Maneuver executed in such a manner that the airplane follows a closed curve approximately in a vertical plane.

Inverted normal.—Loop starting from inverted flight and passing successively through a dive, normal flight, climb, and back to inverted flight.

Inverted outside.—Outside loop starting from inverted flight and passing successively through a climb, normal flight, dive. and back to inverted flight.

Normal.—Loop starting from normal flight and passing successively through a climb, inverted flight, dive, and back to normal flight.

Outside.—Loop starting from normal flight and passing successively through a dive, inverted flight, climb, and back to normal flight, pilot being on outside of flight path.

Loop, radio.—Specified number of turns of wire located in wings or wound around fuselage of an airplane. Small portable loops on a rectangular frame are also used.

Maneuver:

To operate aircraft in a skillful manner so as to cause it to perform evolutions out of the ordinary.

To perform tactical or acrobatic evolutions with aircraft.

Maneuverability.—That quality in aircraft which determines rate at which its altitude and direction of flight can be changed.

Marker, circle.—Circular band marking approximate center of landing area or intersection of principal landing strips on airport or landing field.

Mean line (of airfoil profile).—Intermediate line between upper and lower contours of profile.

Mixture control, altitude.—Device on carburetor for regulating weight proportions of air and fuel supplied to engine at different altitudes.

Monoplane.—Airplane with but one main supporting surface, sometimes divided into two parts by fuselage.

High wing.—Monoplane in which the wing is located at or near top of fuselage.

Low wing.—Monoplane in which wing is located at or near bottom of fuselage.

Midwing.—Monoplane in which the wing is located approximately midway between top and bottom of fuselage.

Parasol.—Monoplane in which the wing is above fuselage.

Multiplane.—Airplane with two or more main supporting surfaces placed one above another.

Nacelle.—Inclosed shelter for personnel or for a power plant. A nacelle is usually shorter than a fuselage, and does not carry the tail unit.

Nose down.—To depress nose of airplane in flight.

Nose heavy.—Condition of airplane in which nose tends to sink when longitudinal control is released in any given attitude of normal flight.

Nose over.—Colloquial expression referring to accidental turning over of an airplane on its nose when landing.

Nose up.—To elevate nose of airplane in flight.

Octant.—Variation of aircraft sextant which measures angles up to 90°. Its artificial horizon is usually the bubble type.

Oleo gear.—Type of oil-damping device that depends on flow of oil through an orifice for its shock-absorbing effect in a landing gear.

Over-all length.—Distance from extreme front to extreme rear of aircraft, including propeller and tail unit.

Overhang:

One-half the difference in span of any two main supporting surfaces of an airplane. Overhang is positive when the upper of the two main supporting surfaces has the larger span.

Distance from outer strut attachment to tip of a wing.

Overshoot.—To fly beyond a designated mark or area such as a landing field, while attempting to land on the mark or within the area.

Panel (airplane).—Portion of airplane wing constructed separately from rest of wing to which it is attached.

Parachute.—Umbrella-like device used to retard descent of a falling body by offering resistance to its motion through the air.

Pilot.—Small auxiliary parachute attached to apex of main parachute, designed to pull latter out of its pack when rip cord is pulled.

Harness.—Combination of straps, buckles, and fastenings used to attach parachute to the wearer.

Pack.—Parachute and its container.

Rigger.—Person who packs, repairs, and inspects parachutes.

Pilot.—One who operates the controls of an aircraft in flight.

Pitch.—Angular displacement about an axis parallel to the lateral axis of an aircraft.

Pitching.—Angular motion about lateral axis.

Pitch (or pitching) indicator.—Instrument for indicating existence and approximate magnitude of angular velocity about lateral axis of aircraft.

Pitch of propeller:

Effective.—Distance aircraft advances along its flight path for one revolution of propeller.

Geometrical.—Distance an element of a propeller would advance in one revolution if it were moving along a helix having an angle equal to its blade angle.

Pitot static tube.—Parallel or coaxial combination of a pitot and a static tube. Difference between impact pressure and static pressure is a function of velocity of flow past the tube.

Pitot tube.—Cylindrical tube with an open end pointed upstream used in measuring impact pressure.

Pitot venturi tube.—Combination of a pitot and a venturi tube.

Propeller.—Any device for propelling craft through fluid such as water or air; especially a device having blades which when mounted on a power-driven shaft produce a thrust by their action on the fluid.

Adjustable.—Propeller whose blades are so attached to the hub that the pitch may be changed while propeller is at rest.

Automatic.—Propeller whose blades are attached to a mechanism that automatically sets them at their optimum pitch for various flight conditions.

Controllable.—Propeller whose blades are so mounted that pitch may be changed while propeller is rotating.

Pusher.—Propeller mounted on rear end of engine or propeller shaft.

Tractor.—Propeller mounted on forward end of engine or propeller shaft.

Propeller root.—That part of propeller blade near the hub.

Pull out.—Maneuver of transition from a dive to horizontal flight.

Pull up.—Maneuver in vertical plane in which airplane is forced into a short climb, usually from approximately level flight.

Radio directive devices:

Landing beam.—Beam projected from field to indicate to pilot his height above the ground and position of airplane on proper path for a glide landing.

Radio marker beacon.—Radio transmitter of low power emitting a characteristic aural signal to indicate course positions with respect to a landing field or an airway.

Radio range beacon.—Radio transmitter supplying directive radio waves that provide a means of keeping aircraft on proper course.

Runway localizing beacon.—Small radio range beacon giving accurate lateral direction along runway of airport or landing field and a few miles beyond.

Radio mast.—Mast attached to aircraft which serves as part of radio antenna structure.

Range, maximum.—Maximum distance a given aircraft can cover under given conditions, by flying at economical speed and altitude at all stages of the flight.

Range at maximum speed.—Maximum distance a given aircraft can fly at full speed at altitude for maximum speed under given conditions.

Rate of climb indicator.—Instrument that indicates rate of ascent or descent of aircraft.

Righting or restoring moment.—Moment that tends to restore aircraft to its previous altitude after any small rotational displacement.

Ring cowling.—Ring-shaped cowling placed around radial air-cooled engine to reduce drag and improve cooling.

Rip cord.—Cord, together with handle and fastening pins, which when pulled releases parachute from container.

Roll.—Maneuver in which a complete revolution about the longitudinal axis is made, the horizontal direction of flight being approximately maintained.

Aileron.—Roll in which the motion is largely maintained by forces arising from displacement of aileron.

Outside.—Roll executed while flying in negative angle of attack range.

Snap.—Roll executed by a quick movement of the controls, in which the motion is largely maintained by autorotational couples on wings.

Roll.—Angular displacement about an axis parallel to the longitudinal axis of an aircraft.

Rolling.—Angular motion about longitudinal axis.

Rotor.—Complete rotating portion of rotary wing system.

Rudder.—Hinged or movable auxiliary airfoil on aircraft, function of which is to impress a yawing moment on the aircraft.

Rudder bar.—Footbar by means of which control cables leading to the rudder are operated.

Rudder pedals.—Footpedals by means of which controls leading to the rudder are operated.

Runway.—Artificial landing strip permitting landing and take-off under all weather conditions.

Sideslipping.—Motion of aircraft relative to the air, in which lateral axis is inclined and airplane has a velocity component along the lateral axis. When it occurs in connection with a turn, it is the opposite of skidding.

Sinking speed.—Vertical downward component of velocity that aircraft would have while descending in still air under given conditions of equilibrium.

Skidding.—Sliding sidewise away from center of curvature when turning. It is caused by banking insufficiently, and is the opposite of sideslipping.

Skid fin.—Longitudinal vertical surface, usually placed above upper wing to increase lateral stability.

Skin friction.—Tangential component of fluid force at a point on a surface.

Slat.—Movable auxiliary airfoil attached to leading edge of wing, which when closed falls within the original contour of the main wing and which when opened forms a slot.

Slip.—Difference between geometrical pitch and effective pitch of a propeller. Slip may be expressed as a percentage of mean geometrical pitch, or as a linear dimension.

Slipstream.—Current of air driven astern by a propeller.

Slot.—Nozzle-shaped passage through wing whose primary object is to improve the flow conditions at high angles of attack. It is usually near leading edge and formed by a main and an auxiliary airfoil, or slot.

Soar.—To fly without engine power and without loss of altitude, as does a glider in ascending air currents.

Span.—Maximum distance measured parallel to lateral axis from tip to tip of airfoil of an airplane wing inclusive of ailerons, or of a stabilizer inclusive of elevator.

Effective.—True span of wing less corrections for tip loss.

Speed:

Ground.—Horizontal component of velocity of an aircraft relative to the ground.

Landing.—Minimum speed of airplane at instant of contact with landing area in a normal landing.

Minimum flying.—Lowest steady speed that can be maintained with any throttle setting whatsoever by an airplane in level flight at an altitude above the ground greater than the span of the wings.

Operating.—Speed in level flight corresponding to 87.5 percent of rated speed of engine.

Rated engine.—Rotative speed of an engine at which its reliability has been determined for continuous performance.

Stalling.—Speed of an airplane in steady flight at its maximum coefficient of lift.

Take-off.—Air speed at which an airplane becomes entirely airborne.

Spin.—Maneuver in which an airplane descends along a helical path of large pitch and small radius while flying at a mean angle of attack greater than angle of attack at maximum lift.

Flat.—Spin in which longitudinal axis is less than 45° from the horizontal.

Inverted.—Maneuver having characteristics of normal spin except that airplane is in inverted attitude.

Normal.—Spin which is continued by reason of voluntary position of control surfaces, recovery from which can be effected within two turns by neutralizing or reversing all controls. Sometimes called "controlled spin."

Uncontrolled.—Spin in which controls are of little or no use in effecting a recovery.

Spinner.—Fairing of approximately conical or paraboloidal shape which is fitted coaxially with propeller hub and revolves with propeller.

Spiral.—Maneuver in which an airplane descends in a helix of small pitch and large radius, angle of attack being within normal range of flight angles.

Spoiler.—Small plate arranged to project above upper surface of wing to disturb smooth air flow, with consequent loss of lift and increase of drag.

Stability.—That property of a body which causes it, when its equilibrium is disturbed, to develop forces or moments tending to restore original condition.

Automatic.—Stability dependent upon movable control surfaces automatically operated by mechanical means.

Directional.—Stability with reference to disturbances about normal axis of aircraft; that is, disturbances which tend to cause yawing.

Dynamic.—That property of an aircraft which causes it when its state of steady flight is disturbed to damp oscillations set up by restoring forces and moments and gradually return to its original state.

Inherent.—Stability of an aircraft due solely to disposition and arrangement of its fixed parts; that is, that property which causes it when disturbed to return to its normal attitude of flight without use of controls or interposition of any mechanical device.

Lateral.—Stability with reference to disturbances about longitudinal axis; that is, disturbances involving rolling or sideslipping. The term lateral stability is sometimes used to include both directional and lateral stability, since these cannot be separated entirely in flight.

Longitudinal.—Stability with reference to disturbances in the plane of symmetry; that is, disturbances involving pitching and variation of the longitudinal and normal velocities.

Static.—That property of an aircraft which causes it when its state of steady flight is disturbed to develop forces and moments tending to restore its original condition.

Stabilizer (*airplane*).—Any airfoil whose primary function is to increase stability of aircraft. It usually refers to fixed horizontal tail surface of an airplane, as distinguished from fixed vertical surface.

Stabilizer, stub wing.—Projection from side of central hull of a flying boat intended to increase buoyancy and stability while the boat is at rest and to increase hydrodynamic lift during take-off. It is an integral part of the hull, and usually takes the form of a stumpy airfoil or a stub wing.

Stagger.—Term referring to longitudinal position of axes of two wings. Stagger of any section is measured by the acute angle between a line joining the wing axes and a line perpendicular to the upper wing chord, both lines lying in a plane parallel to plane of symmetry. The stagger is positive when upper wing is in advance of lower.

Stall.—Condition of an airfoil or airplane in which it is operating at an angle of attack greater than angle of attack of maximum lift.

Static pressure.—Force per unit area exerted by a fluid on a surface at rest relative to the fluid.

Static tube.—Cylindrical tube with a closed end and a number of small openings normal to the axis, pointed upstream, used to measure static pressure.

Step.—Break in form of bottom of float or hull, designed to diminish resistance, to lessen suction effects, and to improve control over longitudinal attitude.

Streamline.—Path of a particle of a fluid, supposedly continuous, commonly taken relative to a solid body past which the fluid is moving; generally used only of such flows as are not eddying.

Streamline form.—Form of a body so shaped that the flow about it tends to be a streamline flow.

Strut.—Compression member of a truss frame.

Oleo.—Shock-absorbing telescopic strut in which an oleo gear is incorporated.

Supercharge.—To supply an engine with more air or mixture than would be inducted normally at prevailing atmospheric pressure. The term supercharged is generally used to refer to conditions at altitudes where pressure in the intake manifold is partly or completely restored to that existing under normal operation at sea level.

Supercharger.—Pump for supplying engine with a greater weight of air or mixture than would normally be inducted at the prevailing atmospheric pressure.

Centrifugal type.—High speed rotary blower equipped with one or more multiblade impellers which through centrifugal action compress the air or mixture in the induction system.

Positive driven type.—Supercharger driven at a fixed speed ratio from engine shaft by gears or other positive means.

Roots type.—Positive displacement rotary blower consisting of two double-lobed impellers turning in opposite directions on parallel shafts within a housing, the impellers rolling together except for a small clearance, meanwhile alternately trapping incoming air or mixture in ends of housing and sweeping it through to outlet.

Vane type.—Positive displacement rotary blower having an eccentrically located rotor provided with one or more vanes.

Sweepback.—Acute angle between a line perpendicular to plane of symmetry and plan projection of a reference line in the wing.

Tab.—Auxiliary airfoil attached to a control surface for purpose of reducing control force or trimming the aircraft.

Tachometer.—Instrument that measures in revolutions per minute rate at which crankshaft of engine turns.

Tail, airplane.—Rear part of airplane usually consisting of a group of stabilizing planes or fins to which are attached certain controlling surfaces such as elevators and rudders; also called "empennage."

Tail heavy.—Condition of an airplane in which the tail tends to sink when longitudinal control is released in any given attitude of normal flight.

Tail skid.—Skid for supporting tail of airplane on the ground.

Tail surface.—Stabilizing or control surface in tail of aircraft.

Take-off.—Act of beginning flight in which an airplane is accelerated from a state of rest to that of normal flight. In a more restricted sense, the final breaking of contact with land or water.

Take-off distance.—Distance in which an airplane will finally break contact with land or water, starting from zero speed. Take-off distance is considered in a calm or at a specified wind velocity.

Tank, service.—Fixed fuel tank near each power unit into which fuel from other tanks is pumped and from which fuel supplying engine is drawn.

Taper in plan only.—Gradual change (usually a decrease) in chord length along wing span from root to tip, with wing sections remaining geometrically similar.

Taper in thickness ratio only.—Gradual change in the thickness ratio along wing span with chord remaining constant.

Taxi.—To operate airplane under its own power, either on land or on water, except as necessarily involved in take-off or landing.

Taxiway.—Specially prepared area over which airplanes may taxi to and from landing area of a landing field.

Thickness ratio.—Ratio of maximum thickness of airfoil section to its chord.

Torque stand.—Test stand on which engine torque is measured.

Traffic control projector.—Projector designed to give light signals to an aircraft pilot.

Trailing edge.—Rearmost edge of an airfoil or of a propeller blade.

Transition strip.—Section of landing area adjacent to a runway or other hard-surfaced area, constructed of crushed stone or other suitable material properly bound, to insure safe landing and taxying of airplanes across such runway or area in any direction.

Trim.—Attitude with respect to wind axes at which balance occurs in rectilinear flight with free controls.

Turn and bank indicator.—Instrument combining in one case a turn indicator and a lateral inclinometer.

Turn indicator.—Instrument for indicating the existence and approximate magnitude of angular velocity about normal axis of an aircraft.

Turnmeter.—Instrument that measures rate of turn of an aircraft about any predetermined axis.

Velocity, terminal.—Hypothetical maximum speed that an airplane could attain along a specified straight flight path under given conditions of weight and propeller operation if diving an unlimited distance in air of specified uniform density. If the term is not qualified, a vertical path angle, normal gross weight, zero thrust, and standard sea level air density are assumed.

Vent:

Fuel tank.—Small tube used to conduct surplus fuel from fuel tank overboard clear of airplane, and to equalize pressures.

Oil tank.—Large tube used to conduct oil vapors from engine to oil tank.

Parachute.—Distendable opening in apex of canopy of parachute designed to relieve excess pressure and to stabilize parachute in descent.

Venturi tube (*or venturi*).—Short tube of varying cross section. Flow through venturi causes a pressure drop in the smallest section, the amount of drop being a function of flow velocity.

Visibility.—Greatest distance at which conspicuous objects can be seen and identified.

Warp.—To change the form of a wing by twisting it. Warping was formerly used to perform the function now performed by ailerons.

Wash.—Disturbance in air produced by passage of an airfoil. Also called "wake" in general case for any solid body.

Washing.—Warp of airplane wing giving an increase of angle of attack toward tip.

Washout.—Warp of airplane wing giving a decrease of angle of attack toward tip.

Weight:

Empty.—Structure, power plant, and fixed equipment of an aircraft. Included in this fluid equipment are water in radiator and cooling system, all essential instruments and furnishings, fixed electric wiring for lighting, heating, etc.

Fixed power plant for a given airplane.—Weight of power plant and its accessories, exclusive of fuel and oil and their tanks.

Gross (*airplane*).—Total weight of airplane when fully loaded.

Wheel, tail.—Wheel used to support tail of airplane when on the ground. It may be steerable or nonsteerable, fixed or swiveling.

Wind indicator.—Device that indicates direction and velocity of surface wind.

Wind, relative.—Velocity of air with reference to a body in it. It is usually determined from measurements made at such a distance from the body that the disturbing effect of the body upon the air is negligible.

Wind tee.—Large T-shaped weather vane located on landing field or on top of an adjacent structure to indicate direction of wind. It may have the form of an airplane and may be illuminated for night landings. Also called "landing tee."

Wind tunnel.—Apparatus producing an artificial wind or air stream in which objects are placed for investigating air flow about them and aerodynamic forces exerted on them.

Wing.—General term applied to the airfoil or one of the airfoils, designed to develop major part of lift of heavier-than-air craft.

Wing heavy, right or left.—Condition of airplane whose right or left wing tends to sink when lateral control is released in any given attitude or normal flight.

Wing-over.—Maneuver in which airplane is put into a climbing turn until nearly stalled, at which point nose is allowed to fall while continuing the turn, then returned to normal flight from ensuing dive or glide in a direction approximately 180° from that at start of evolution.

Wing profile.—Outline of a wing section.

Wing rib.—Chordwise member of wing structure of airplane used to give wing section form and to transmit load from fabric to spars.

Compression.—Heavy rib designed to perform function of an ordinary wing rib and also to act as a strut opposing pull of wires in internal drag truss.

Former (or false).—Incomplete rib. frequently consisting only of a strip of wood extending from leading edge to front spar which is used to assist in maintaining form of wing where curvature of airfoil section is sharpest.

Wing section.—Cross section of a wing parallel to plane of symmetry or to a specified reference plane.

Wing skid.—Skid placed near wing tip to protect wing from contact with the ground.

Wing spar.—Principal spanwise member of wing structure of an airplane.

Wing tip.—Outer end of an airplane wing.

Wing tip rake.—Term referring to shape of tip of wing when tip edge is sensibly straight in plan but is not parallel to plane of symmetry. Amount of rake is measured by acute angle between straight portion of wing tip and plane of symmetry. Rake is positive when the trailing edge is longer than leading edge.

Wire (*airplane*):

Antidrag.—Wire intended primarily to resist forces acting forward in the chord direction. It is generally inclosed in the wing.

Drag.—Wire intended primarily to resist forces acting backward in the chord direction. It is generally inclosed in the wing.

Landing.—Wire or cable which braces wing against forces opposite to normal direction of lift.

Lift.—Wire or cable which braces wings against lift force; sometimes called "flying wire."

Stagger.—Wire connecting upper and lower wings of airplane and lying in a plane substantially parallel to plane of symmetry; also called "incidence wire."

Yaw.—Angular displacement about an axis parallel to normal axis of an aircraft.

Yawing.—Angular motion about normal axis.

Yawmeter.—Instrument that measures angle of yaw of an aircraft.

Zoom.—To climb for a short time at an angle greater than normal climbing angle, the airplane being carried upward at the expense of kinetic energy.

SECTION II

FUSELAGES

5. General.—Fuselages of the various types of airplanes have much in common from the standpoint of outline and general design. They vary principally in size and in arrangement of the different compartments. In the case of single-engine airplanes the power plant is mounted on the nose of the fuselage, while on the multiengine airplanes nacelles are used for this purpose. Detail design varies with manufacturer and requirements of the service for which intended. In some cases the fuselage extends laterally to include stub wings which are really a part of the fuselage and built integral with it, as shown in figure 10. On the amphibian-type airplanes the boat hull replaces the fuselage.

6. Structural features.—*a.* Fuselages of most military airplanes are of all-metal construction assembled in a modification of the monocoque design. The monocoque design relies largely on the strength of the skin or shell (covering) to carry the various loads. This design may be divided into three classes—monocoque, semimonocoque, and reinforced shell—and different portions of the same fuselage may belong to any one of these classes. The monocoque has as its only reinforcement vertical rings, station webs and bulkheads; the semimonocoque in addition to these has the skin reinforced by longitudinal members, that is, stringers, and longerons, but has no diagonal web members; and the reinforced shell has the skin reinforced by a complete framework of structural members.

The cross-sectional shape is derived from bulkheads, station webs, rings, etc., and longitudinal contour is developed with longerons, formers, and stringers as shown in figure 11. The skin (covering) which is riveted to all these members carries primarily the shear load,

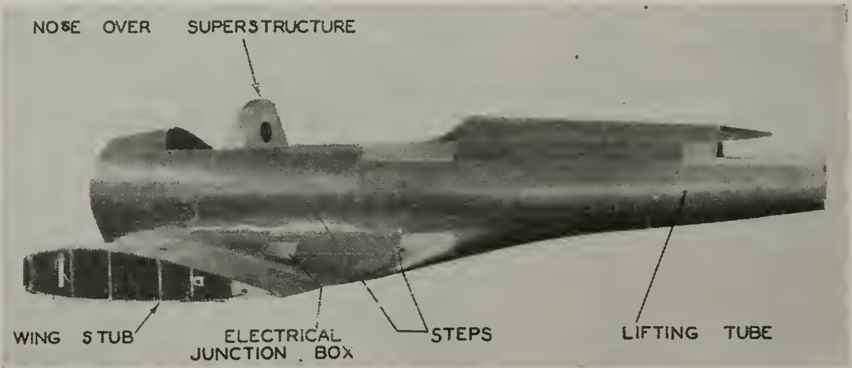


FIGURE 10.—Fuselage assembly.

and together with longitudinal members, the loads of tension and bending stresses. Station webs are built-up assemblies located at intervals to carry concentrated loads and at points where fittings are used to attach external parts such as wings, landing gear, engine mounts, etc. Formers and stringers may be single pieces or built-up sections.

b. The metal in general use for fuselage construction is aluminum alloy, principally one or the other of the two alloys commercially known as 17ST and 24ST. These are about three times lighter than steel and after being heat-treated have a strength approximately equal to that of mild steel. For some uses, generally surface covering, this alloy is made in sheets with a thin covering of pure aluminum on both sides. In this form it is known commonly by the trade name "Alclad." The pure aluminum serves as a protective coating to the base metal and need not be painted to protect the surface from corrosion.

c. Nacelles may be constructed as complete separate units, streamlined by cowling and installed on the airplane above, below, or, in the case of biplanes, between the wings. As a general rule, however, they are built either into or as an integral part of the leading edge of the wing structure as shown in figure 12. Welded tubular steel framework construction is extensively used, although they are sometimes of a semimonocoque construction similar to that of the fuselage. In some of the larger types of airplanes this latter construction is employed to

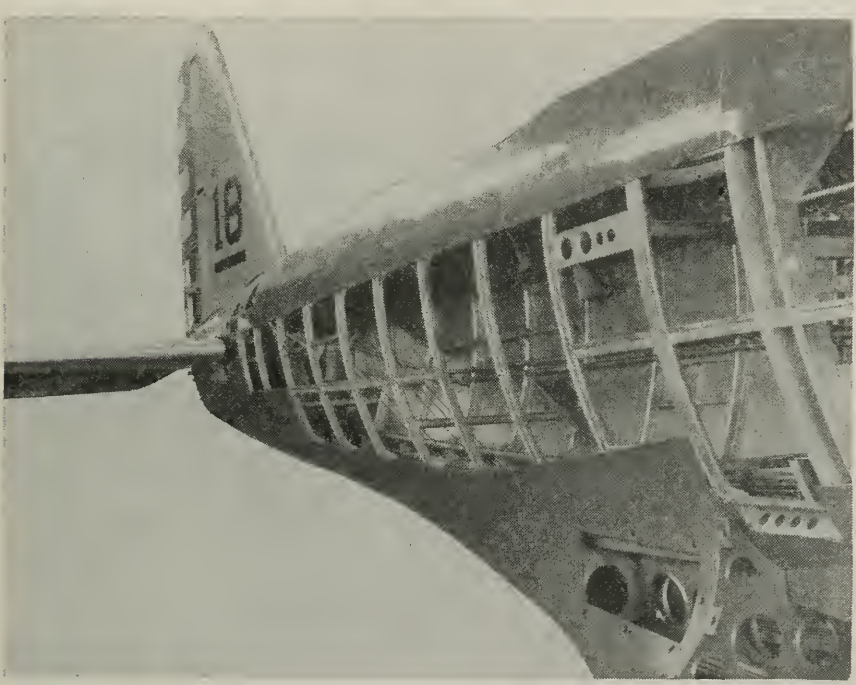


FIGURE 11.—Fuselage structure assembly.

permit access of crew personnel to the engine for the purpose of making adjustments, repairs, or replacement of accessories during flight.

d. A firewall is used to separate the engine compartment from the main structure of the airplane in order to localize any fire that might originate around the engine. On single-engine airplanes, it is mounted on the main fuselage structure and on multiengine airplanes it forms a part of each nacelle structure. The firewall is made of comparatively thick material, usually terneplate or stainless steel. All openings for conduits, tubing, controls, etc., are closed as nearly as possible by stuffing glands, gaskets, or closely fitted sections of fiber composition. Fiber is less likely to cut or damage such lines through vibration than the metal edges of openings in the firewall.

7. Inspection and maintenance.—Since inspection and maintenance procedure of fuselage and wing structure is so similar, details for both are given in paragraph 13.

Section III

ENGINE MOUNTS

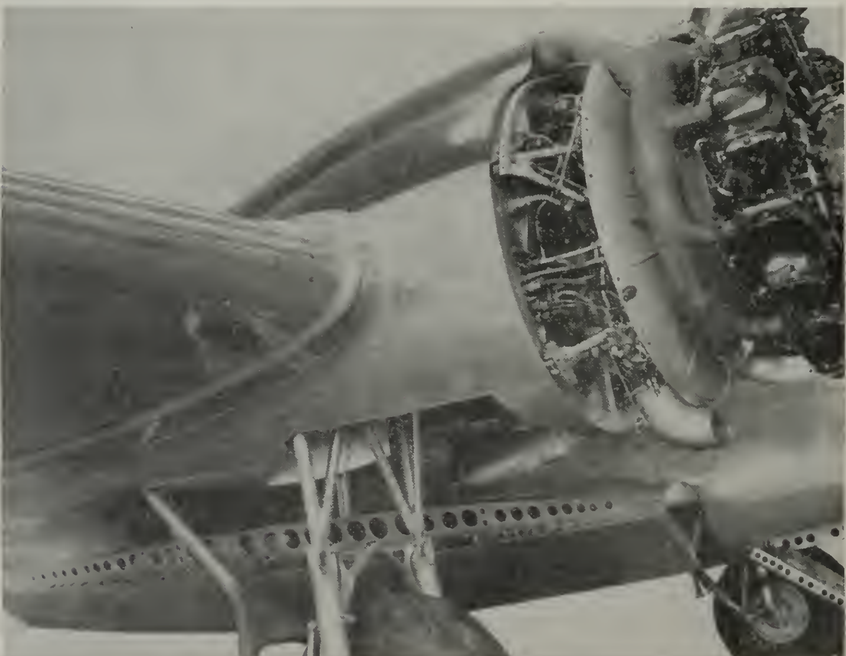


Figure 12.—Nacelle complete with engine mount and engine.

8. General.—Engine mounts are designed to meet particular conditions of installation such as location on airplane, methods of attachment, and size, type, and characteristics of the engine they are intended to support. Although they vary widely in their appearance and in arrangement of their members, the basic features of their construction are similar and are accepted commonly as standard practice. They are usually constructed as a single unit which may be detached quickly and easily from the remaining structure and in many cases are removed from the airplane and replaced with the engine and its accessories as a complete assembly or "power unit." This not only speeds up engine changes but also facilitates maintenance and overhaul.

9. Structure.—*a.* A primary consideration in design of engine mounts is to render the engine and its equipment accessible for maintenance and inspection. A framework construction of welded chrome-molybdenum steel tubing is well adapted to this purpose and is used extensively. Forgings of chrome-nickel-molybdenum are used for

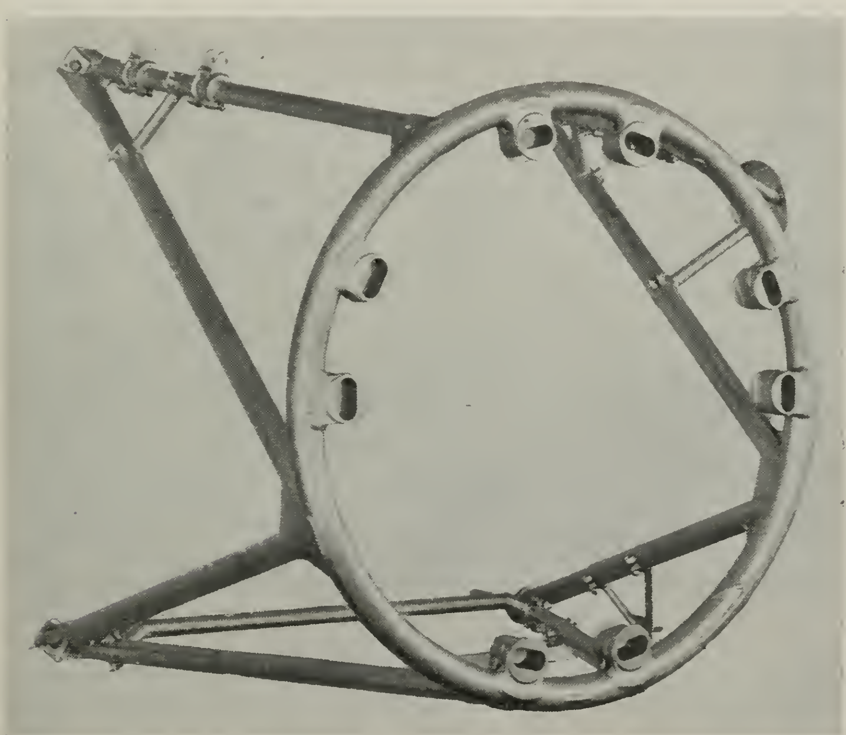


FIGURE 13.—Mount, radial engine.

the more highly stressed fittings, these being accurately machined at points of rigid connection to the engine or other structures. After construction or major repair, engine mounts are subjected to a normalizing process to remove strains due to forging, bending, and welding. Typical engine mounts of the above construction for use with a radial and an inline engine are shown in figures 13 and 14, respectively.

b. Although the exact location depends entirely on design of the airplane, points of attachment of the engine mount are either at or just forward of a flametight, fireproof bulkhead which separates the engine compartment from the rest of the structure. Vibrations originating in the engine will be transmitted to the engine mount and through it to the airplane structure unless provision is made to damp them out, and use of some one of the standard devices for that purpose is mandatory on service equipment. These are usually rubber cushions or pads installed where the engine is bolted to the mount. In some cases additional units are installed between mount and airplane structure. The primary purpose of these vibration-absorbing elements is to produce a natural period of vibration of the assembly below that of the engine at the lowest possible cruising r. p. m. The maximum absorbing characteristics are obtained when the engine mount vibra-

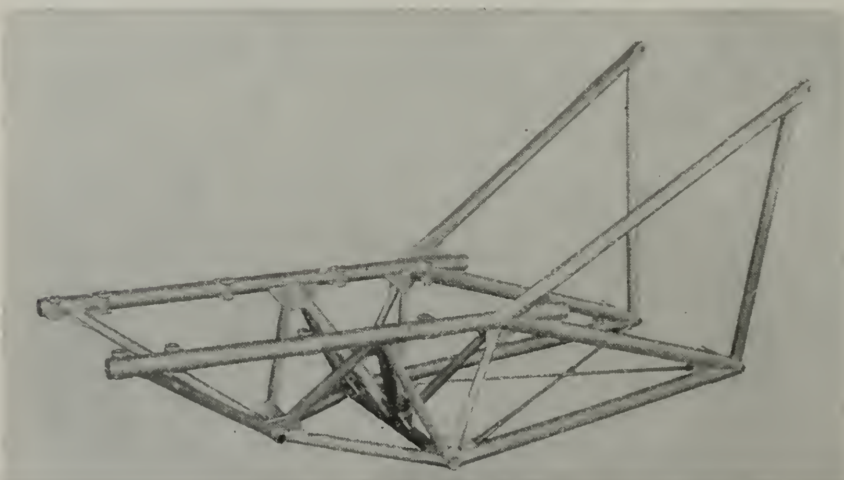


FIGURE 14.—Mount, inline engine.

tion-absorber bolts are so tightened that the engine is restrained from any fore and aft motion, but is permitted to move or rotate within certain limits, in a torsional direction. Tightening the bolts excessively reduces the flexibility of the mount and tends to bring period of resonance of the engine mount into synchronism with or above that of the engine at minimum cruising r. p. m. which is highly undesirable. When limits to which these bolts are to be tightened are specified in the handbook of instructions, they must be adhered to exactly.

10. Maintenance.—Cracked, bent, or broken members of these structures constitute a highly dangerous condition and without exception must be replaced or repaired by activities authorized to do such work before the airplane is permitted to be flown. In general, cracks are most likely to occur at the welded joints, and small cracks particularly may be difficult to discern through the protective coatings. This is especially so if the structure is not kept thoroughly clean and special care must be exercised in making inspections at these points. Mounting clamps and bolts if not properly tightened will allow movement of the mount with consequent rapid wear of the bolts, elongation of bolt holes, and a resultant serious vibration. Protective coatings if damaged should be retouched promptly to prevent rustings of exposed steel surfaces.

Section IV

WINGS

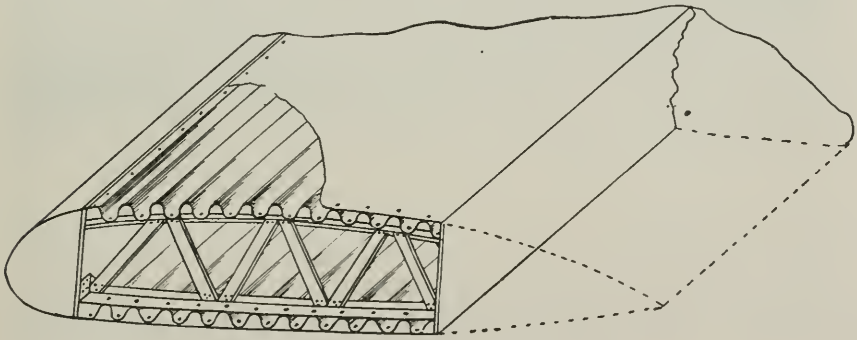


Figure 15.—Stressed skin wing construction.

11. General.—Wings of an airplane are surfaces designed to give lifting forces when moved rapidly through the air. The particular design for any given airplane depends on a number of factors; for example, size, weight, and use of airplane, desired landing speed, and desired rate of climb. Frequently the larger compartments of the wings contain or are themselves used as gasoline tanks or for flotation cells.

12. Structure.—*a.* Wing construction is very similar in many respects to that of fuselages. Variations of design and constructions depend upon manufacturer and specifications outlining assignment and performance requirements. Wing structures of most modern military airplanes are of all-metal construction, usually of the cantilever design, that is, so constructed that no external bracing is required. With few exceptions they are all of the stressed skin type shown in figure 15, where the skin is a part of the basic wing structure and carries part of the wing stresses.

b. One of the numerous methods of general arrangement and fabrication is shown in figure 16. In this case two main spars are used with ribs and bulkheads placed at frequent intervals between the spars to space them and develop wing contour. In this assembly the cross sectional members are stamped in one piece; however, these may be built-up sections or trusses as shown in figure 17.

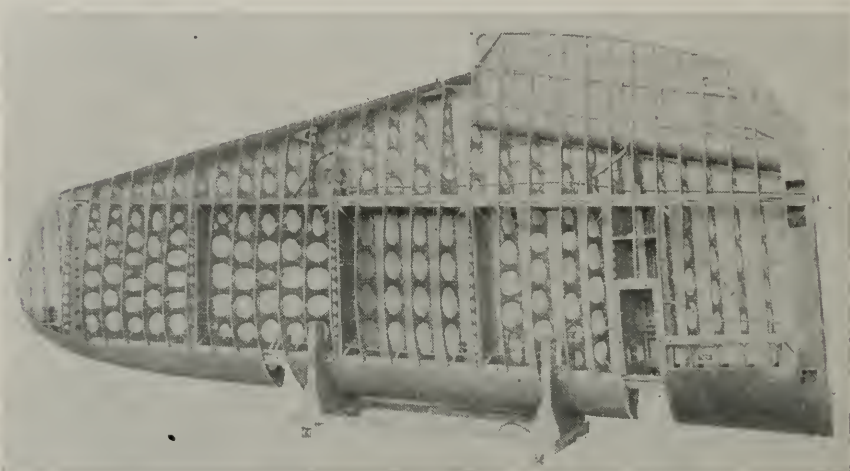


FIGURE 16.—Two-spar wing construction using stamped ribs.

Other variations of wing construction include monospar and multi-spar types. During flight applied air loads which are imposed on a wing structure act primarily on the wing covering. From the covering they are transmitted to the ribs and from the ribs to the spars. The spars support all distributed loads as well as concentrated weights such as fuselage, power plants, etc.

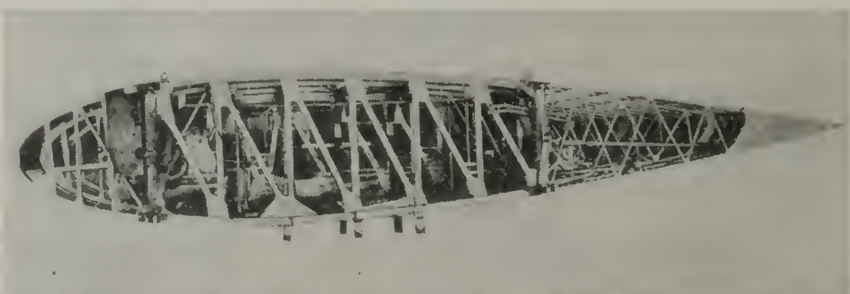


FIGURE 17.—Wing cross section showing truss construction.

c. Corrugated sheet aluminum alloy is often used as a subcovering for wing structures as shown in figure 15. Corrugations are laid parallel to the spars so as to assist the structure in resisting bending loads. The smooth outer covering is attached with either flush head or brazier head rivets placed fairly close together and the joints are carefully fitted so that the stresses on the wing covering are evenly distributed.

d. As in the case of fuselages the metal in general use for wing structures is heat-treated aluminum alloy, Alclad being largely used for the outer covering. Wings of some airplanes, particularly those used for training, are covered with fabric. This covering is made taut and protected against deterioration by several coats of a cellulose base material known as airplane "dope." Cuts, tears, and holes in the covering are easily repaired by patching, but such operations should be done by workmen specially trained for this type of work.

e. Inspection openings and access doors are provided, usually on the lower surface of the wing, and drain holes are placed in the lower surface along the trailing edge. Walkways are provided on areas of the wing where it is intended that personnel will step or walk. The substructure is stiffened or reinforced in the vicinity of the walkways to take such loads. Areas intended as walkways are usually covered with a skidproof surfacing such as ground cork, rubber matting, or carborundum grit, and areas on which walking is prohibited are marked "No Step."

13. Inspection and maintenance of fuselage and wings.—*a.* In inspecting wings and fuselages, it is very important to watch for evidence of corrosion on the inside. This is most likely to occur in pockets and corners where moisture and salt spray may accumulate and therefore drain holes must always be kept open.

b. While an injury to the covering caused by impact with an object is plainly evident and readily identified, a defect such as distortion or failure of the substructure may not be apparent until some evidence develops on the surface, that is, buckled or displaced covering, loose rivets, etc. External indications of internal injury must be watched for carefully and correctly interpreted when found. In this case, a thorough investigation of the substructure in this vicinity should be made and suitable steps taken immediately to correct the trouble. Warped wings are usually manifested by parallel wrinkles running diagonally across the wing and extending over a major area. This condition may develop from unusually violent maneuvers, extremely rough air, or extra hard landings, and while there may be no actual rupture of any part of the structure it might be distorted and weakened. Similar failures may also occur in fuselages.

c. Small cracks in the covering leading away from rivets frequently occur. These are usually caused by vibration of the covering. A small hole may be drilled at extremities of the crack to arrest temporarily its development until a permanent repair can be made by patching. Aluminum alloy sheets in heat-treated condition are springy and hard to bend. No attempt should be made to straighten bent or dented covering of this material as it is likely to crack or break. Repairs of this kind should be done by specially trained sheet metal workers and usually consist of riveting a patch over the damaged area.

d. Aluminum alloy surfaces having protective coating chipped off, scratches, or worn spots which expose surface of the metal should be recoated at once as corrosion may develop rapidly. The same principle applies to Alclad surfaces. Scratches which penetrate the pure aluminum surface layer will permit corrosion to take place in the alloy beneath. Small spots on enameled or lacquered surfaces may be covered using a small brush, but if the condition is poor over a large area it should be refinished properly with a spray gun by a specially trained workman.

e. The special inspections of fabric-covered internally braced wings should be followed as outlined in the Air Corps Technical Orders pertaining to this particular equipment.

SECTION V

STABILIZERS

14. General.—Stabilizing units of an airplane consist of vertical and horizontal airfoils located at the rear portion of the fuselage as a part of the empennage or tail assembly. The vertical surface is generally called the "fin" and the horizontal surface is generally referred to as the "stabilizer."

15. Structure.—*a*. Construction features of stabilizers are in many respects identical with that of wings. They are usually of all-metal construction of the cantilever type having two main members or spars, and ribs to which the metal skin is attached. Fabric-covered structures may be braced internally with tie rods against drag. Fairing is used to round out the angle formed between stabilizers and fuselage.

b. The vertical stabilizer or fin maintains directional stability of the airplane in flight, that is, about its turning or vertical axis. In the case of single-engine airplanes the fin is almost invariably offset. A fin is offset when its leading edge is located away from the center line and toward one side of the fuselage. This is done to obtain more accurate directional stability by balancing out the forces acting on the airplane as a result of engine torque and unsymmetrical airflow of slipstream from the propeller. The vertical fin also serves as the base or anchorage to which the rudder is attached.

c. The horizontal stabilizer provides longitudinal stability of the airplane in flight, that is, about its lateral axis. The stabilizer is generally constructed in a continuous section mounted on or through the fuselage although it is sometimes built in left- and right-hand sections. The stabilizer is similar to the vertical fin in internal construction and serves as a support for the elevators.

16. Maintenance.—Maintenance of stabilizers corresponds to that of fuselages and wings (see par. 13).

SECTION VI

FLIGHT CONTROL SURFACES AND WING FLAPS

17. General.—*a.* Flight control surfaces are hinged or movable airfoils designed to be rotated or otherwise moved by the pilot in order to change the attitude of the airplane during flight. They consist of—

(1) Primary group made up of ailerons, elevators, and the rudder, by which the airplane is moved about its various axes.

(2) Secondary group composed of trim tabs, balance tabs, and servo tabs used for reducing force required to actuate primary control surfaces, or for trimming and balancing airplane in flight.

(3) Wing flaps which are intended to reduce landing speed of fast airplanes, shorten length of landing roll, and to facilitate landing in small or obstructed areas by permitting gliding angle to be increased without appreciably increasing gliding speed.

b. Rudder and elevators are members of the empennage, and ailerons are hinged sections of the main wings. The rudder controls the airplane directionally about its vertical axis, the elevators control the airplane longitudinally about its lateral axis, and the ailerons control the airplane laterally about its longitudinal axis. To reduce the effort required by the pilot to operate the controls, these primary control surfaces are aerodynamically balanced. This involves hinging the surface so that a portion of the area is forward or ahead of the hinge line. As a result the forces acting on this area tend to balance some of the forces acting on the area behind the hinge line. Control surfaces also may be balanced statically by addition of lead weights in front of the hinge line. This is done to prevent any tendency of the control surface to flutter.

18. Structure.—*a.* Primary control surfaces are movable surfaces and usually consist of an aluminum alloy structure built around a single spar member or torque tube. Ribs are fitted to the spar at the leading edge and at the trailing edge are joined together with a suitable band or metal strip. The leading edge or nose portion

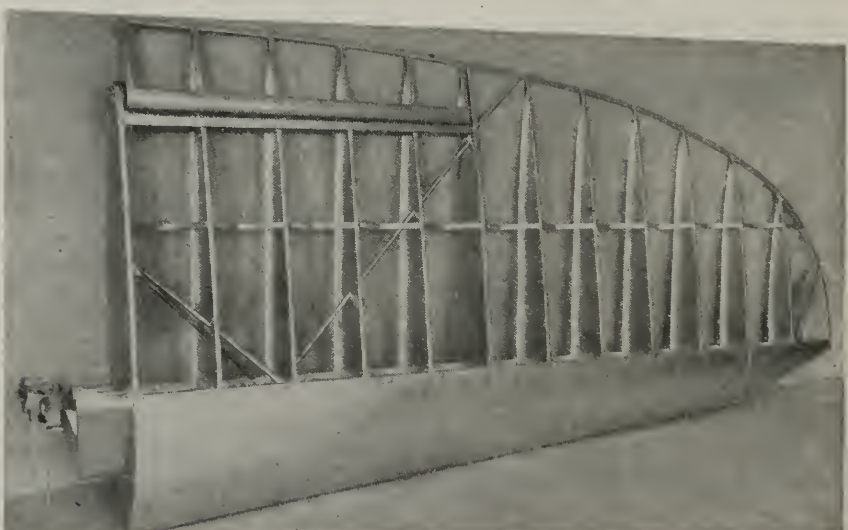


FIGURE 18.—Rudder framework with solid ribs.

of the surface is covered with thin aluminum alloy sheet back to the spar member, thus forming the front part of the structure. The above construction is shown in figures 18 and 19. The former shows a rudder framework which has solid stamped ribs while the latter shows an elevator framework made up of ribs having lightening holes. Both are equipped with secondary control surfaces. Many of the primary control surfaces are fabric-covered. Such surfaces, being lighter than those with metal covering, require addition of less weight to produce proper static balance.

b. Secondary control surfaces are relatively small airfoils attached to or recessed into the trailing edge of the primary control surfaces and consist of trim tabs, balancing tabs, and servo tabs.

(1) Trim tabs are used to control the balance of an airplane in flight so that it will maintain straight level flight without pressure on the control stick or rudder pedals. This is accomplished by moving or deflecting the tab in the direction opposite to that in which the primary control surface is to be moved. The airflow striking the tab causes the main surface to move to a position that will correct the unbalanced condition of the airplane. Trim tabs may be controlled from the cockpit or are of the ground adjustable type. In the latter case the tab is simply a strip of metal attached to the trailing edge of the primary control surface. In this case the tab is bent up or down as required to obtain desired result.

(2) Balancing tabs are similar in appearance to and are hinged in approximately the same location as controllable trim tabs. The essential difference between the two tabs is that the balancing tab is so connected to the wing structure by a rod that when the control surface is moved in any direction, the tab is rotated in the opposite direction. The result is a decrease in effort required by the pilot to move and to hold the control surface in any given attitude. When the control is released, the control surface will return to its neutral position. In case the rod between the tab and the wing structure is adjustable, the tab also becomes a ground adjustable trim tab.

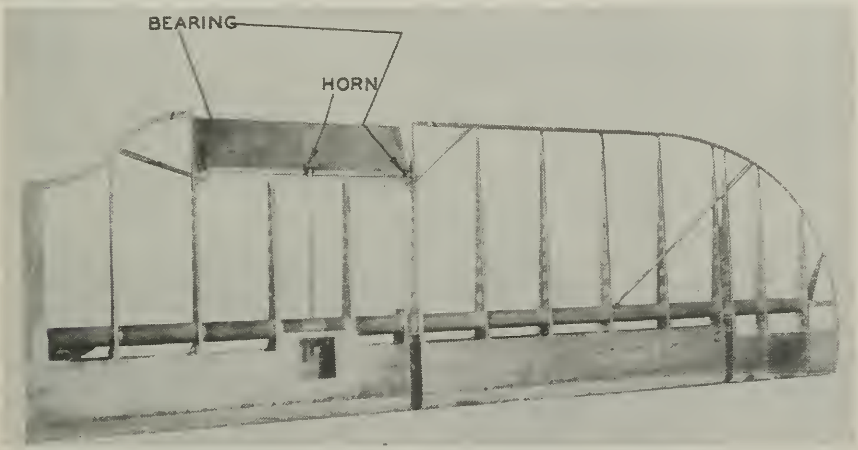


FIGURE 19.—Elevator framework with ribs having lightening holes.

(3) Servo tabs are used primarily on large airfoils to aid the pilot in moving primary control surfaces. The tab control linkage is cross-connected in parallel with the primary control linkage which is also connected in parallel with a spring-loaded cartridge. The purpose of the spring is to allow the servo tab movement to precede the move-

ment of the primary control surface. The airflow striking the tab moves the primary surface in the opposite direction, thus all the pilot does is move the tab, but should the airflow not be sufficient, further movement of the controls by the pilot will compress the spring and move the primary control surfaces manually.

c. Wing flaps are relatively large airfoils hinged to the wing structure. As a rule, the lower surface of the rear portion of the wing extending from the aileron inward toward the fuselage becomes the flap. When closed, the flap constitutes a section of the lower surface of the wing, and usually swings downward to open as shown in figure 20. Wing flaps are operated hydraulically or by means of an electric

FIGURE 20.—Wing flaps in down position.

motor. A mechanical system which can be operated by a hand crank in the cockpit is generally provided for emergency use. In taxying, the flaps should be fully retracted to protect them from stones or other objects thrown back by the propellers or kicked back by the wheels.

19. Maintenance.—*a.* All movable parts and bearings must be kept well lubricated as specified in the handbook of service instructions for the particular airplane involved. Care must be exercised when cleaning around metal-shielded ball and roller bearings as they are packed with grease at time of assembly and under normal conditions this is sufficient for the life of the bearings. Washing with grease solvent would remove the lubricant and necessitate replacement of the bearing assembly. Such bearings are disassembled and lubricated only by repair depots during the overhaul of the airplane.

b. Ground adjustable trim tabs should be bent to desired setting by using a clamp or wooden blocks so that entire surface of tab is adjusted evenly.

Section VII

FLIGHT CONTROL MECHANISMS

20. General.—Flight controls of an airplane consist of the control stick (or column and wheel) and the rudder pedals with which the primary control surfaces are actuated, and the levers, wheels, and handles with which the secondary control surfaces are actuated. A complete set of flight controls is located in the pilot's cockpit and in some two-place airplanes in both cockpits. Controls installed in the cockpit are connected to control surfaces installed on wings and empennage by a system of cables, rods, bell cranks, etc., called flight control linkage. These assemblies for control of ailerons, elevators, rudder, tail wheel, and tabs are shown in figures 21 to 24, inclusive. Extra flexible steel cable consisting of 7 strands having 19 wires per strand is generally used in control linkage. These cables are guided through fair leads and over pulleys in such a manner as to avoid contact with other mechanisms and structural members of the airplane. Cables carrying relatively low initial tensions are often led through flexible steel conduit. Fair leads and pulleys are made of a nonmagnetic phenolic composition. Push and pull rods (or tubes) if of considerable length are supported and guided by rollers as shown in figure 25. All rods throughout the control linkage are adjustable at one or both ends.

21. Operation.—When the control stick (or column) (fig. 21) is pulled rearward, the trailing edge of the elevators is raised and when the stick is pushed forward the motion is reversed. When the control stick (fig. 22) is pushed to the right, the right aileron trailing edge is raised and that of the left aileron is lowered. The stick pushed in the opposite direction reverses this action. When the right rudder pedal is pushed forward the rudder trailing edge is swung to the right, and by pushing the left rudder pedal forward the rudder trailing

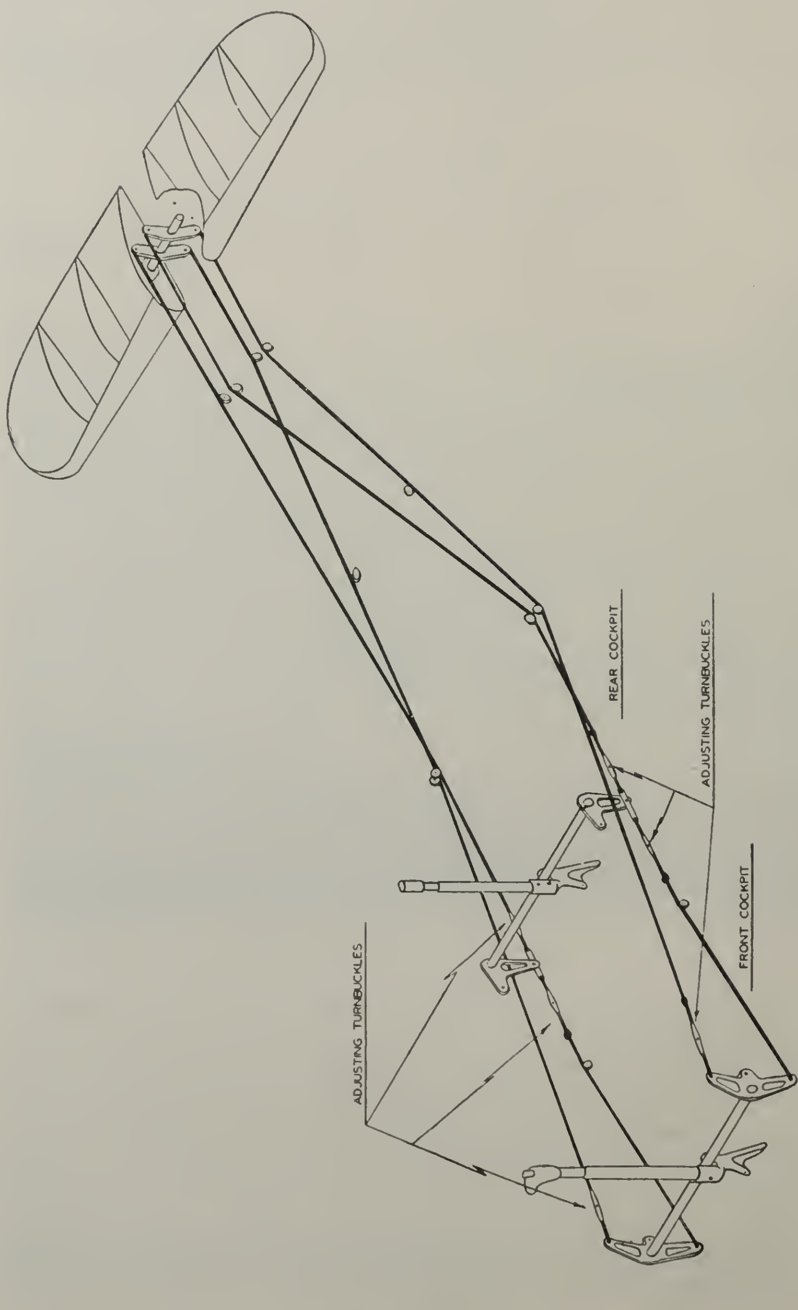


FIGURE 21.—Elevator control linkage.

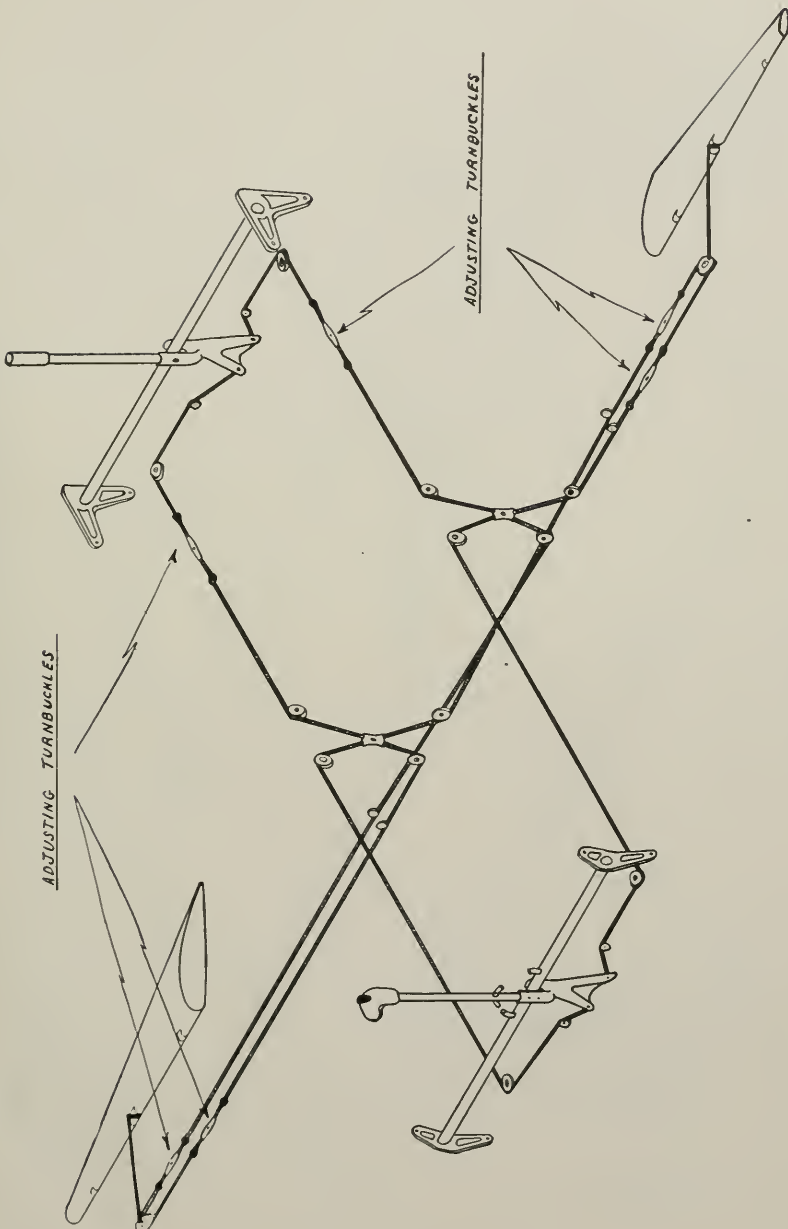


FIGURE 22.—Aileron control linkage.

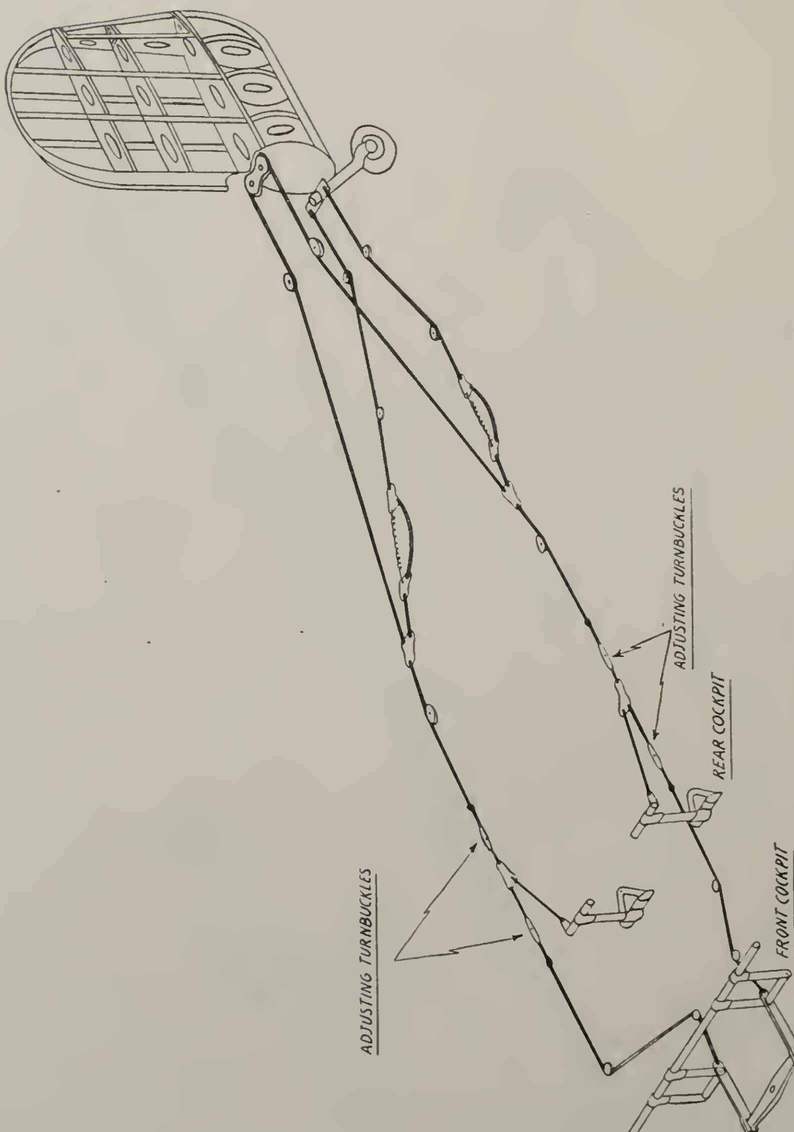


Figure 23.—Rudder and tail wheel control linkage.

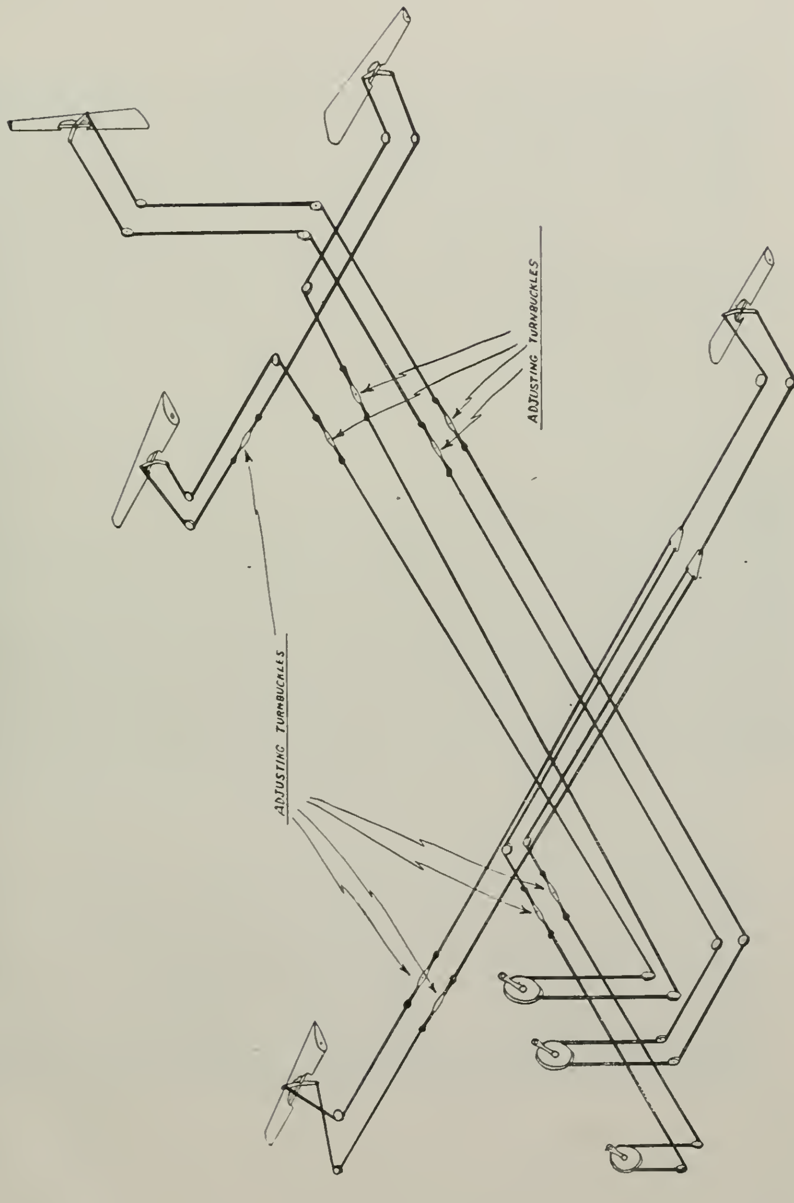


FIGURE 24.—Tab control linkage.

edge is moved to the left. As shown in figure 23, the tail wheel is subject to the same control as the rudder. In the case of tabs, the directions in the cockpit for moving the control are always stated in terms of effect on attitude of the airplane and not necessarily direction in which the tab is moved, as shown in figure 26.

22. Alinement.—*a.* Each control has a neutral position. The neutral position of the control stick is slightly forward of the center of its range of movement in all directions. The exact amount that the top of the stick should be forward of this midposition usually is specified in the Technical Order Handbook on the airplane. Rudder

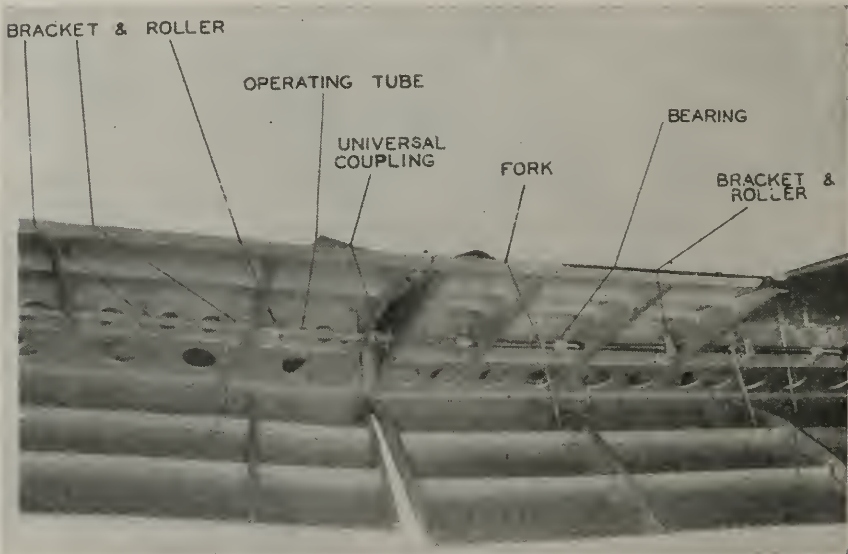


FIGURE 25.—Wing flap and control rod and tube.

pedals are in neutral when they are in the center of their movement range. Tab controls are marked to indicate their neutral position.

Caution.—Rudder pedals are also adjustable to suit leg length of each pilot, but this should not be confused with rudder cable adjustments.

b. The neutral position of control surfaces are as follows:

(1) Rudder is in neutral when it alines with the center line of the fuselage; that is, lies in the plane of symmetry of the fuselage. In some few cases, neutral position of the rudder is specified as the position in which it streamlines with the vertical fin. The rudder movement is equal in both directions from neutral.

(2) Elevators are in neutral when they streamline with the horizontal stabilizer, the latter if adjustable being in its neutral position.

The range of elevator movement from neutral is greater upward than downward to provide adequate control for holding tail of the airplane down during landing, especially after the wheels touch the ground.

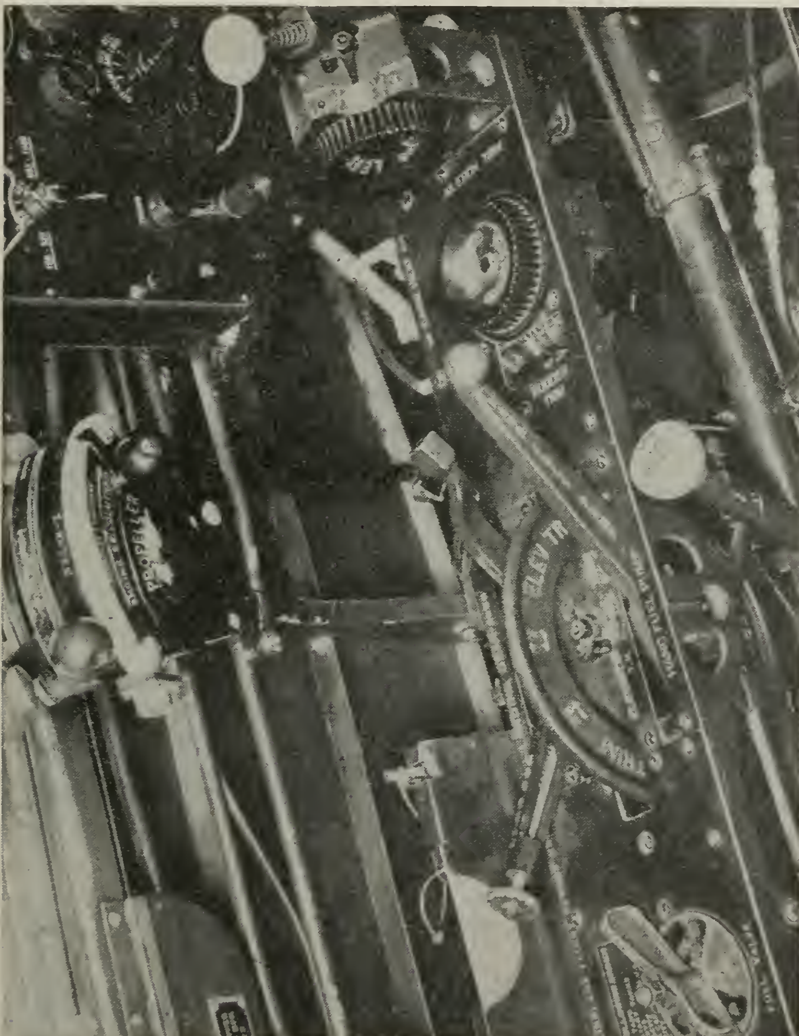


FIGURE 26.—Tab controls.

(3) Ailerons are in neutral when they streamline with their respective wings, or in case droop is specified, they droop by similar amounts. An aileron droops when it hangs below the position in which it streamlines with the wing. Droop is measured as the distance of center of trailing edge of aileron below center of trailing edge of wing. Ailer-

ons usually have a greater up travel than down. This causes a greater drag on the down wing (up aileron) than on the upper wing (down aileron) and assists the rudder in making correct turn for a given direction of bank. Difference in extent of travel of ailerons is accomplished by means of a differential incorporated in the aileron control linkage.

c. (1) The three phases in alinement of flight control systems are—

(*a*) Synchronize controls and control surfaces in neutral.

(*b*) Establish proper tension in control cables.

(*c*) Limit movement of controls.

(2) In the first phase, the controls in the cockpit are placed and held in their neutral position. The control surfaces, each in turn, are then brought into their neutral position by means of adjustments provided in the control linkage. One turnbuckle is tightened and the opposing one loosened.

(3) In the second phase, tension of control cables is checked by means of a tensiometer in accordance with tensions authorized for the particular cable and airplane. In case tension of a cable is found to be incorrect, the two turnbuckles are each shortened or lengthened a given amount until correct tension is obtained. If these two turnbuckles are not adjusted in like manner, alinement of controls already attained will be altered. Where authorized initial tensions are not given, the tensiometer is not used and the tension is checked by feel of cables and action of controls. Some tab controls employ two main cables and one balance cable which extends directly from one tab to the other, each having one turnbuckle. In this case the simplest procedure is to aline to neutral one tab only by using the two main cable turnbuckles, ignoring the other tab and the balance cable turnbuckle. With this tab in neutral and proper tension in control cable, the other tab is then alined to neutral by using the balance cable turnbuckle and the turnbuckle in the main cable that extends to the second tab. Care should be taken not to alter adjustment of the other main cable turnbuckle and to let out and take up exactly similar amounts on the two turnbuckles controlling alinement of the second tab.

(4) In the third phase, each control in the cockpit is moved in turn longitudinally or laterally as far as it will go, and in each case the extent of movement of the control surface is checked. A protractor is commonly used for this purpose. The limiting stop shown in figure 27 is adjusted until extreme attitude of the control surface in that one direction is satisfactory. The control is then moved in

the opposite direction and the procedure repeated. No readjustment of control cables is involved in this procedure.

It is extremely important that the pilot be able to move the control surfaces through entire specified range. A reduction of only a few degrees in allowable movement may reduce the maneuverability of the airplane and result in poor recovery from spins. After a turnbuckle has been adjusted, it must be properly safetied in such a manner that the safety wire opposes the tendency of the turnbuckle to loosen.

23. Maintenance.—*a.* Ball-bearing assemblies used on control mechanisms are usually of the sealed type and do not require an external application of lubricant. Some of the pivots where the load is light or the movement relatively slow are plain bearings. This type of bearing must be lubricated and fittings are always provided for this purpose.

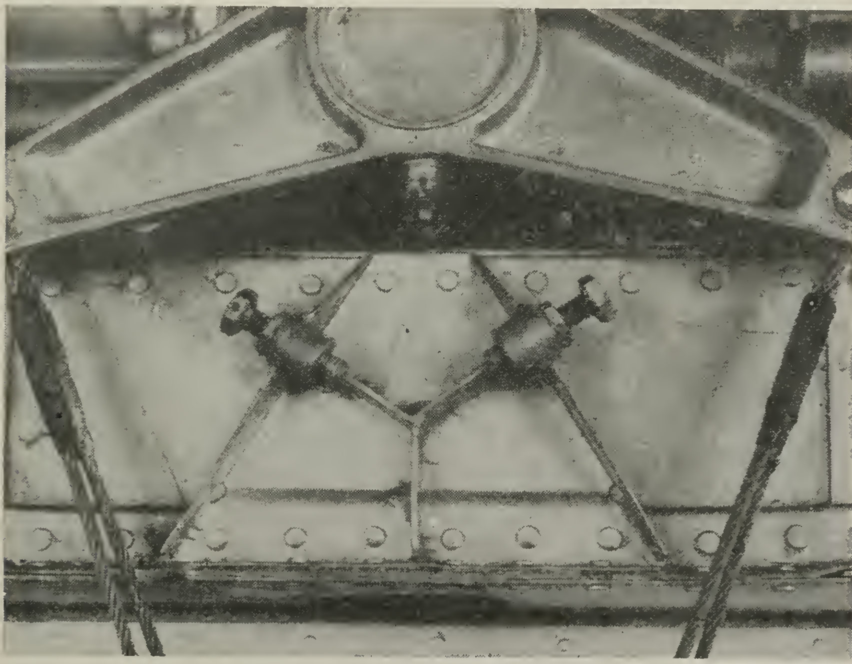


FIGURE 27.—Aileron travel limiting stop.

b. Because of the number of wires in control cables, their failure is never abrupt but is progressive over periods of extended use. Many broken wires encountered in use show up soon after placing the cable in service due to the fact that some of the wires are under greater tension or are much harder than the rest. After these overstressed or overhard wires have broken, very few additional broken wires will be encountered in normal service for a considerable time. Control cables are generally considered serviceable unless there are more than six broken wires in any 1 inch length of cable. Close attention should be given to that portion of cable which passes over pulleys or through fair leads. Any indications of rust should be investigated with reference to extent of internal damage.

24. Precautions against fouling.—Serious hazard is present in the possibility that flight controls might be jammed when articles such as microphones, flashlights, oxygen mouthpieces, etc., are dropped to the floor and come in contact with the controls. All personnel are cautioned that each time microphones, oxygen tubes, or other accessories in aircraft are used, they are replaced and securely seated in the carrying hooks or other receptacles provided. In the case of microphones and oxygen mouthpieces, an extra length of wire and tubing is taped to a convenient part of the airplane in a manner that will prevent them from contacting any part of the controls if they are dropped.

Section VIII

LANDING GEAR

25. General.—Landing gear of the airplane consists of main and auxiliary, both of which may be retractable or nonretractable. The main landing gear consists of that portion of alighting gear which forms the principal support of aircraft when on land or water. It may include any combination of wheels, floats, skids, shock-absorbing mechanisms, brake and steering operating mechanisms, retracting mechanisms with their controls and warning devices, fairings and framing or structural members necessary to secure any of above to the primary structure. The auxiliary landing gear consists of tail or nose landing wheel installations, outboard pontoons, skids, etc., and any necessary cowling or bracing members or structural reinforcement added to or incorporated in the aircraft to facilitate or safeguard landings and ground or water handling.

26. Main.—*a.* The nonretractable landing gear is rigidly attached to structural members of the airplane and is generally equipped with cowling to reduce air resistance. This fairing, as shown in figure 28, is assembled in sections and motion occurs between these sections; abrasion shoes are used to prevent fouling or excessive wear. At high speeds exposure of the landing gear creates a considerable loss of power by its resistance or drag. This resistance has been decreased or eliminated by use of retractable landing gear which is drawn up into wells in the wings or recesses in the sides or bottom of the fuselage. On some airplanes, the lower section of the wheels and sometimes part of the landing gear fairing remain exposed, while on others the gear is completely retracted and covered with fairing. Figure 29 shows

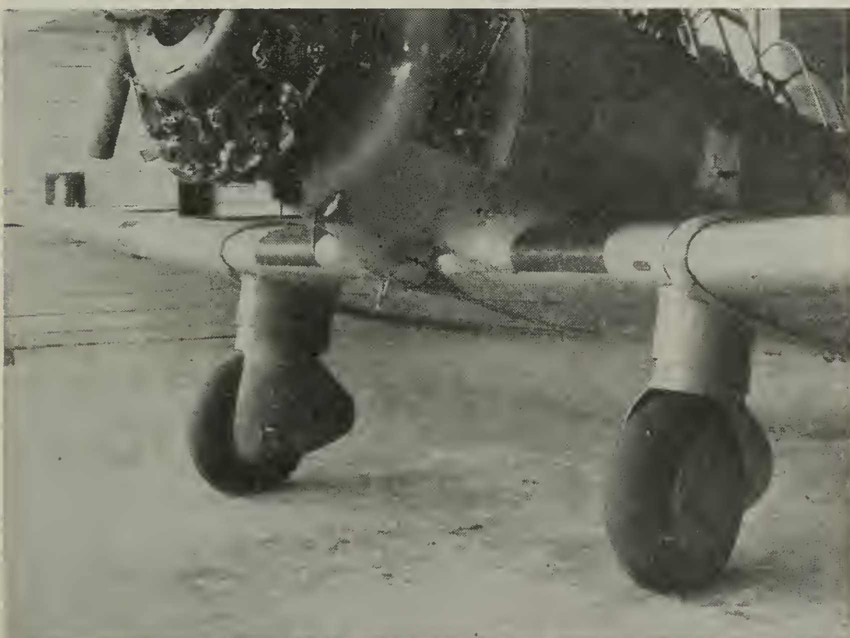
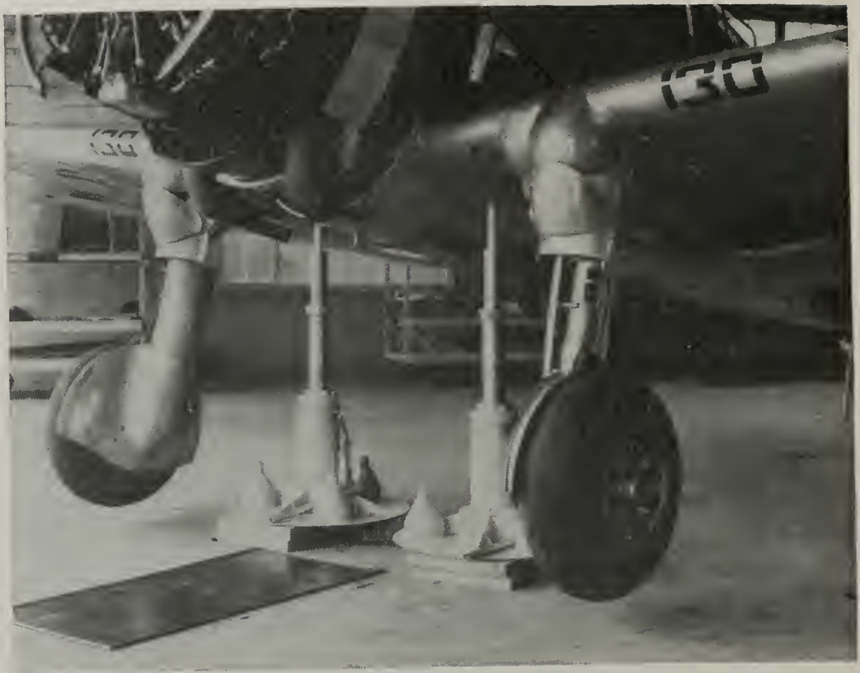


FIGURE 28.—Nonretractable landing gear.

such a landing gear in extended and retracted positions. In this case retraction is rearward, however, on some airplanes the gear folds either inward or outward in a lateral direction.

b. Retraction of gear is accomplished by one of three means, manual, electric, or hydraulic. Usually manual control is provided along with electric or hydraulic operation as a safety precaution. An indicator is provided to show position of the gear "up" or "down" and in some cases intermediate positions. Locks which are controllable from the cockpit are provided for locking the gear in its "down" or extended position. In some cases, the gear is also locked by a safety pin or lock



① Extended.

② Retracted.

FIGURE 29.—Retractable landing gear.

managed from the ground which precludes any possibility of the gear being retracted inadvertently from the cockpit while the airplane is at rest on the ground.

c. Warning signals are generally used in conjunction with retracting mechanism. Signals usually consist of an electric horn, an electric vibrator mounted on the rudder pedal, or a red warning light mounted in a conspicuous position in the cockpit. These warning devices are wired to the engine throttle in such a manner that if the landing gear is not fully extended and positively locked in such position the warning signal will operate when the throttle is pulled back to idling position.

d. Use of landing skis permits the airplane to be operated in deep snow where it would be impossible to operate with wheels only. The

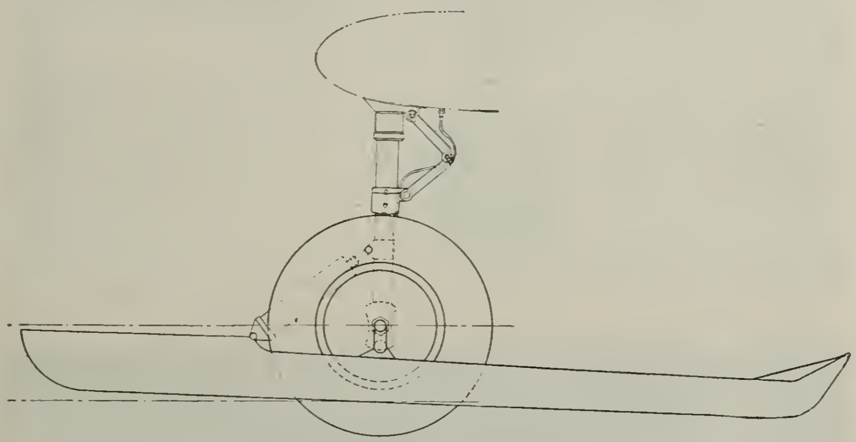


FIGURE 30.—Landing ski installation.

type of ski in general use is usually of all-metal construction and so designed that the wheel is not removed from the axle for its installation. It is equipped with an opening through which the wheel protrudes a given distance and a means of attachment to the landing gear on each side of the wheel. The installation is shown in figure 30. This design proves more satisfactory for general operation of airplanes in snow than those which are equipped with skis only.

27. Auxiliary.—*a.* Auxiliary landing gear may also be retractable or nonretractable, the former being used on most high speed airplanes. It usually retracts with the main landing gear and employs the same controls and similar position indicators. Figure 31 shows a tail wheel in extended and retracted positions.

b. All tail wheels are designed to swivel and in most instances are controllable with the rudder through its range of movement. An automatic disengaging device or release mechanism, shown in figure 32, disengages the control just at or slightly before limit of rudder movement. This assures control of tail wheel for taxying, allows full rudder movement even though the tail gear might bind, and beyond

① Extended.

② Retracted.

FIGURE 31.—Retractable tail gear.

control range permits free swiveling for ground handling of the airplane. This release also serves as a safety device to prevent injury to the pilot's legs and to the fuselage structure resulting from violent twists imposed on the gear by rough ground.

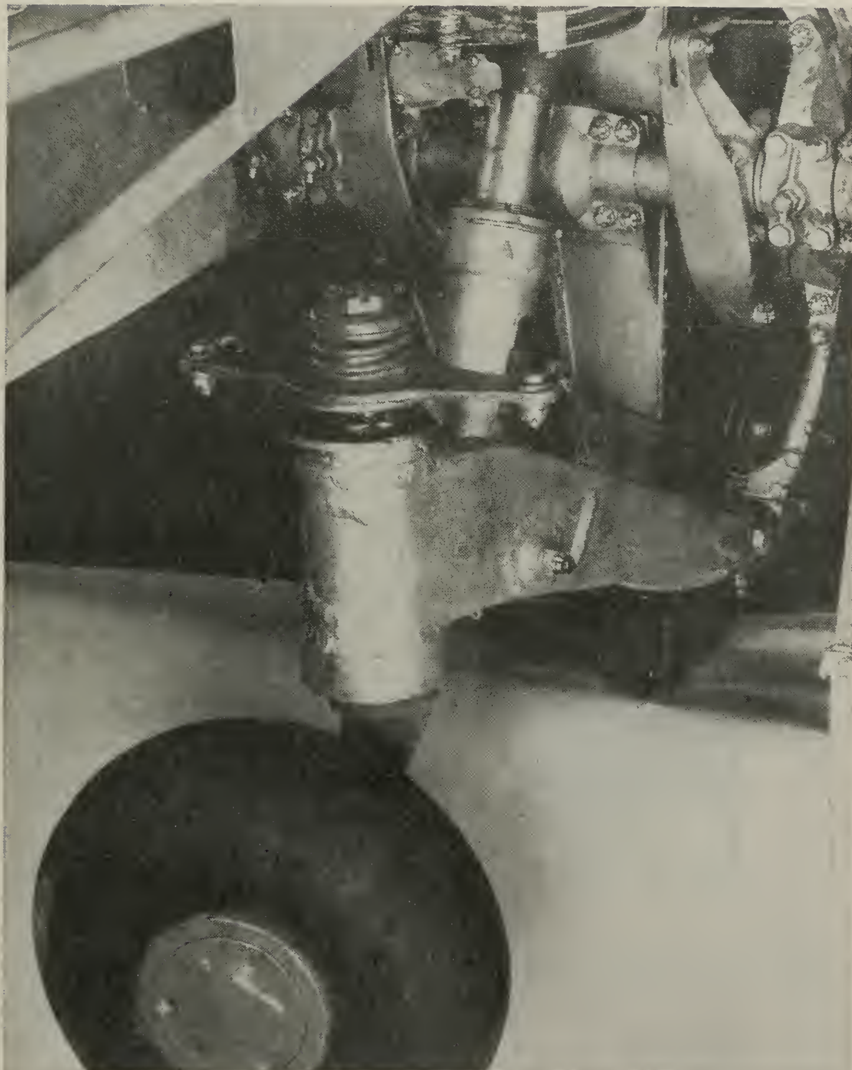
c. Most tail gears are provided with an antishimmy device to minimize tendency of the tail wheel to oscillate violently during landing and taxying. This device usually consists of two friction disks held in contact with each other by a coil spring, also shown in figure 31. One disk is carried by and rotates with the tail gear spindle while the other is fixed to the spindle support, and friction between the two serves to dampen oscillations. Sometimes the tail wheel is restrained toward the trailing position by a centering arm, and in some cases a latch operated from the pilot's compartment is used to lock the tail wheel in the trailing position during take-off and landings. Tail gear control cables incorporate a shock unit (coil spring) connected either in series or parallel with the cable, as shown in figure 23. This unit absorbs shocks caused by oscillation of the tail gear, preventing their transmission to rudder control cables.

28. Shock struts.—*a.* Shock struts in most general use for main and auxiliary landing gear are of the air-oil type. Although internal construction of the several models is somewhat different, their operation is essentially the same. Figure 33 shows the cross section views of a typical air-oil strut in deflated and extended positions. This unit consists of an inner and outer steel cylinder and a movable steel piston. A steel head holds the two cylinders in position and piston movement is accomplished using two bearing surfaces, one attached to the top of the piston and the other at the base of the inner cylinder. A packing gland installed at the lower end of the outer cylinder prevents leakage of the fluid. The base of the inner cylinder has a hole or orifice through which a tapered metering pin mounted on the base of the piston operates to control flow of fluid. A snubber tube surmounted by a flap valve is integral with the base of the inner cylinder and both the cylinder and the snubber tube are equipped with ports to allow passage of fluid between the three chambers.

b. The cross section view (fig. 33 ①) shows the strut in deflated position. An air valve assembly mounted on the upper end of the strut permits compressed air to be pumped into the cylinders which partially extends the strut. The metering pin enters the orifice but never completely fills it. When the airplane takes off, compressed air and weight of the wheel fully extend the strut as shown in figure 33 ② and the fluid flows down through the orifice to occupy the space in the hollow piston created by this extension. When the airplane contacts the ground on landing, the strut is compressed and the fluid is forced back up through the orifice. Rate of flow of fluid through the orifice is restricted by the metering pin. Since the smaller end of the metering pin enters the orifice first, as the piston nears the end of its stroke, the flow of fluid becomes progressively more restricted. This slows the piston down to a gradual stop, thus absorbing the landing shock. During contraction of the strut, the flap valve permits

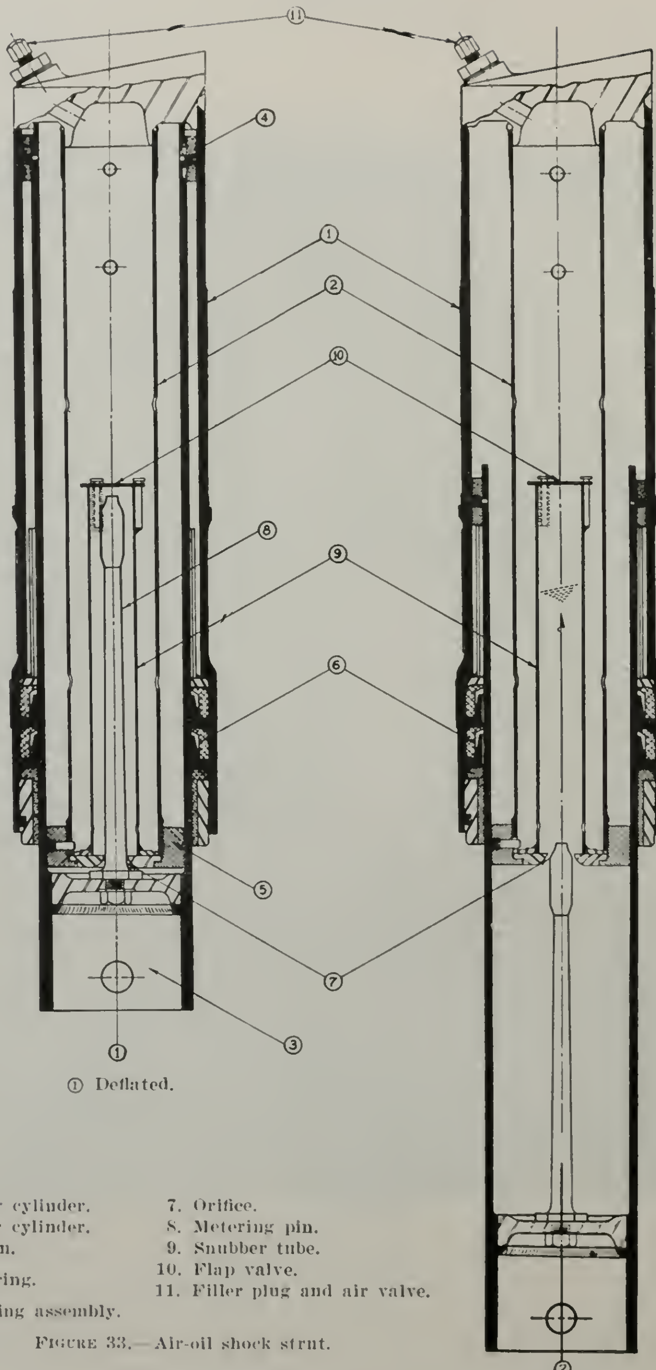
① Engaged.

FIGURE 32.—Tail wheel disengaging and antishimmy device.



② Disengaged.

FIGURE 32.—Tail wheel disengaging and antishimmy device—Continued.



① Deflated.

② Extended.

1. Outer cylinder.
2. Inner cylinder.
3. Piston.
4. } Bearing.
5. }
6. Packing assembly.
7. Orifice.
8. Metering pin.
9. Snubber tube.
10. Flap valve.
11. Filler plug and air valve.

FIGURE 33.—Air-oil shock strut.

the fluid to flow freely from the snubber tube, but during extension of the strut, the flap valve is held shut and the fluid must return to the orifice through the small return ports.

29. High-pressure pumps.—Since pressures required sometimes run as high as 1,000 pounds per square inch, special pumps are required for inflating air-oil struts. The two pumps now in general use are the high-pressure hand pump and the automatic pressure pump.

FIGURE 34.—High-pressure hand pump.

a. The high-pressure hand pump (fig. 34) is a hand-operated pump of small bore and long stroke. It is designed to boost a moderately high supply pressure ten or twelve times.

The air usually is fed to the booster pump by a motor-driven air compressor at about 100 pounds per square inch. In case this pressure is not available, any reasonably good automobile tire pump operated by a second man can be used as an emergency source of supply. The two methods are shown in figure 35. Instrument oil should be applied to the pump shaft when necessary, and cup leather oiled occasionally to keep it soft and pliable.

Caution.—The handle of the pump should be in the out or fully extended position when attaching air hose from the compressor to prevent any possible injury to personnel by a sudden extension of the piston.

b. The automatic booster pump shown in figure 36 is also operated by air pressure from any compressed air line and is capable of increas-

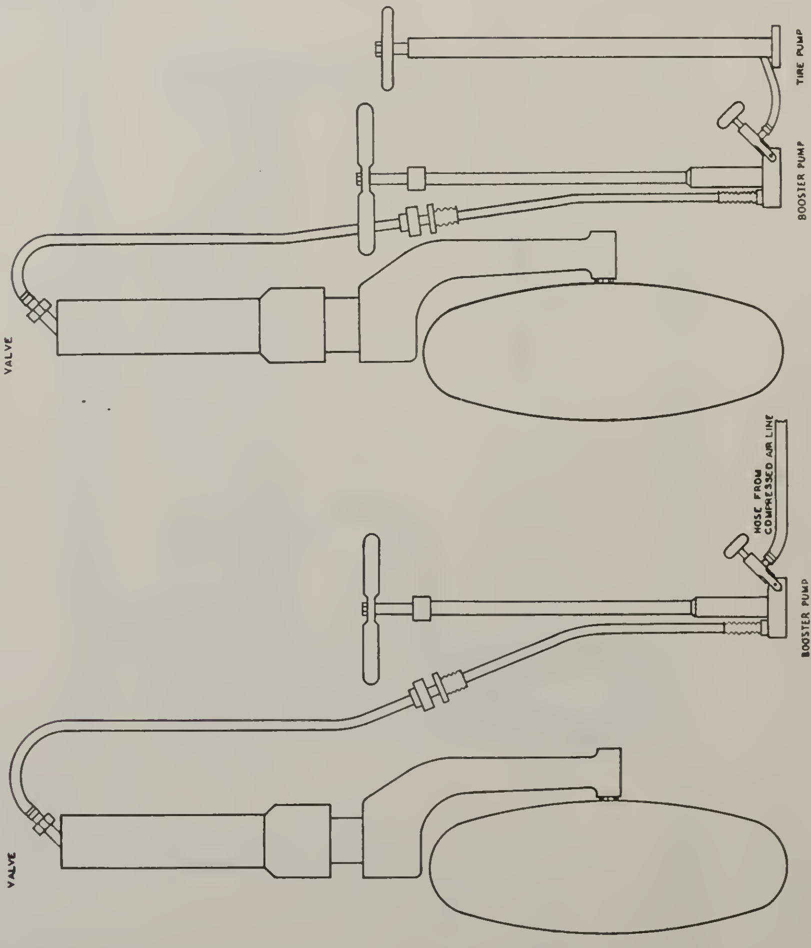


FIGURE 35.—High-pressure hand pump connection.

ing this pressure a maximum of ten times. Thus, if air at 100 pounds per square inch is supplied to the pump, it will deliver air at 1,000 pounds per square inch to the strut. A few drops of light oil should be placed in the intake port occasionally to lubricate operating mechanism.

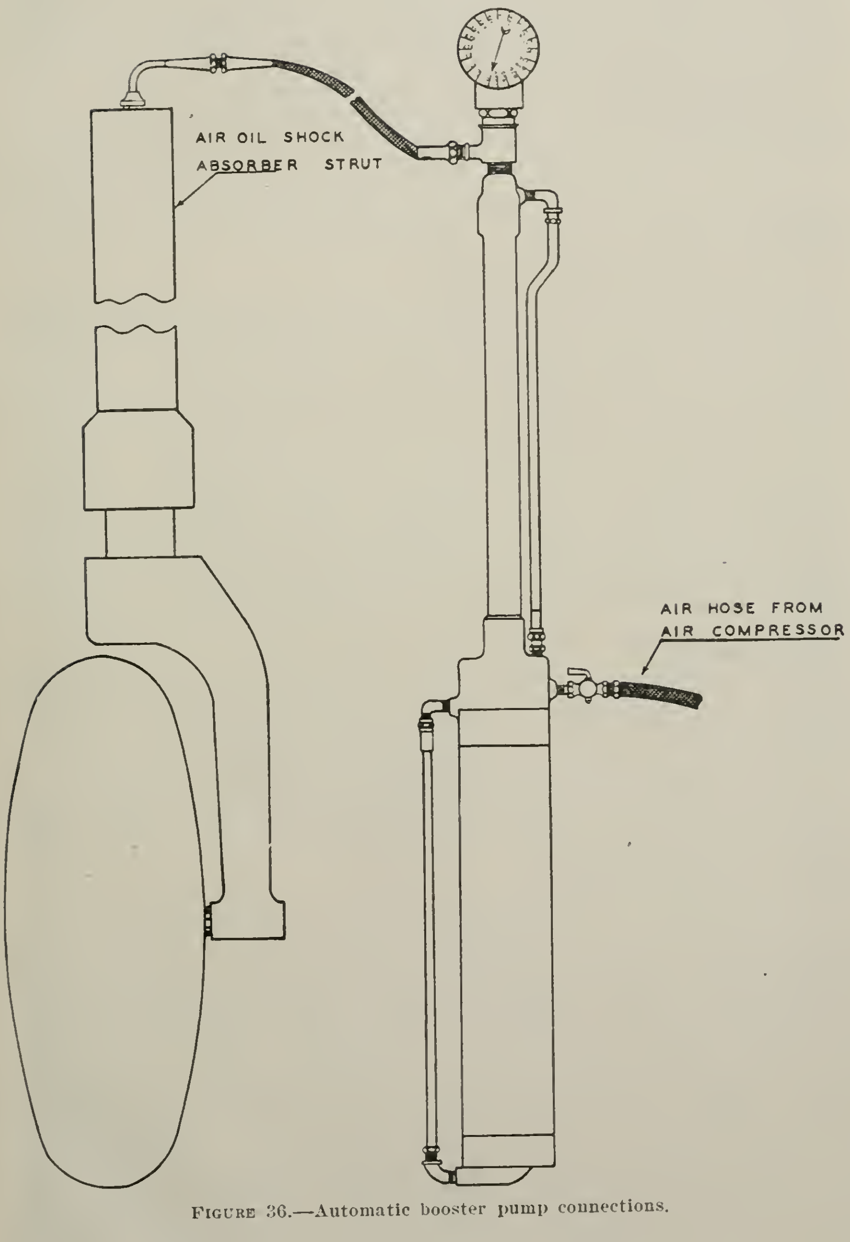


FIGURE 36.—Automatic booster pump connections.

30. Maintenance.—*a. Landing and tail gear.*—The Technical Order Handbook of Instructions for the airplane must be studied carefully before performing maintenance operations as the following instructions are of a general nature only, and must be supplemented by specific information for each type of airplane.

(1) Periodically each airplane with retractable landing gear is placed on jacks as described in section XVI and all mechanisms operated through complete cycles with all controls. As the landing gear is retracted and extended, a careful check should be made to see that it operates freely throughout its total range and that no part binds on any part of the airplane structure.

(2) Cables, if used, are checked for broken wires and proper tension. In case bungees are used, the shock cord should be inspected for breaks, weakening, or fraying of the covering. Bungees should not be allowed to become soaked with grease or oil as this will cause rapid deterioration of the shock cord. Function of the locking device must be checked very carefully and nothing short of perfect is acceptable. The landing gear position indicator, especially in the extended and retracted position, is checked for proper indication and the landing gear position warning signal is checked to see that the signal is distinct and operates whenever the landing gear is in any position other than down and locked.

(3) Since action of the tail gear antishimmy device depends on friction, it is obvious that grease or oil between the friction disks will reduce its effectiveness. The disks may be separated, as shown in figure 32 ②, and washed with unleaded gasoline or alcohol.

b. Air-oil shock struts.—Periodically it is necessary to check level of fluid in shock struts and to replenish the supply due to leaks. It is necessary that all air pressure in the strut be relieved before this operation can be performed.

(1) Deflating a strut improperly is very dangerous, therefore care must be exercised when performing this operation. Two types of filler plugs are in use, one with a straight thread and another with a tapered pipe thread. When the former is used, the strut is deflated by unscrewing the plug slowly until the pressure relief vent is uncovered, which allows the air to escape. However, no attempt should be made to deflate a strut employing the pipe thread type filler plug in this manner, as this plug has no vent in the side and if unscrewed too far will be blown out with dangerous force by the air pressure in the strut. The strut in this case is deflated by carefully depressing the valve core and the plug is not unscrewed until all air pressure has been relieved. Even if carefully done, the core may be damaged, but this

is the only method by which struts with this type of filler plugs can be deflated safely, and when the core is damaged it is replaced with a new one. The cores used in both types of plugs are quite similar to those used in automobile tires, but are especially designed for use in air-oil type shock absorbers and have a special composition seat material instead of rubber to resist deterioration by fluid. Under no circumstances will ordinary tire valves be used, as the rubber seat will deteriorate rapidly after contact with shock strut fluid.

(2) After all air is exhausted the filler plug is removed to check the fluid level, which should be even with the filler-plug opening. Fluid should be added at any time the level is below this point. During this operation the airplane must be in taxying position and the strut fully collapsed. It is advisable to rock the airplane slightly after deflating the strut to be sure that it is fully collapsed. When filling a strut which has been entirely empty or very low in fluid, special effort must be made to work out any air which may be trapped in the strut. This is done by filling the strut as described above and inserting the plug loosely. The strut is then extended and collapsed several times, preferably by raising and lowering the airplane by means of a hoist and/or hydraulic jacks. The air will escape through the loosely screwed-in plug and fluid is then added to bring the level up to the filler plug hole and the strut again extended and collapsed. These operations are repeated until the fluid level does not change, which indicates that all air has been eliminated. The filler plug is then screwed in tight, a copper gasket being used on the straight thread type plug.

(3) After the strut has been filled properly, it is inflated with a high-pressure pump. Care should be exercised to prevent damage to filler plug assembly by excessive tightening of the air-hose connection. When tightening this connection, if leakage cannot be stopped by hand tightening, the fitting gasket should be replaced. Under no circumstances will wrenches or pliers be used for tightening this connection. The amount of inflation is usually specified on the instruction plate attached to the strut or may be found in the handbook of instructions for the particular airplane. Amount of inflation of any air-oil strut is indicated by amount of extension of the strut with the airplane normally loaded and resting on a level surface in taxying position. It is specified in inches measured between two points as designated on the instruction plate, one on the cylinder and one on the piston. During inflation it is important that the airplane be rocked slightly to extend and compress alternately the strut to overcome packing friction. A plus or minus tolerance of ¼ inch is per-

missible for the specified amount of extension. The airplane should be sheltered from the wind while struts are being inflated and checked.

(4) It is possible to release a small amount of air from the strut by depressing the valve core. However, extreme care should be exercised in doing this and the air should be allowed to escape slowly to avoid damage to the valve-core seat. It is best to support the tool used to depress the core against the lip of the valve stem. In this manner the core may be depressed slowly and the escape of air controlled. This method may be used when a strut is accidentally overinflated, but should not be used when completely deflating a strut, except when the pipe threaded type plug is used.

(5) After inflation, the valve assembly is carefully checked for leaks, using soapy water. Leaks around the filler plug, valve, and other parts will be evidenced by a seepage of fluid. A small seepage around the packing gland is desirable for lubrication of the piston and should not be confused with a leak at this point. In case of leakage at the packing gland as evidenced by excessive fluid seepage or by air bubbles when soapy water is applied, the packing nut should be tightened firmly but not excessively. However, before tightening air pressure must be released, weight of airplane removed from the strut, and all safeties removed from the packing nut. The packing cannot be tightened properly under pressure, and if normal tightening does not stop the leakage, the packing must be replaced. Replacement of packing is done normally by a repair depot or base engineering shop.

(6) Alcohol is the only fluid which may be used for cleaning or flushing out struts containing hydraulic fluid. Any mineral-oil compound or derivative will destroy the packing materials, and carbon tetrachloride, upon contact with the fluid, forms hydrochloric acid which is a very powerful corrosive agent.

Section IX

TIRES AND TUBES

31. Tire casings.—*a.* Airplane tire casings are divided into four general groups, streamline, smooth contour, low pressure, and airwheel. The principal difference between these groups is in the shape of the casing in cross section as shown in figure **37**.

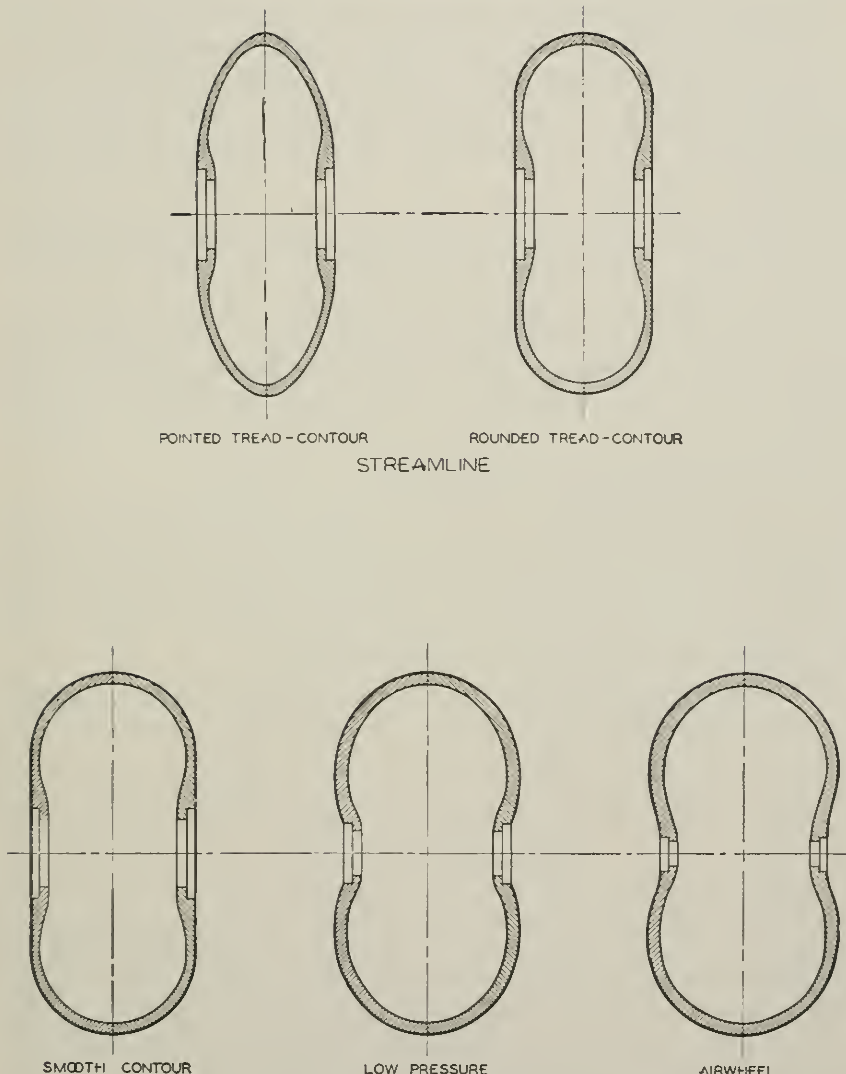


FIGURE 37.—Casing contours.

(1) The streamline casings are of two types. pointed tread contour and rounded tread contour. Their only difference is in the shape of the tread.

(2) Smooth contour casings differ from streamline casings principally in the increased distance between the tire beads at the rim flanges.

(3) The low pressure and airwheel casings carry comparatively low air pressures relative to their large over-all tire dimensions.

b. Some tires have nonskid treads for additional braking traction and because of the difference in traction between these and tires with plain treads, casings for landing gear wheels should be used only in like pairs.

c. Casing sizes are usually designated by maximum outside diameter of casing when inflated, but in some types width of inflated casing and hub diameter are also used.

32. Inner tubes.—Inner tubes are furnished for each of the principal shapes of casings. In many sizes, tubes are obtainable in both regular and punctureproof types. Punctureproof tubes have a puncture-resisting compound bonded to the inside of the tube with the thickest portion at the tread, tapered at both edges and of sufficient width to cover tread portion of the tube.

33. Tire pressures.—*a.* If tire pressure is allowed to become too low the tire will completely collapse on hard impact, causing abnormal loads on the wheel. On the other hand if the pressure is carried too high the force on the rim will be abnormal which may in time cause failure of the wheel. It is therefore essential that tire pressures be kept within close limits of recommended values.

b. Most tires, except older types, have deflection markers moulded into the side walls for the purpose of determining proper inflation. When using these markers, tires should be resting on a smooth, firm surface and tires are inflated to a point where deflection markers just touch the ground as shown in figure 38. Some tires have the amount of inflation pressure moulded on the side wall. In such cases these indicated pressures are maintained, except when the tire is used as an "oversize" on certain airplanes. When tires have neither deflection markers nor pressures moulded on the side wall, the handbook of instructions for the airplane and the Air Corps Technical Order "Aircraft Tire Pressures" should be consulted for this information.

c. When operating airplanes equipped with streamline tires from frozen, rutted fields, the tire pressures may be increased 25 percent above normal to prevent tire damage. This increase in pressure can be determined by checking normal inflation with a tire gage and increasing pressure required amount. When operating from soft, sandy, or muddy fields with either streamline or standard tires, pressure may be reduced 25 percent below normal to facilitate take-offs.

34. Maintenance.—*a.* Landing and tail wheel tires, with a few exceptions as specified in the basic handbook of instructions for related equipment, are removed by line personnel only when there is evidence of need for further inspection or possibility of internal defects. It should be realized that considerable damage may be done to a tire and tube during removal or reinstallation if improperly done. Care must also be taken that the wheel rim is not damaged by careless use of tire-mounting tools or impact with other objects during repairs or replacements.

b. Tire casings are replaced with serviceable like casings if any of the following defects are found:

(1) Internal or side wall ruptures or breaks.

(2) Tread cuts or wear exposing fabric to moisture or dirt.

(3) Side wall blisters which cannot be repaired.

(4) Damage to beads extending through outside rubberized chafer fabric.

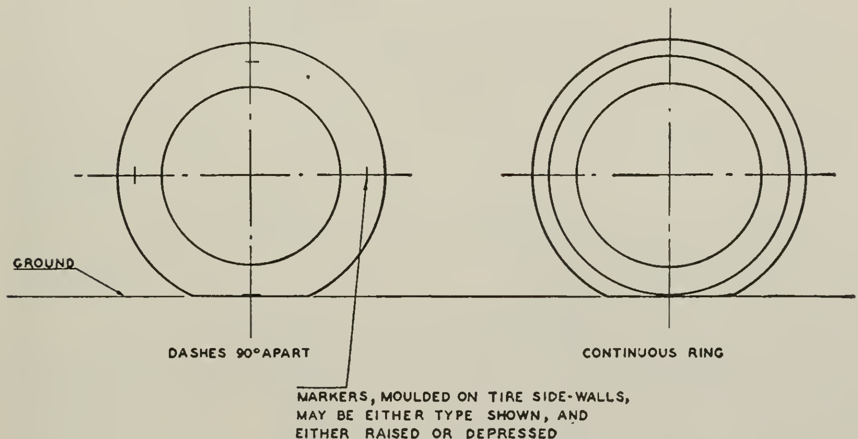


FIGURE 38.—Tire deflection markers.

c. Each time a tire is removed, the wheel rim should be thoroughly cleaned and if protective coatings are worn through to the metal they will be renewed with the same material as the original. Areas worn through to the primer should be retouched.

d. Procedure for mounting casings on wheels with a drop center rim is as follows:

(1) Rub both beads of casing with soft soap. The soap can be applied either in solid form or heavy lather, as desired. This is to aid in seating beads.

(2) Mount one bead of casing on rim. When casings have red balancing dots on the side wall, they are to be so mounted that the red dot coincides with location of inner tube valve.

(3) Dust entire tube surface with tire talc, insert tube in casing, properly aline valve in valve hole and apply lock nut loosely.

(4) Add enough air to shape the tube properly, and smooth out the folds by hand. If too much air is added, difficulty will be encountered when mounting remaining bead of casing.

(5) Mount second bead of casing starting at valve and add air slowly until casing beads seat. If beads do not seat properly, deflate casing and realine them so that they will seat properly when tire is inflated.

(6) Remove valve core and fully deflate tube to relieve pressure on any folds or wrinkles and to permit tube to assume its proper contour within the casing. Be sure that both casing beads remain properly seated on rim.

(7) Replace valve core, inflate to required pressure, and tighten valve lock nut.

e. Tread cuts which do not penetrate the first layer (ply) of fabric, may be repaired by cleaning thoroughly and filling with commercial cut filler. Side wall blisters which can be cleaned with no damage to the fabric may be repaired with rubber cement. If the rubber fairing immediately above the rim flange has separated from the fabric and there is no injury to the fabric, this may also be repaired in the same manner. Inner tubes having extra thickness in the portion coming in contact with the wheel rim need not be replaced because of wrinkles, provided there is no evidence of damage due to chafing. Punctures, small cuts, or holes may be repaired by patching if it is obvious that such repairs will render the tube serviceable. For such repairs a repair kit is used and instructions on the kit container must be followed carefully. Inner tubes will be replaced if any of the following defects are found:

(1) *Valve.*—Physical damage or faulty attachment to the tube.

(2) *Tube body.*—Evidence of thin spots, chafing, or damaged areas due to casing breaks.

Section X

WHEELS

35. General.—*a.* Most wheels used on main and auxiliary landing gear of military airplanes are cast from aluminum or magnesium alloys. This construction combines strength with light weight but permits very little repair to the wheel itself. These alloys corrode readily, consequently all surfaces except bearing and friction surfaces must be well covered with protective coatings. The rim contour, tire well, bearing cups, and brake drum liner surfaces are machined for accuracy and uniformity. All steel parts except brake surfaces and those parts fabricated from stainless steel are cadmium plated. Aluminum and aluminum alloy parts are either anodically treated, or protected with one spray coat of oil base primer and two coats of aluminum enamel or aluminum lacquer. The interior of the wheel between the inner and outer bearings is treated as described above, or covered with a light coating of bearing lubricant.

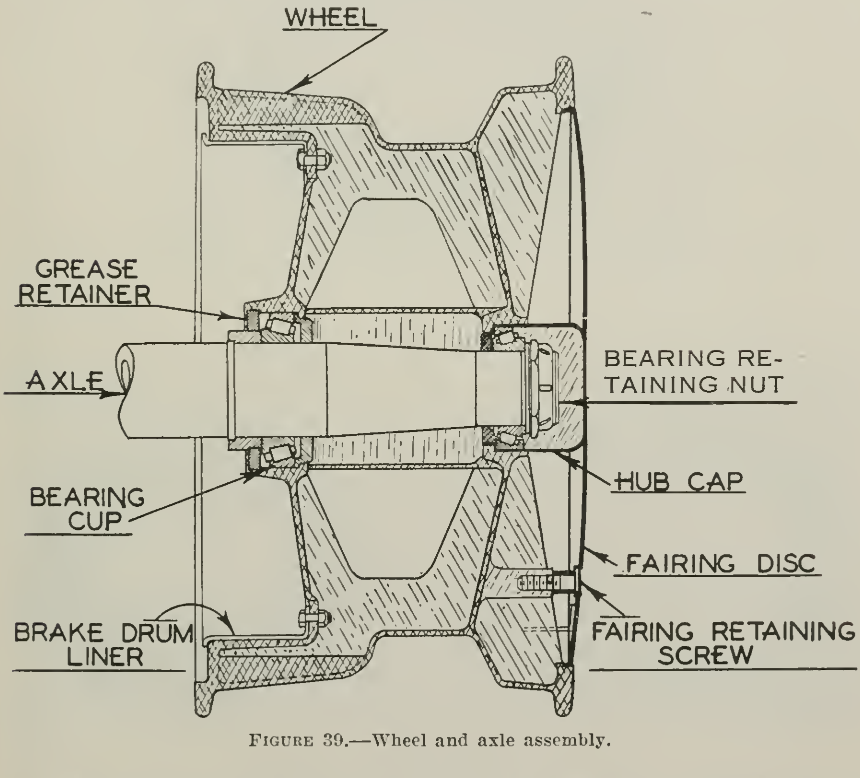
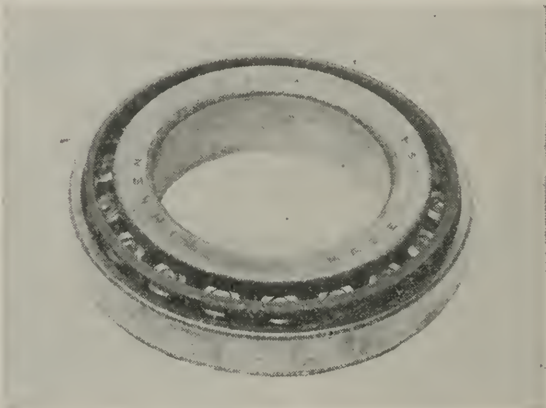
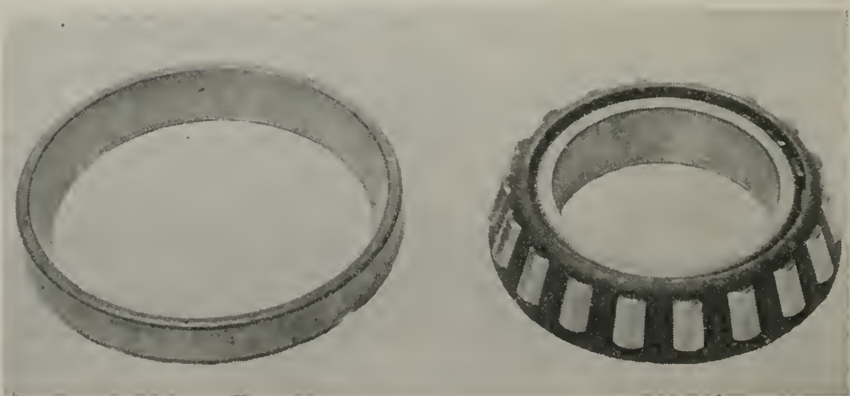


FIGURE 39.—Wheel and axle assembly.

b. Wheels are not stocked at depots with tires and tubes assembled, but each must be ordered separately as required. Brakes are also a separate item and are not issued as a part of the wheel. A typical wheel assembly is shown in figure 39. Airplane wheel bearings are of the tapered roller type consisting of bearing cone, rollers with retaining cage and bearing cup, as shown in figure 40 ②. Each wheel has the bearing cup pressed into place and is furnished with a hub cap to prevent foreign matter from entering the outside bearing. Suitable retainers are provided inboard of the inner bearing to prevent grease from reaching the brake lining. Seals are provided on amphibian airplanes to exclude water. Wheel side contour is obtained by a disk formed as a structural part of the wheel or by an auxiliary fairing disk. In either case the contour of the wheel is maintained smooth and free from imperfections as far as possible.



① Assembled.



② Disassembled.

FIGURE 40.—Wheel bearing assembly.

c. Wheels used by the Air Corps on main and auxiliary landing gear include a number of varieties and types, which may be classified according to features of their construction and types of casings used.

(1) *Main landing gear.*—(*a*) Fixed flange, drop center rim for streamline casings and for smooth contour casings.

(*b*) Removable flange, drop center rim for low pressure casings.

(*c*) Removable flange, flat base rim for low pressure casings.

(*d*) Air wheels, for air wheel casings.

(2) *Auxiliary landing gear.*—(*a*) Removable flange, drop center rim for streamline casings and for smooth contour casings.

(*b*) Split wheel, flat base for low pressure casings.

(*c*) Air wheels, for air wheel casings.

36. Main landing gear.—*a.* Wheels for the main landing gear having a fixed flange at the present time are all of drop center rim construction. The principal difference between those used for streamline casings and those used for smooth contour casings is that the latter are wider between the rim flanges. Figure 41 shows a typical fixed flange wheel with drop center rim and shows the outboard radial ribs which give added support to the rim at the outboard bead seat, as well as a portion of the internal ribs which help to support the rim at the well bottom. The outboard view of the wheel shows the tapered roller bearing cups and the threaded holes for the outer fairing attaching screws while the inboard view shows the brake drum side and the method of attaching the brake drum liner to the wheel. It will be noted that the brake drum liner is held in place by steel bolts projecting through the castings with elastic stop nuts on the inner side which can be tightened readily through the spokes of the wheel. On some of the larger sizes the wheels have a hub cast between the two bearing hubs which eliminates use of the two felt seals on the inside of the tapered roller bearing.

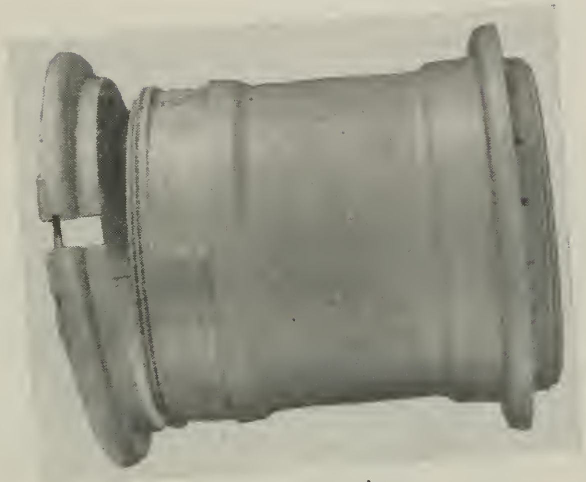
b. The main landing gear wheels of the removable flange type are now used with low pressure casings and may have either a drop center rim or a flat base rim. Figure 42 shows examples of both, ① shows the flat base rim which may be withdrawn readily from the tire by disconnecting the bolts which hold the halves of the two-piece removable flange in place, and lifting the flange from its seat in the rim. A brake drum of conventional type is installed on each side of the wheel providing a dual brake assembly. The wheel shown in figure 42 ② is the drop center rim construction and uses a one-piece removable flange which is held in place by means of a retainer snap ring. Provision is made for a multiple disk brake as shown.

c. Air wheels are designed for the low pressure air wheel casings for use on main or auxiliary landing gear. They are essentially hubs with usual wheel structure eliminated. The removable flange of the air wheel generally screws onto the main hub which is of the flat base type. The cross sectional area of the assembled air wheel is much greater than that of the usual wheel and tire combination, but probably due to its shape, tests indicate that its air resistance is approximately the same. An installation on the main landing gear showing use of the multiple disk brake is shown in figure 43.

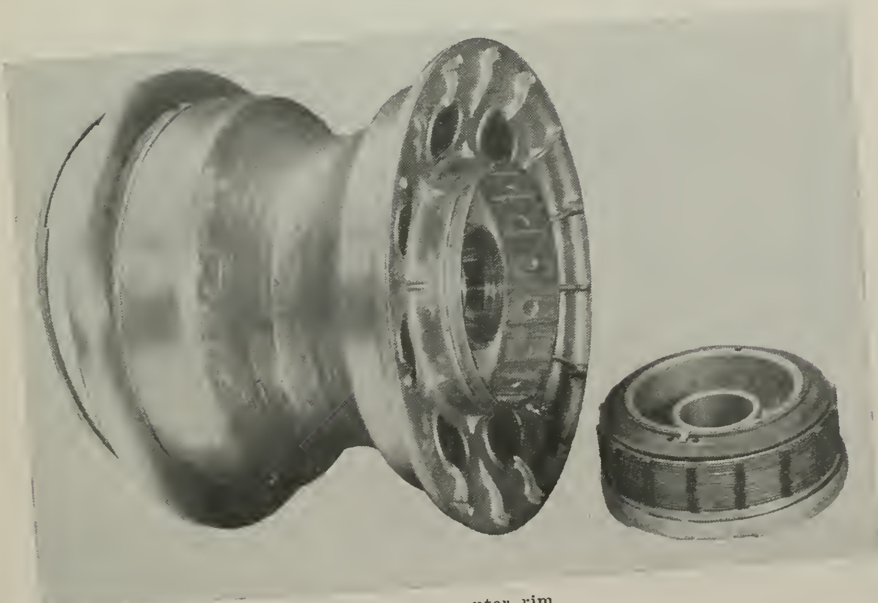
① Outboard side.

② Inboard side.

FIGURE 41.—Fixed flange wheel with drop center rim.



① Flat base rim.



② Drop center rim.

FIGURE 42.—Removable flange wheel.

37. Auxiliary landing gear.—*a.* Tail or nose wheels may be classified generally as removable flange or split wheel type both of which are shown in figure 44. The principal feature of the split wheel type shown in figure 44 ① is that the wheel is made in two halves held together by bolts and nuts, which permits easy removal or installation of tire and tube. In mounting the tire on the wheel the nuts are removed from tie bolts, one-half of wheel removed, tire installed over remaining half of wheel, removed half replaced, and two sections of wheel bolted together. Care should be taken to see that the inner

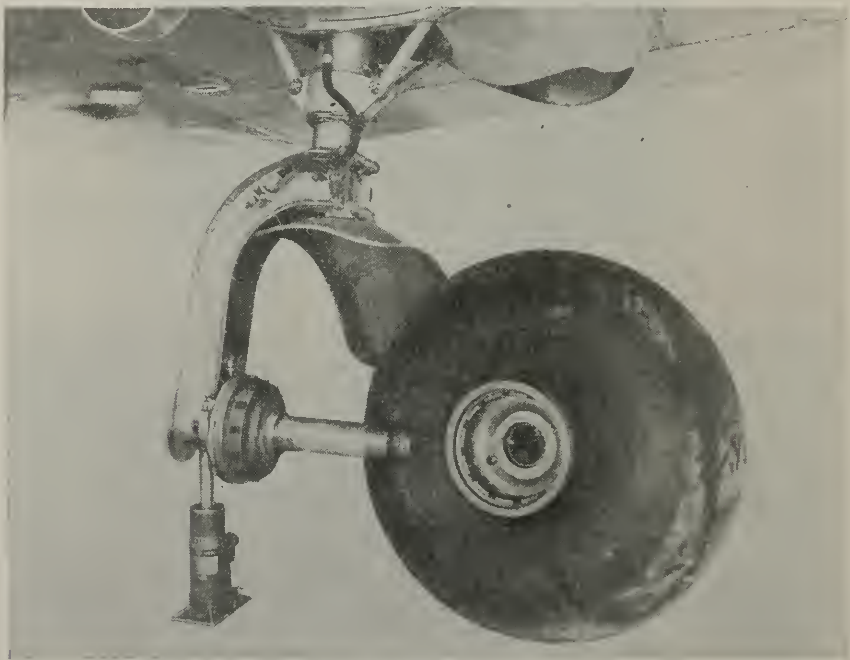
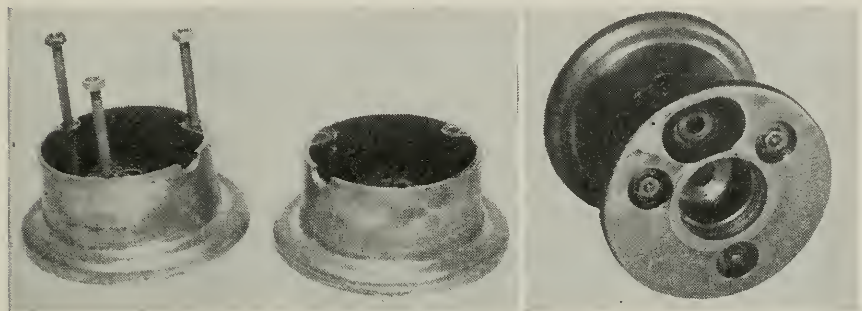


FIGURE 43.—Air wheel installation.

tube is not pinched between the halves and the valve stem is not binding in its mounting hole. If the tube is slightly inflated before mounting, no difficulty should be encountered. When mounted on a tail wheel fork, proper spacers should be placed on the axle which will allow the wheel to fit without excessive end play. The axle nuts then should be tightened until the wheel turns freely without lost play in the bearings. The nuts are then safetied with cotter pins.

b. On the removable-flange wheels with drop center rim shown in figure 44 ②, the flange forms a joint with the wheel-rim well, which is smooth and continuous to prevent chafing or pinching of the inner tube. This flange is held in position by a snap ring making removal of a tire an easy operation. To install this type of wheel, the fairing screws which hold the fairing in place are first removed; the hub cap which is held in place by the fairing is then taken off, and the wheel is then placed on the axle. There is no difference between the smooth contour and streamline types except that the former is wider to accommodate the smooth contour tire.



① Split wheel type.

② Drop center rim, removable-flange type.

FIGURE 44.—Auxiliary landing-gear wheels.

c. All types of tail or nose wheels have grease retainers on the outside of each bearing, as shown in figure 45, to retain grease in bearings and to exclude dust and water. Closures are provided where needed which rotate with the wheel and act as bearing retainers when the wheel is removed from the axle. The outer fairing makes a tight joint with the rim, providing a smooth contour, and is of sufficient stiffness to press down and retain the rubber valve stem.

38. Maintenance.—*a.* At the time wheels are removed for inspection, the entire surface of the wheel, both inside and out, is cleaned thoroughly. Grease retainers and bearings are removed. These bearing cavities and any other surfaces where grease may accumulate are cleaned with unleaded gasoline. An air blast should be used to dry the grease seals and the bearing assembly and remove foreign matter, but care should be taken that the bearing is not permitted to spin in the air blast as very high speeds can be obtained which may damage the bearing, or the bearing may disintegrate from centrifugal force with resultant injury to personnel. The air

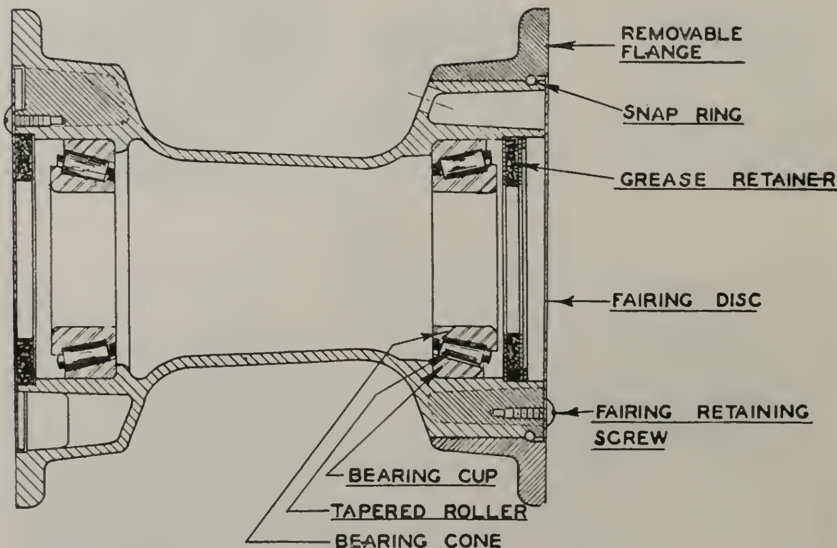


FIGURE 45.—Cross section, auxiliary landing-gear wheel.

line used for this purpose should have a separator to remove water. The wheel should be thoroughly dry before the tire and tube are remounted.

b. During the cleaning operation all surfaces of wheels are inspected carefully for defects, including nicked hubs, flanges, webs, or rims, and scored or loose brake-drum liners. The wheel is replaced with a new one if a loose liner cannot be corrected by tightening or replacement of screws, wheel is cracked or corroded, or rims are bent or distorted. It is important that surface of rim between bead seats be free from defects that would be injurious to casing or tube. Chipped off, cracked, or otherwise damaged protective coatings should be corrected whenever found as corrosion will take place rapidly at such places. The same material as the original coating should be used for this purpose.

c. When bearings are free from all dirt and grit and thoroughly dry if defects are found such as roughness of rollers, pitted or corroded rollers, cones and cups out of round, or distorted or broken cage, the bearing is replaced with a serviceable assembly.

FIGURE 46.—Lubrication of wheel bearing.

d. Bearing cups may be replaced locally if facilities are available. Cups are removed by an arbor press or if done carefully with a hammer and metal bar (preferably brass). Use light hammer blows and move driving bar about one-third the circumference of the bearing cup between blows. To install new cups an arbor press must be used. The smaller size wheels have a felt grease seal behind the bearing cup and these seals will be damaged beyond repair when the bearing cup is driven out. Therefore in these cases when reassembling, new grease seals are always installed behind the bearing cups. Other than brake drum liner screws and bearing cups, no replacement of wheel parts is made except at repair depots.

e. It is very important that proper lubricant be used in wheel bearings. The latest technical order pertaining to the particular type of equipment should be consulted in this respect. The proper method of applying lubricant to the roller bearing assembly, shown in figure 46, is to place a small amount of the proper lubricant in palm of left hand. Grasp cone of bearing assembly with thumb and first two fingers of right hand, keeping cage side of bearing assembly next to palm of left hand. Move bearing assembly across palm toward the thumb, forcing lubricant into opening between the rollers, turning or rotating assembly with each stroke until openings are filled with lubricant. Remove surplus lubricant from cone and outside of cage and then install assembly in wheel.

f. Installation of wheels on the axle is simple. However, adjustment of roller bearings must be made carefully as this adjustment may affect operation of wheel and brake. Using an axle nut wrench, tighten axle nut until a bearing drag is noticed when spinning the wheel by hand. Back off the nut to the next castellation and lock it in position with proper cotter pin. Brake drag must not be confused with bearing tightness when making bearing adjustment and it is well to make sure that brake adjustment is backed off so that there is plenty of clearance between brake band and brake drum.

Section XI

BRAKES

39. General.—The three general types of brakes on airplane wheels are internal expanding shoe, multiple disk, and expander tube. The internal expanding type employs either mechanical or hydraulic control system and the multiple disk and expander tube types either hydraulic or pneumatic control systems.

40. Internal expanding shoe.—*a*. Internal expanding shoe brakes may be classified as one-way (single-servo) (fig. 47), or two-way (reversible) (fig. 48). The term "servo" as applied to brakes refers to utilization of forward rotary motion of the brake drum to expand further or apply the brake shoes. Single-servo action operates in one direction of rotation only, while reversible operates in either. Both these brakes are furnished in single-shoe and two-shoe type construction and all types may be operated mechanically or hydraulically. The brakes are attached to the brake flange by bolts, the torque arm of the brake usually having twelve equally spaced holes with bolts installed only in alternate holes. The extra holes are provided to permit a greater number of trial positions when installing the brake the first time.

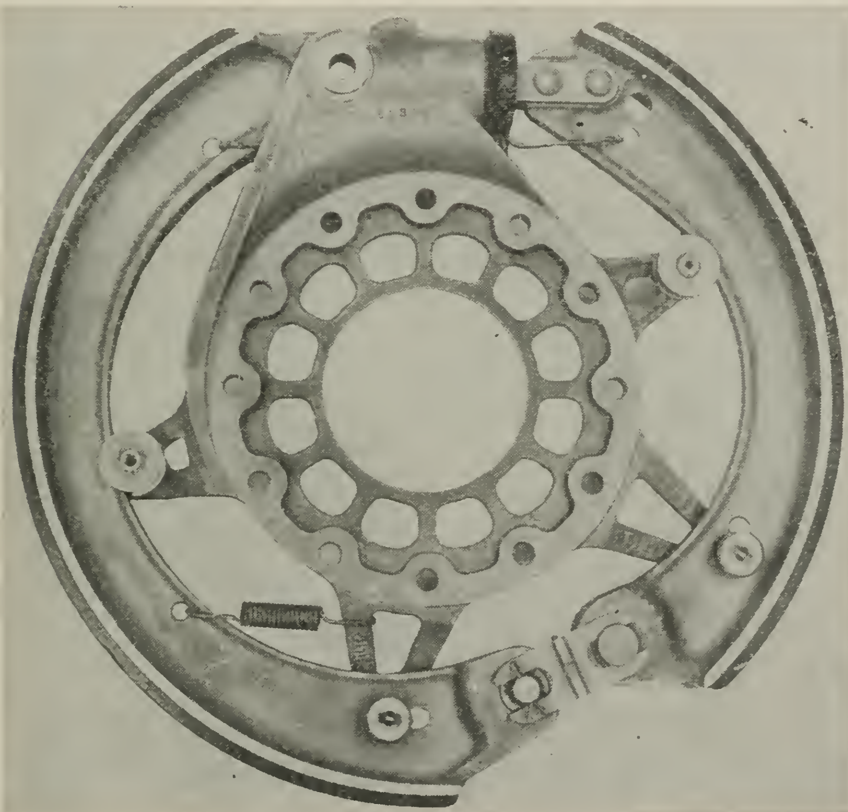


FIGURE 47.—Single-servo brake assembly.

b. The internal expanding shoe brakes of the one-way or single-servo type are marked either "right hand" or "left hand" by the manufacturer and care must be taken to see that the brakes are installed on the correct side. Figure 49 shows a dual brake installation and indicates location of right-hand and left-hand brakes. (It should be noted that RH and LH as applied to brakes refers to direction of rotation of brake drum over the shoes as could be seen through the wheel if it were transparent. RH and LH as applied to the wheels indicate their position on the airplane with respect to right or left side of pilot.) In all cases brakes marked "right hand" are installed on the left side (as determined from pilot's cockpit) of installed wheels, and brakes marked "left hand" are installed on the right side of installed wheels. Proper location may be assured also by installing assembly so that

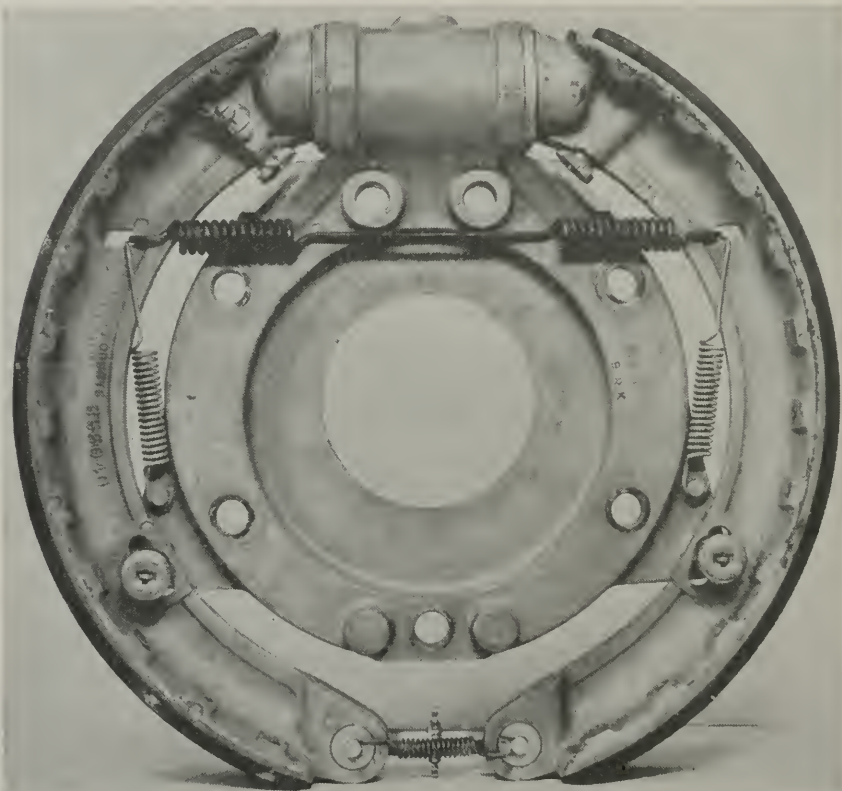


FIGURE 48.—Reversible brake assembly.

direction of rotation of brake drum follows from anchor pin toward toe of primary shoe.

c. The single-servo brakes (Hayes) use a one-piece cast aluminum alloy brake band of internal expanding type and are operated either mechanically or hydraulically as shown in figure 50. The mechanical brakes are made in sizes from 9-inch to 13-inch diameter for use in 21-inch to 31-inch wheels and the hydraulic brakes in sizes from 10-inch to 20-inch diameter for use in all sizes of wheels from 24-inch to 45-inch.

Figure 50 shows the one-piece brake band construction and three bell cranks which control radial clearance between band and drum, and which also serve to hold the band in alinement with the drum. In both cases the brake torque is transmitted to the axle torque flange. The brake mechanism is carried on the torque plate (A) as is the actuating means which in the mechanical brake is the operating shaft (B), and the operation lever (C), and in the hydraulic brake is the cylinder assembly (D). On the mechanical brake, the brake band is held in the released position by the spring (E), which is connected directly between the brake band locating plate (J) and the anchor pin (F) of the brake band. On the hydraulic brake, the spring is connected from the torque plate to the crank (G) which holds the operating end of the brake band in its released postion. When force is transmitted to the end of the band, either through the operating shaft or the hydraulic

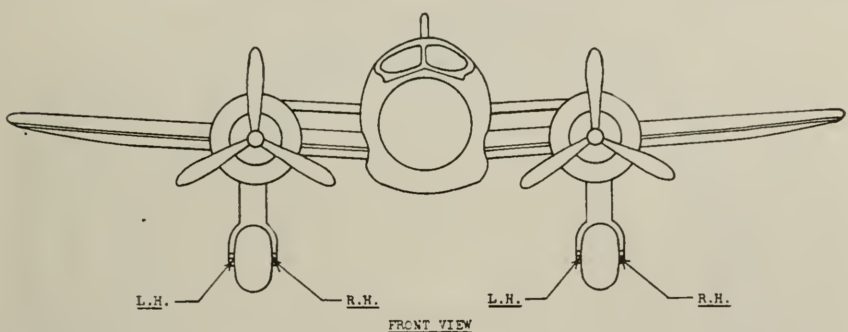
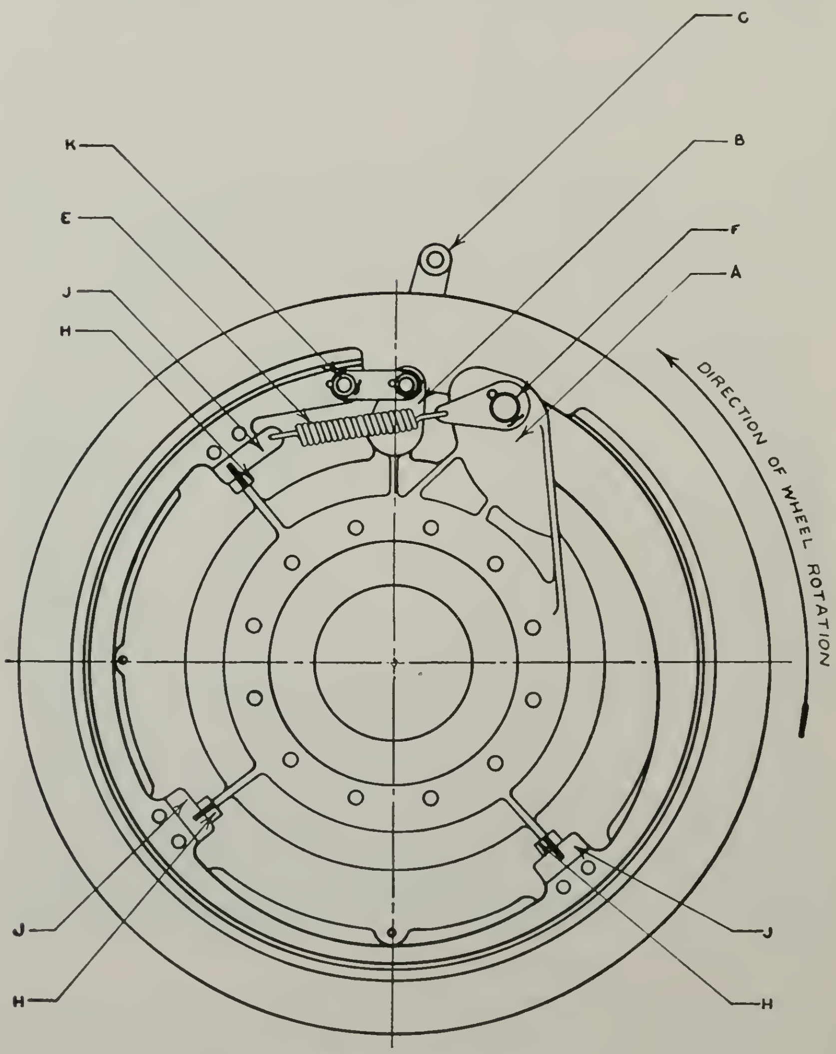


FIGURE 49.—Dual brake installation. (Brakes are stamped "right hand" and "left hand." When mounting on wheels having dual brakes place the brakes as shown above.)

piston, the band is applied to the drum near the heel end first, and as the brake is applied further, the entire surface comes into contact. The only adjustments necessary are to maintain proper radial clearance between brake drum and brake lining. This is done through the three adjusting bell cranks (H) which work against the three hardened steel plates (J). The latter are fastened to the brake band at the three points, as shown in the figure.

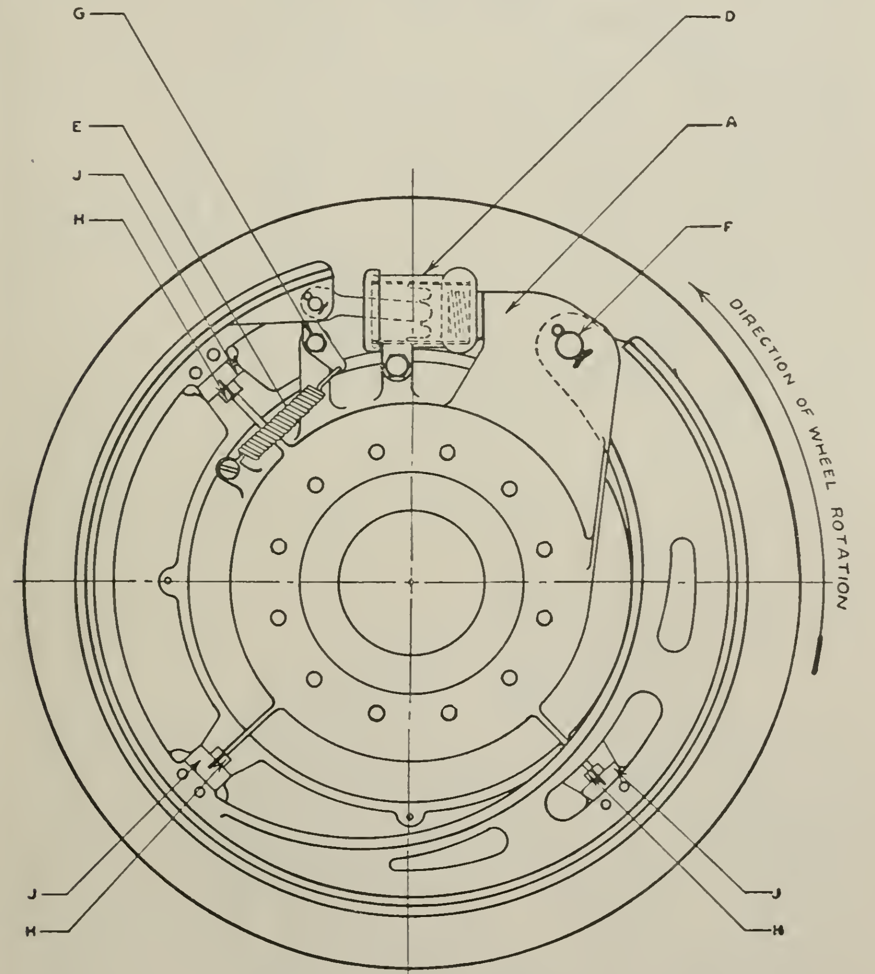
d. The single-servo brakes (Bendix) are the two-shoe internal expanding type. Some of the smaller brakes up to and including the 13-inch are operated mechanically (by means of a cam and lever) and the brakes larger than 13-inch are usually operated by hydraulic pressure, both of which are shown in figure 51. It should be noted in both cases that the torque arm (O) of the brake is the basic unit and that no built-up or attached members are added for its reinforcement. On the mechanical brake the torque arm is designed to permit installation of a forged steel operating shaft, one end being forged to provide an internal lever (A) which is attached to the primary brake shoe through steel links (B). The brake is applied by rotating



① Mechanically operated.

FIGURE 50.—Single-servo brake, one-shoe construction.

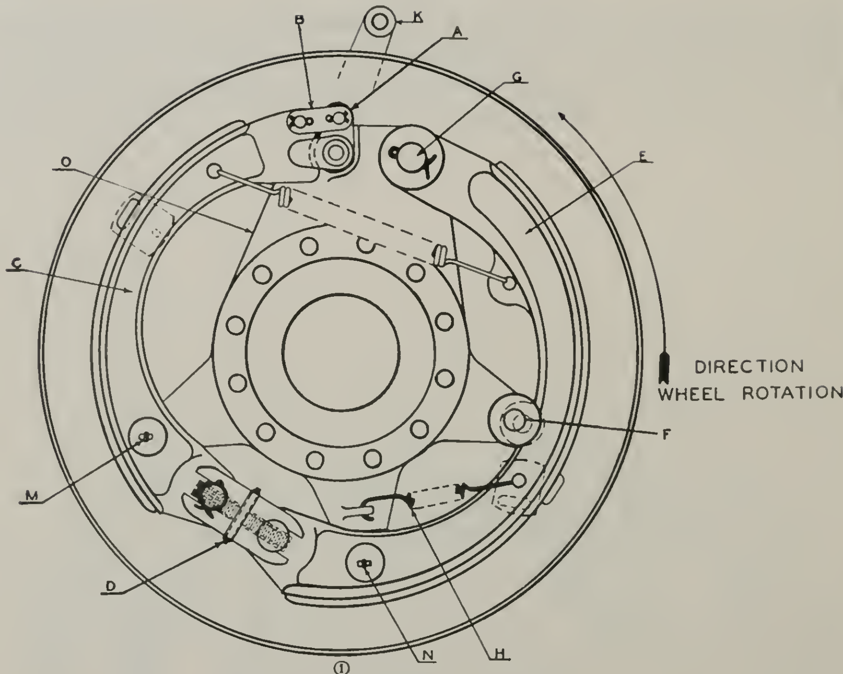
the control lever (K) which causes the internal lever (A) to force the shoe outward. On the hydraulic brake, the torque arm is designed to incorporate a cylinder (A), fitted with a thin sleeve (S). When hydraulic pressure is admitted to the cylinder behind piston (P), the force of application is transmitted through connecting link (B) to primary shoe (C) forcing it against the drum. In both the mechanical and hydraulic brakes, the primary and secondary shoes are



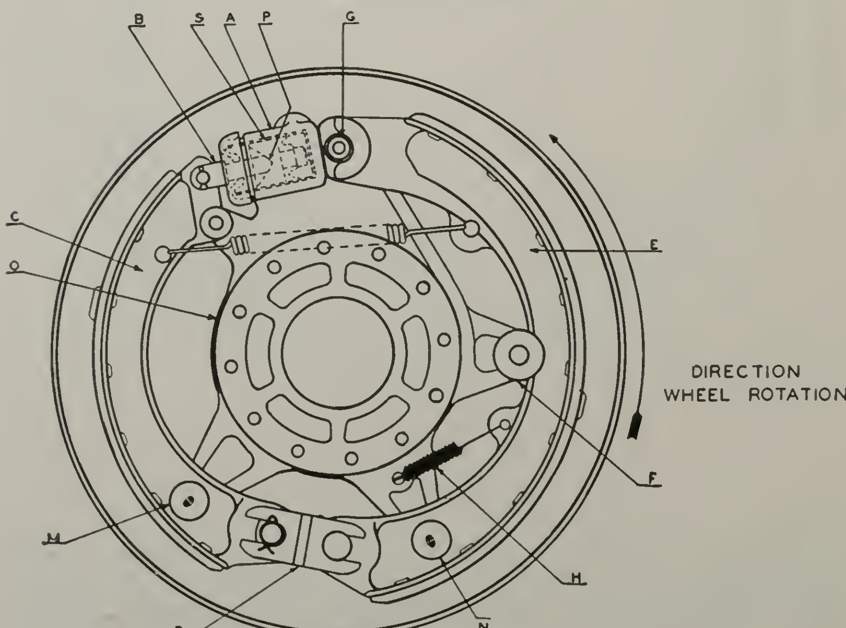
② Hydraulically operated.

FIGURE 50.—Single-servo brake, one-shoe construction—Continued.

connected by means of a star adjusting screw (D), which has a right-hand thread on one end and a left-hand thread on the other, thus permitting spreading or contracting the shoes. An eccentric cam (F) is provided for adjusting the clearance of the secondary shoe (E),



① Mechanically operated.



② Hydraulically operated.

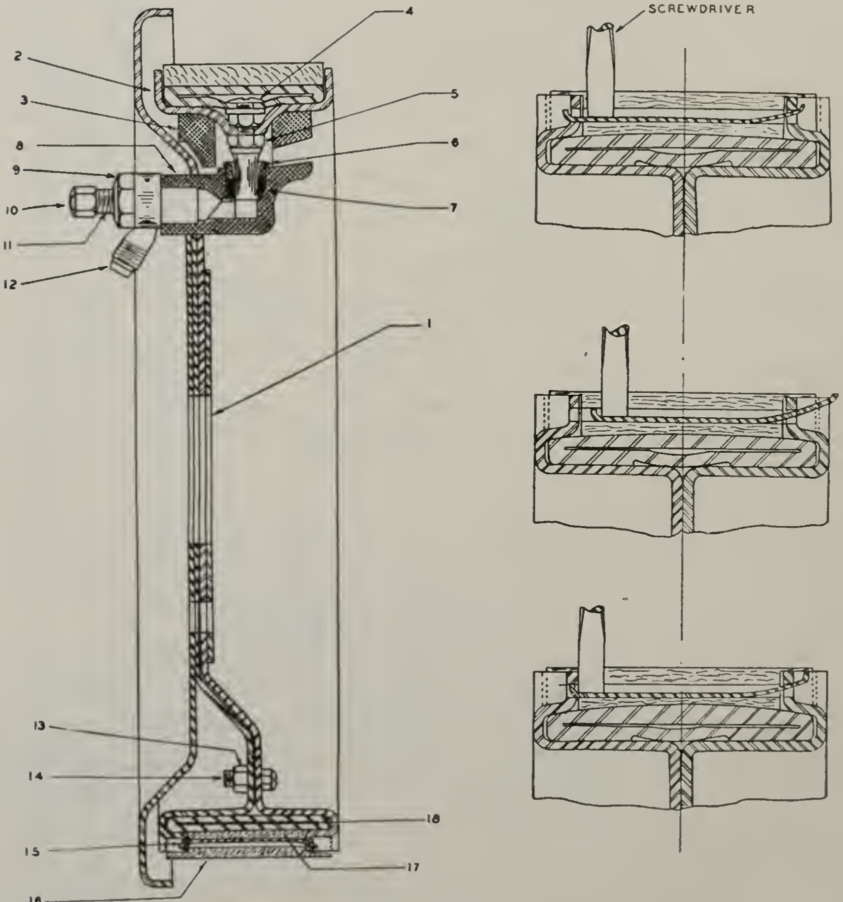
FIGURE 51.—Single-servo brake, two-shoe construction.

which is held against the eccentric by means of a spring (H). As the brake shoes are anchored to the torque arm (O) at only one place (G), it is evident that any variation in the secondary shoe clearance will change the primary shoe clearance. Therefore, the secondary shoe must always be adjusted for clearance by eccentric (F) before the primary shoe is adjusted. After the secondary shoe has been set to the correct clearance, the primary shoe may be adjusted by means of the star wheel (D). As the brake drum rotates in the direction indicated by the arrow, the friction between the primary shoe and drum with brakes applied causes the shoe to follow the drum. In so doing, the primary shoe operating through adjusting screw (D) forces secondary shoe (E) in contact with the brake drum. At (M) and (N) steady rests are provided for primary and secondary shoes respectively, their purpose being to keep the shoes in correct alinement with the brake drum.

e. The two-way or reversible brakes of the internal expanding type are similar to the single-servo in most features except that instead of one end of the brake shoe assembly being anchored by a stationary anchor pin, it is connected to a second piston in the actuating cylinder. Thus when hydraulic pressure is admitted to the cylinder, the application of force is transmitted in opposing directions through connecting links to the two ends of the brake shoe assembly. These brakes may be of either single- or two-shoe type and are interchangeable as either right-hand or left-hand brakes by reversing the return springs. For information on installation and adjustments of these brakes, reference is made to the Air Corps Technical Order pertaining to the particular equipment on which the brake is installed.

41. Multiple disk.—The multiple disk brake may be pneumatically or hydraulically operated. It is used in only a few models of airplanes where structural and operating limitations require a relatively large braking area within a small diameter. As shown in figures 42 and 43, the assembly is composed of a series of alternately stationary steel disks between others which engage in recesses of the wheel hub and revolve with it.

42. Expander tube.—*a*. The expander tube brake, shown in cross-section in figure 52 ①, consists of three main parts, brake frame, expander tube, and brake blocks. It is furnished in two styles, single which has one row of brake blocks around the circumference, and duplex which has two rows. An inner fairing or shield fits between the torque flange on the axle and the brake frame to protect the frame against water. The brake expander tube is a flat tube ¼ inch thick of rubber compound and fabric which is stretched over the brake frame between the side flanges. It is equipped with a nozzle which is connected with the brake fluid connection through suitable packing means. The brake blocks are made of special material and the number used corresponds to the number of inches of brake diameter, for example, 20-inch diameter brakes have 20 blocks. These blocks have notches on the sides to engage with bosses on the brake frame and have slots



① Cross-section view.

② Removal and replacement of brake lining retracting spring.

1., 2. Brake frame.
3. Reinforcement block.
4. Nozzle.
5. Nozzle nut.
6. Packing nut.
7. Packing.
8. Nozzle connection.
9. Tube connection bolt.
10. Bleeder screw cap.
11. Bleeder screw.
12. Connection tube.
13. Elastic stop nut.
14. Brake frame screw.
15. Brake lining retracting spring.
16. Brake block.
17. Expander tube shield.
18. Expander tube.

FIGURE 52.—Expander tube brake.

across their ends into which flat springs are inserted. The ends of these springs fit into slots in the side flanges of the brake frame which hold the brake blocks against the expander tube and keep them from dragging when brake is released. The correct method for removing and replacing these springs is shown in figure 52 ②.

b. This type brake is operated by brake fluid and may be used with one of the conventional hydraulic brake systems. Applying brake pedal forces the brake fluid into the expander tube which is restrained from movement inwardly and to the sides. The fluid in the expander tube forces the individual brake blocks out radially against the brake drum. They are held from rotating by the lugs on the brake frame fitting into notches in the sides of the brake blocks. As soon as the pressure is released the springs in the ends of the brake blocks tend to force the fluid out of the expander tube. This action is assisted by the tube itself which is molded slightly smaller in diameter than the brake frame and which tends to retract itself without the aid of the springs in the brake block. As each block is independent in its action, there is no build-up of servo action and therefore no tendency for the brake to grab.

c. These brakes have a radial clearance between the brake lining and the brake drum which varies with the size of brake. There is no way of changing this amount except by grinding off the face of the blocks. As the lining wears, fluid displacement of the brake increases and when pedal movement becomes too great, it is necessary to reline the brake by installation of new blocks.

43. Actuating systems.—*a.* A typical mechanically operated system is shown in figure 53. These systems which employ control cable pulleys and in some instances bell cranks vary widely in detail with different airplanes.

b. A typical hydraulic brake system is shown in figure 54. There are two separate systems for any airplane, one for each brake, although on some installations the reservoir is common to both. The principal units are—

(1) *Reservoir.*—The purpose of this unit is to compensate for any slight leaks in connecting lines, to prevent admittance of air into the system, and to keep piston of master cylinder completely submerged at all times.

(2) *Master cylinder.*—This unit when operated builds up fluid pressure between master cylinder and brake cylinder, causing brake cylinder piston to move and in so doing to operate the brakes.

(3) *Wheel cylinder.*—This is the unit located in the brake assembly which through the piston actuates the brake shoe.

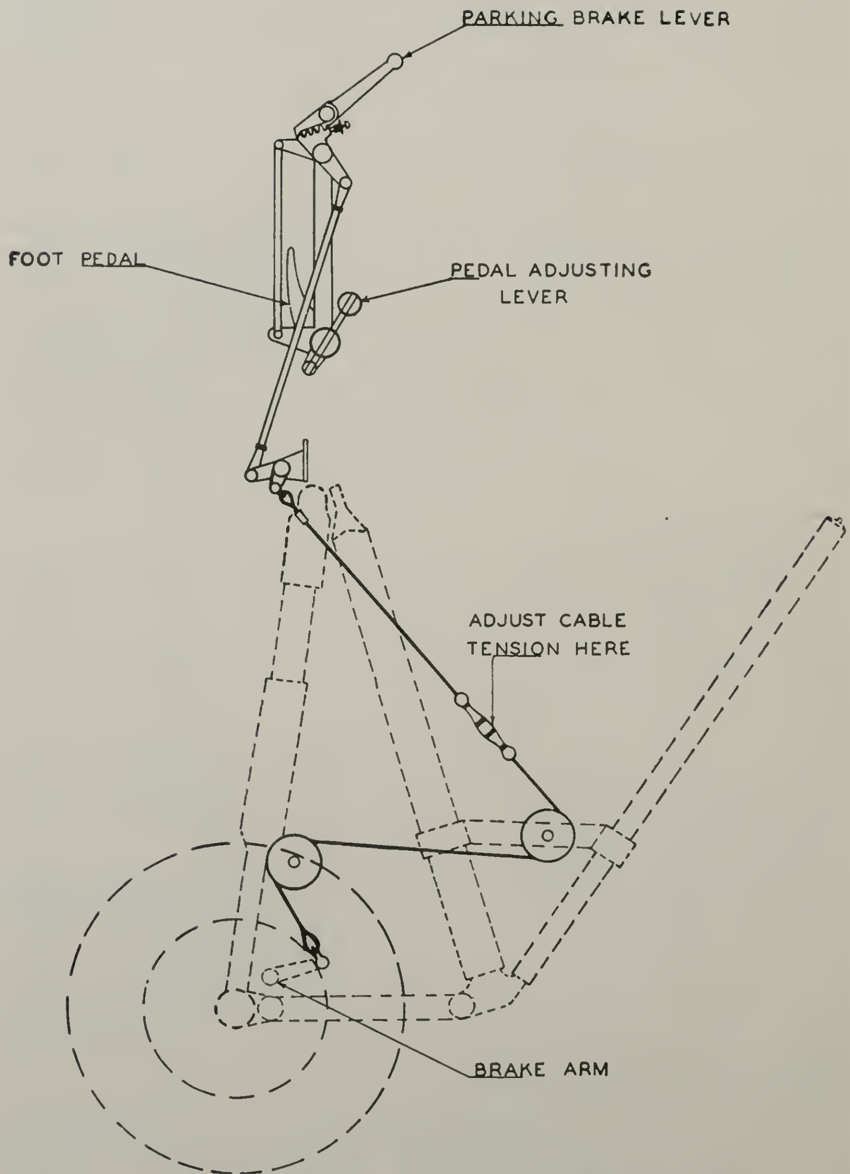


FIGURE 53.—Mechanical brake system.

(4) *Fluid lines.*—These lines transmit pressure from master cylinder to brake cylinder.

c. The major parts of the air-operated system are air storage tank and compressor, metering valves at toe pedals, pressure gage, parking brake lever and wheel and brake unit. The air compressor is automatic and when in operation should maintain a predetermined pres-

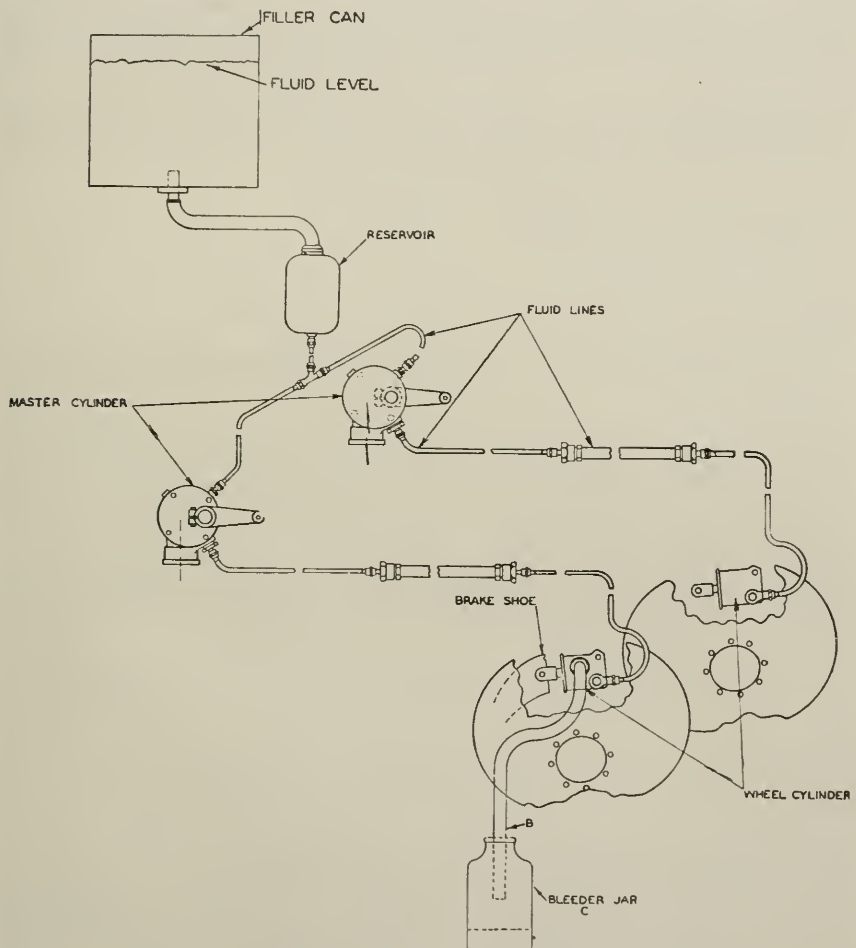


FIGURE 54.—Hydraulic brake system and bleeding equipment.

sure, depending upon the particular airplane. About 15 minutes is required to develop the tank pressure which should always be checked before starting the engines or landing the airplane. The metering valves are operated by either the pilot's or copilot's brake pedals admitting air to the brake on the forward stroke and releasing it on the backward stroke. Rapid deceleration of airplanes of large size requires absorption of a tremendous amount of energy by the brakes with the consequent development of extremely high temperatures in the metal disks. The effect of the comparatively small contact area (tire to ground) is noticeable in the ease with which the wheels slide. For these reasons it is recommended that all braking be done with caution. and overuse of brakes avoided. Locking the brakes with parking brake immediately after extended taxying when the disks are hot should be avoided since the combination of heat and pressure may cause sticking.

44. Maintenance.—*a.* During inspection of brakes, the assembly is renewed if any of the following are found:

(1) Corroded, broken, or cracked parts.

(2) Distorted brake shoes.

(3) Loose rivets.

(4) Brake linings badly scored, excessively worn, or impregnated with oil.

b. Some maintenance instructions pertaining to brakes in general are given below:

(1) Distorted brake shoes will not allow full contact of the lining with the brake drum. Greasy brake lining may cause "grabby" or ineffective brakes, depending on amount of grease. Brake lining does not absorb grease rapidly and in cases where the condition is found early enough the grease can be washed off the lining with unleaded gasoline. Remove all worn particles of lining from recesses in the lining over the rivet heads. Wipe the lining clean with a dry cloth or with a fine wire brush.

(2) The backing plate is a dust cover made of thin gage aluminum stock and may be reformed readily in case interference is noted between the backing plate and wheel. Care should be exercised in doing this, however, because if the plate is pulled out sufficiently for air to get between the plate and wheel when the airplane is in flight, the thin cover plate will buckle.

(3) All return springs should be inspected carefully to see that they have good initial tension and that the hooks at each end of the spring have not been straightened out. In such cases the spring must be either reformed to insure security, or be replaced.

(4) Wipe all dirt and foreign particles from the brake machanism. See that the felt retaining washers are in good condition (not saturated with grease). This is necessary to prevent lubricant from working out of the bearing and into brake drum and lining. Clean brake drum cavity of the wheel and bearing retainer with a cloth moistened with

cleaning fluid obtained by mixing equal parts of naphtha and carbon-tetrachloride. Wipe dry with a clean cloth.

c. Before the brakes are adjusted it is essential that the hook-up be checked over thoroughly. Before attempting to adjust the brake, jack up the wheel and apply the brake several times to be sure the brake releases properly and promptly. The hook-up must be gone over carefully, frayed cables replaced, all interference with the cable or control removed, and all pulleys and bell crank bearings thoroughly lubricated. If these bearings are of the sealed type, under no circumstances will a grease solvent be used in cleaning them. The hook-up is tested to ascertain that brakes release rapidly and to the full "off" position.

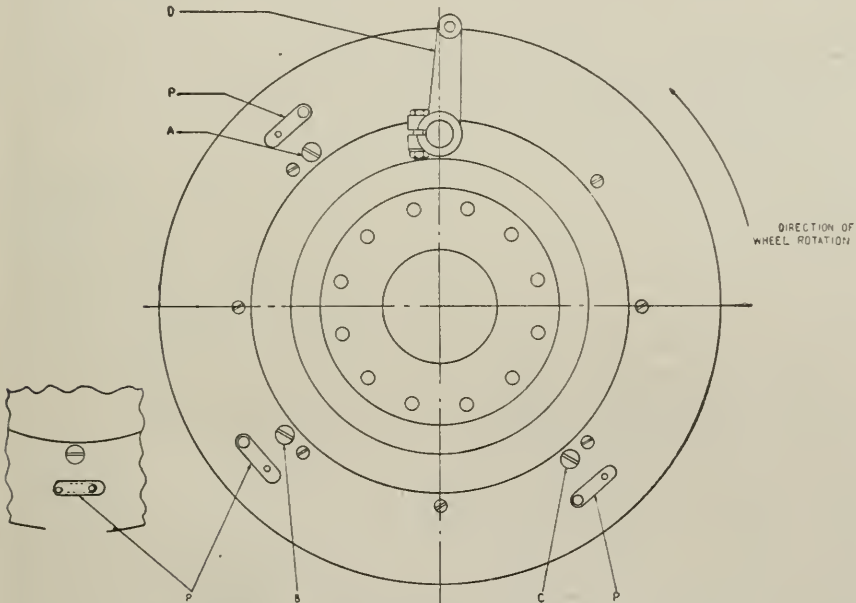


FIGURE 55.—Adjustment of single-shoe single-servo brake (Hayes).

d. Brake adjustment procedure for the single-shoe single-servo internal expanding type brake (Hayes) is as follows (see fig. 55):

(1) First open the three inspection holes (P), then with a screwdriver turn the adjusting screw (A) clockwise until the clearance specified in the airplane handbook is obtained. If the clearance is not given in the handbook adjust to approximately 0.010 inch between the brake shoe and drum. This can be measured by a feeler gage of this thickness through the inspection holes (P). The adjusting screws (B) and (C) are then tightened in turn until there is 0.010 inch clearance between the brake lining and brake drum at each of these two

points. Return to the first adjusting screw (A) nearest the toe of the brake shoe and reduce the clearance to 0.010 inch. After this, it may be necessary to go over the adjustment again in the same order and slightly change each one to give required clearance. While adjusting brakes extreme care must be taken to see that the brakes are not applied while the wheels are removed as this will cause the one-piece shoe to be distorted and rendered unfit for further service. If mechanically operated, the cable is adjusted until the released position of the brake pedal is in the proper position in the cockpit before making adjustments at the brake shoe.

(2) As the above is the only adjustment, it will be noted that as the lining wears the operating arm (D) will change its angular position and it may be necessary to remove the arm and relocate it on the operating shaft so as to keep the cable pull at approximately 90° to the arm at midpoint between the "Off" and "On" position of the brake.

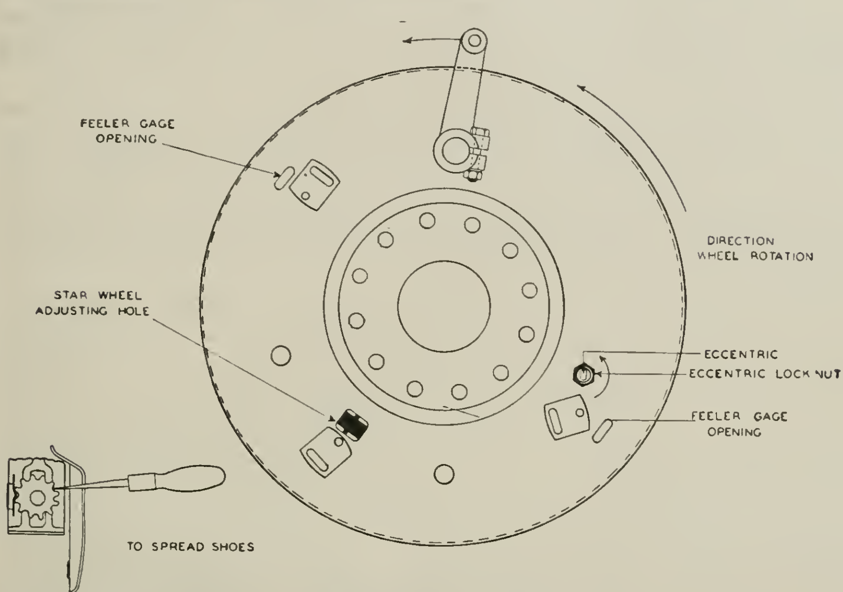
(3) After the brakes have been adjusted, the hook-up should be gone over carefully and the rods, foot pedals, and bell cranks set so that they will be working in the most advantageous position. The brake pedals are adjusted so that with pedals fully extended and the rudder full "On" the pedals will be unhindered in operation. Brake pedals are adjusted so as to allow some small movement of the pedals toward the "On" or braking position before the brakes actually take hold in order to avoid accidental application of the brakes by the pilot.

e. Brake adjustment procedure for the two-shoe single-servo internal expanding brake (Bendix) is as follows (see fig. 56):

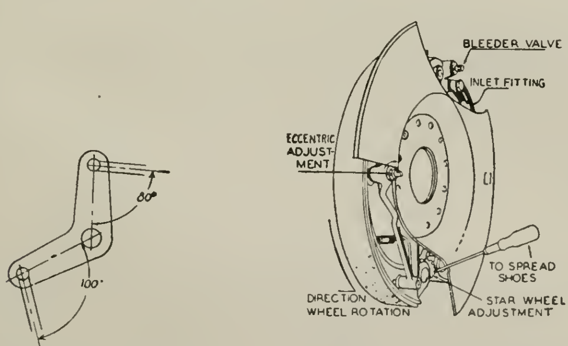
(1) Loosen eccentric lock nut and turn eccentric in direction of wheel rotation until wheel is locked. Back off eccentric until wheel just rotates freely and with a close-fitting wrench hold eccentric in this position and tighten lock nut. Uncover star wheel adjusting screw hole by rotating cover plate. With a screwdriver turn star wheel of adjusting screw away from axle until a brake drag is noticed when turning the wheel by hand, and then back off star wheel until there is no brake drag. On brakes using star adjusting screw there is a positive stop provided for actuating end of primary shoe which definitely sets the "Off" position of this shoe. Therefore no adjustment is necessary to the brake control lever other than outlined below.

(2) On the mechanically operated brakes the angle between the actuating rod or cable and the brake control lever should not be over 80° when the brake is fully applied. This angle should be checked and corrected if necessary, but need not be changed when once corrected, as the star wheel adjustment entirely compensates for lining wear. Due to cable stretch it may be necessary to adjust the operat-

ing cable sufficiently to bring the brake pedals into a position convenient for the pilot to operate. In all cases the basic handbook for the particular airplane must be consulted.



② Star wheel adjustment. ① Mechanically operated brake.



③ Brake control lever. ④ Hydraulically operated brake.

FIGURE 56.—Adjustment of two-shoe single-servo brake (Bendix).

f. Adjustment of the Hayes reversible single-shoe brake is similar to the single-servo except the former has four adjusting bell cranks instead of three. The only adjustment of the reversible Bendix two-shoe brake is the star wheel adjustment described above.

g. Instructions for the multiple-disk brake may be found in the technical publications covering the particular airplane on which they are installed and the expander tube brakes require no adjustment.

h. The following instructions apply specifically to hydraulic systems used for operating brakes and should not be considered as complete instructions for hydraulic systems in general:

(1) Whenever the hydraulic line connecting master cylinder to brake cylinder is disconnected, air will be admitted to the system. The same condition may develop if the fluid reservoir becomes empty. Air in the system is indicated by spongy action of brake pedals when applying brakes. When this occurs the system must be bled to remove the air.

(2) It will be noted in figure 54 that there are two fittings in the brake actuating cylinder, that is, the inlet fitting and the bleeder. The bleeder is a needle valve with a cap or dust cover. To bleed properly a brake hydraulic system, the special equipment illustrated in figure 54 is required. The free end of the filler can hose is attached to the filler plug opening of the master cylinder reservoir. The can is then partially filled with the proper hydraulic fluid. The hose (B) is attached to the bleeder valve and the free end submerged in hydraulic fluid in the glass jar (C). The brake pedal is then operated back and forth slowly. During this operation the bleeder valve is kept open one to one and one-half turns. The fluid coming out of the hose submerged in the glass jar will contain air bubbles. Operation of the pedal is continued until air bubbles no longer appear. This will require pumping at least one pint of fluid through the system. The bleeder valve is then closed tightly and the hose removed. During the bleeding operation it is essential that the fluid level in the filler can be watched so that the supply of fluid is not exhausted, otherwise air will again be introduced into the system.

(3) Maintenance of the hydraulic brake system consists chiefly of keeping fluid in the reservoir. The lines unless properly supported to prevent vibration may leak at the fittings. These leaks must be corrected at once. Gaskets which have been scored or damaged must be replaced. If leaks are noticed at the brake cylinder, the piston and piston cup should be removed and inspected. Replacement of the rubber cup should correct such leaks unless the cylinder sleeve is scored. If the rubber cup is not soft and pliable, or if it has been cut by the piston, it should be replaced. Care should be used in replacing these parts that no fluid is allowed to contact the brake lining. The master cylinder may be disassembled for replacement of piston cups. After long periods of service the rubber hose connections may show signs

of deterioration such as swelling or cracking. In such cases these connections should be replaced. When checking lines and connections for leaks brake pedals must be depressed, thus placing the system under pressure so that leaks which otherwise would not be apparent may be found. When flexible lines are found bulged, kinked, or swollen due to oil saturation, they are replaced. All hydraulic brake lines are marked with paint bands of blue-yellow-blue.

i. In checking operation of brakes, they should—

(1) Hold wheels from turning against full ground throttle.

(2) Hold evenly and not grab.

(3) Be equally effective for a similar movement of brake pedals.

(4) Not drag when off. Listen for rubbing sounds indicating high spots on the lining, distorted brake drum, or distorted backing plates.

Section XII

COCKPITS AND CABINS

45. General.—*a*. The pilot's cockpit is that portion of the airplane occupied by the pilot or by the pilot and assistant pilot from which all controls radiate and in which furnishings, instruments, and equipment are installed in positions accessible or usable to the pilot or to the pilot and assistant pilot, as the case may be. Single-place airplanes have one cockpit (accommodation for pilot only) and two-place or tandem-seat airplanes have two. In the latter case certain controls, instruments, and equipment are either duplicated or placed in positions visible and accessible from both cockpits. Bombardment, cargo, and other large and special type airplanes have a pilot and copilot compartment in addition to the bomb compartments, cabins, etc. In most cases the cockpits are designed to be completely inclosed to protect the pilot and crew from atmospheric conditions.

b. All airplanes are equipped with a baggage and tool compartment appropriate to the crew and intended mission of the airplane. These compartments are readily accessible from cockpits, cabins, or from the outside of the airplane and are provided with locks mounted flush with the covering or embodied in the handles.

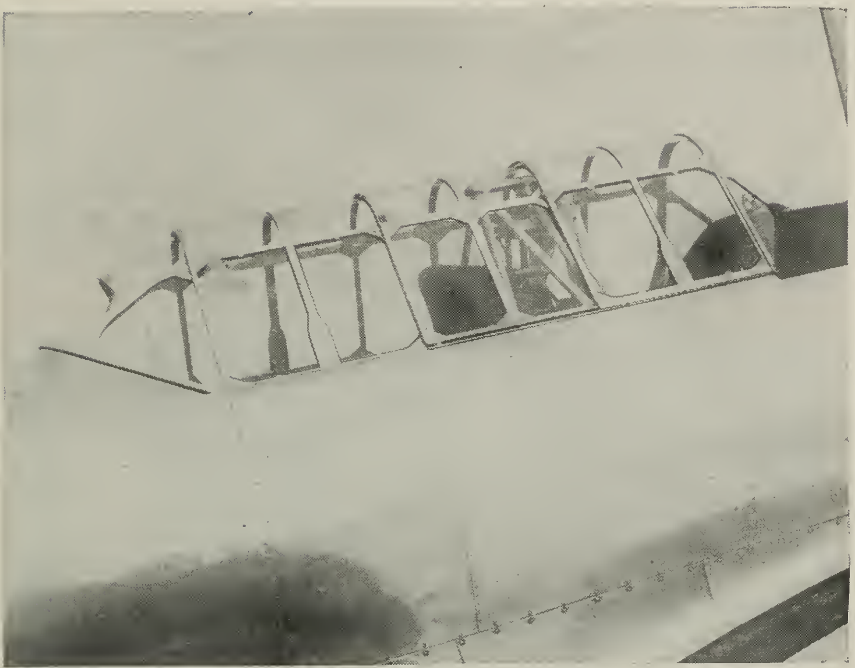
46. Inclosures, windshields, and windows.—To provide necessary vision and facilitate inspection, transparent materials are used in these units, and where practicable in covering parts requiring frequent inspection. The two types of materials used are laminated glass and noninflammable transparent sheet usually mounted in a metal frame which is kept as inconspicuous as possible, particularly where it intercepts vision. Canopies as shown in figure 57 completely inclose the cockpit opening. They generally consist of several sections which are mounted to slide, using rollers and a track, thereby providing an entrance to and exit from the cockpit. For use in an emergency a panel of the canopy and in some instances the entire canopy is designed for quick release. Emergency releases are always prominently marked and are within easy reach of the pilot and crew, as shown in figure 58. Gunner canopies are often dome-shaped and mounted on a turntable or turret.

47. Doors.—All doors provided for entrance to and exit from the cockpits and cabins of airplanes hinge along the forward or the bottom edge of the closed door and are provided with latches. The latch handle on the outside of the door is comparatively small and is streamlined, while the latch handle on the inside of the door is generally large and conspicuous, often surmounted by a knob. On transport airplanes, the cabin door is arranged so that it can be disengaged completely from its attachment by a single movement of a release lever to facilitate rapid evacuation of passengers in an emergency.

48. Ventilators.—*a.* Ventilation of airplanes, whether separate from or in conjunction with the heating system, is usually provided by ventilating ports opening to the outside and equipped with controllable deflectors at the inner ends. Such ports are so located that they promote a circulation of fresh air throughout the entire cockpit or cabin which may be regulated and directed at discretion of the occupants.

b. Temperatures injurious to radio equipment, instruments, etc., will develop in closed cockpits of airplanes parked in the sun in hot weather. In order to prevent such excessive temperatures all airplanes so parked, other than those on which locking all means of ingress to the airplane is mandatory, should have the cockpit inclosures, doors, hatches, and windows kept open to allow circulation of air.

49. Seats.—*a.* Pilot seats used in military airplanes, as shown in figure 59, are made of sheet aluminum or aluminum alloy pressed to shape. Edges are rolled and sides cut low to provide freedom of arm movement of the occupant. The bottom of the seat is deeply dished to accommodate the seat-pack parachute carrier which serves as a seat cushion. The back of the seat is usually high and provided with clips for supporting a life preserver pad which serves as a back



① Closed.

② Open.

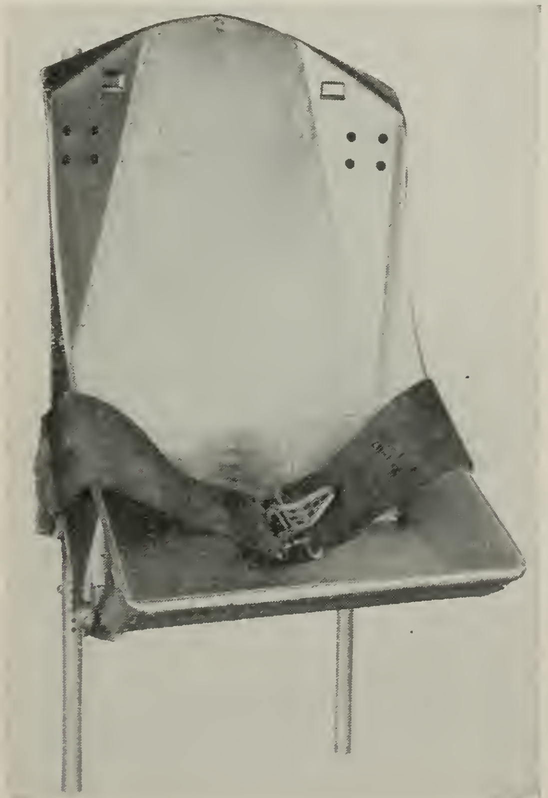
FIGURE 57.—Cockpit inclosure.

cushion. On most airplanes this seat is adjustable as to height. This is accomplished by mounting the seat between tubular uprights, one on either side of the cockpit, and using locking pins or pawls carried on journals attached to the seat to engage the uprights at selected points. The seat height is regulated by first operating the release lever mounted on the seat base to disengage the locking pins. The seat may then be pulled upward by the shock cord or forced downward by the occupant's weight. Usually a choice of six to eight positions is provided.

FIGURE 58.—Emergency exit release, cockpit inclosure.

b. Observer seats are identical with the pilot seat. Gunner seats, however, are usually mere pedestal stools, pivoted and mounted so as to afford the gunner full range of movement. Cabin seats are similar to the pilot seat, but as a rule are nonadjustable for height. Provisions are made in the means of attachment for quick removal of cabin seats for conversion of the cabin into an ambulance or cargo compartment.

c. All seats and chairs are equipped with safety belts as shown in figure 59. Normally a safety belt should be fastened properly about each occupant at all times during take-offs, flights, and landings. Before taking off the pilot should see that the safety belt is properly secured to the airplane and fastened about each occupant, and that each person taking part in the flight understands fully the method of releasing the belt. Where possible, each safety belt should be installed or fastened so that the movable hook or latch of the fastening device is on the left of the two connecting belt ends. In some installations, pilot belts of standard length cannot be shortened sufficiently by strap adjustment only to fit properly all individuals. In



① Front view.

FIGURE 59.—Pilot seat.

such cases the belt may be shortened further by overlapping and stitching the webbing in an approved manner.

50. Maintenance.—*a.* Seats should be inspected regularly for cracks and sharp projections which might catch or tear the parachute or clothing of the occupant. If a damaged seat cannot be repaired satisfactorily, it should be removed and replaced. The adjustment mechanism should be lubricated periodically and the shock cord renewed when it becomes deteriorated or weakened.

b. Windshields, canopies, and windows are all subject to scratches and clouding. Clouding of glass sections may be minimized by sealing the laminated edges with paint. These sections may be cleaned and polished with metal polish, care being taken not to rub hard particles of sand or grit into the surface. First rinse the surface

② Rear view.

FIGURE 59.—Pilot seat—Continued.

with water, then wipe lightly with a soft cloth. Kerosene or naphtha may be used to remove grease or oil. The padding provided about each individual section of glass or composition should be maintained to minimize cracking resulting from vibration and the frame must be kept attached firmly in place. A cracked unit should be replaced as soon as possible. Foreign matter must be kept out of the turret tracks and all sliding sections must be so maintained as to operate freely.

c. All safety belts are tested in the stretched-out position, as shown in figure 60, with a weight of 500 pounds, with the exception of some types of gunner safety belts which are tested with a weight of 250 pounds. When testing the weight must be raised gently from the floor to avoid impact loading, and lowered immediately to avoid placing unnecessary stresses on the belt. No attempt should be made to tear the stitching or webbing of safety belts by hand. Each belt found to be defective or deteriorated in any part or shows any evidence of weakening or failure during the test will be condemned. As each belt is tested, the date on which the work is accomplished is stenciled on the webbing of each section, using figures approximately ½ inch high. The first date recorded should be so arranged and located that the subsequent test can be recorded in chronological order. The date recorded will show the month, day, and year, for example, 1-1-38, 7-1-38, 1-1-39, etc.

Section XIII

COWLING AND FAIRING

Paragraph

51. General.—Cowling and fairing are the many relatively small sheet metal units of aluminum or aluminum alloy attached to the structure of an airplane or engine mount for various purposes, but which are not usually considered a part of the basic structure of the airplane.

52. Cowling.—*a.* Cowling consists of detachable sections used to cover certain portions of an airplane structure such as engine mounts, nacelles, landing gear, and other places to which a ready means of access is necessary. The individual sections are of a size and weight convenient for one man to handle. They do not fasten one to the other, but are independent units so far as their assembly and disassembly are concerned.

b. Since the engine section is required to be fireproofed and the engine readily accessible for maintenance, it is usually completely sheathed with detachable metal cowling. Engine compartment cowling is provided with air inlets and outlets to permit a circulation of air about the engine and accessories. This is to assist in cooling and to prevent accumulation of gases. Engine ring cowling, shown in figure 61, is the cowling that encircles a radial engine. It is of rel-

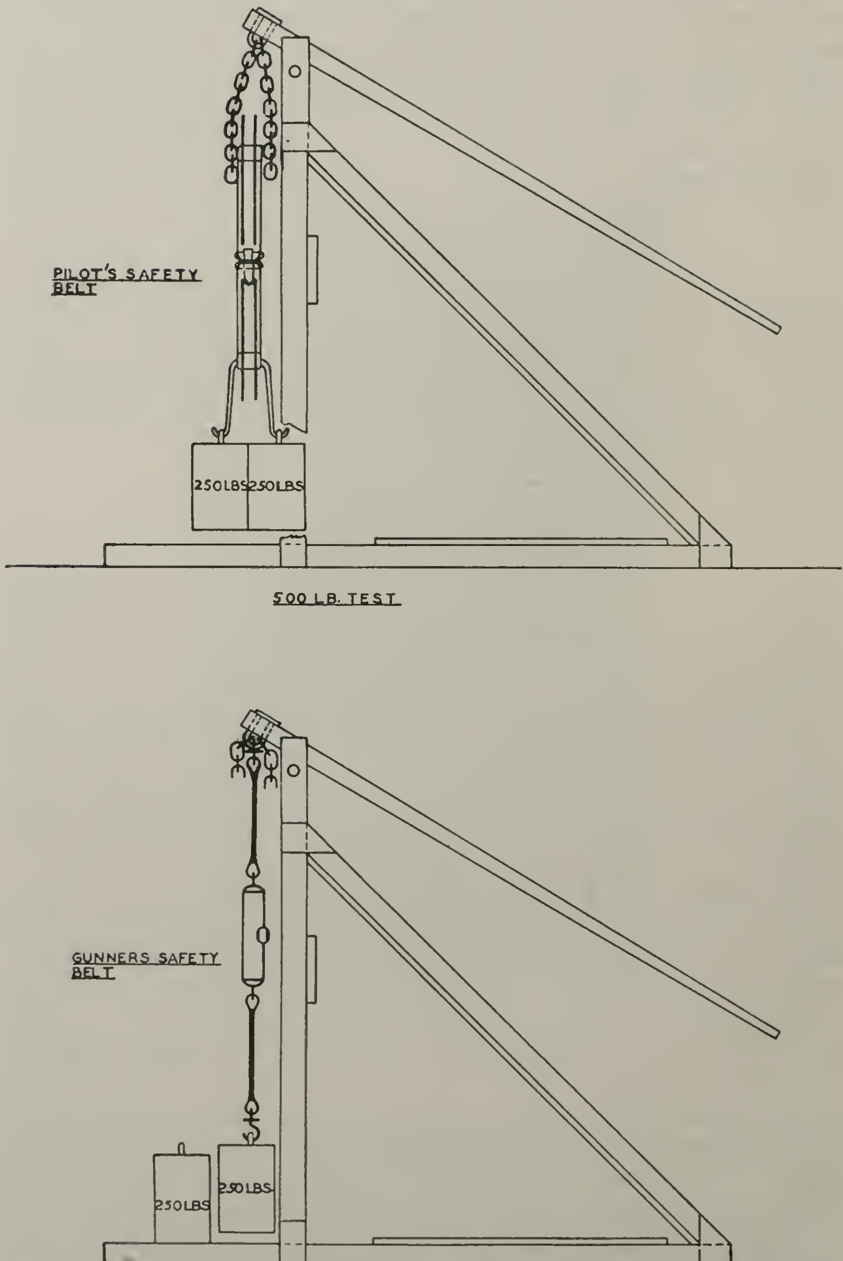
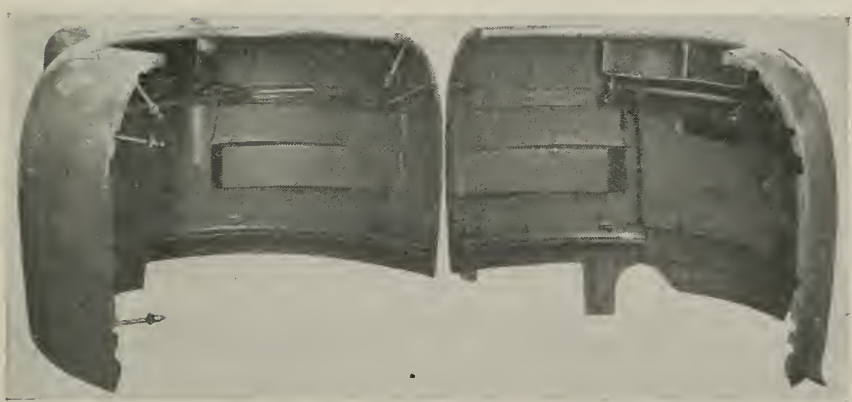


FIGURE 60.—Safety belt tester.

atively heavy sheet aluminum alloy and is usually supported by pads secured to the inside of the cowl which rest on the valve cover caps of the engine when the cowl is installed. It is made in two or more sections having turnbuckle type fasteners provided on the inside at the ends where the sections meet. It is important that these fasteners be tightened carefully to the correct extent with regard to the tempera-

① Closed.

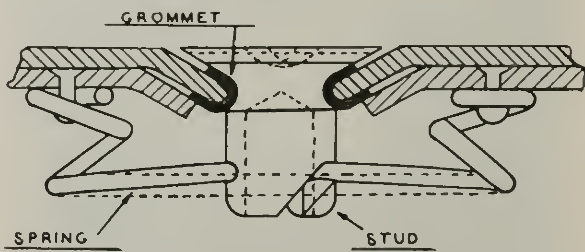


② Open.

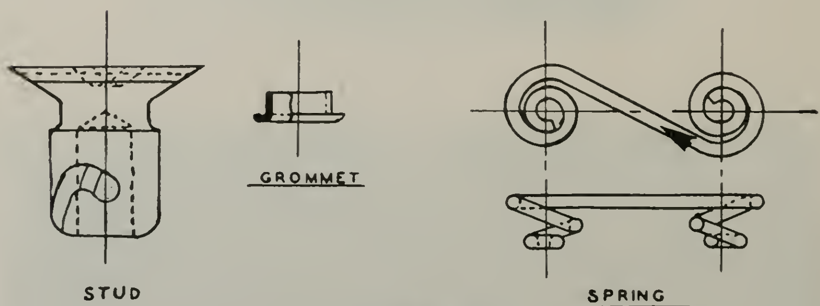
FIGURE 61.—Engine ring cowling.

ture of the engine. Excessive tightening of the turnbuckles when the engine is cold is likely to produce failure of the fasteners or the fastener brackets when the engine becomes heated and expands. If not tightened sufficiently when mounted on a hot engine, vibration of the cowling will result in possible serious injury to both engine and cowling. In either case the cowl should fit snugly but not too tight, and especially in the case of a cold engine turnbuckles should be tightened by hand only, and must always be safetied. Bottom cowling is shaped so that it is self-draining with the airplane in taxying position.

c. Cowling is attached to frames so spaced as to support the sections along their edges and at reinforced areas. Attachment is made by means of flush type (Dzus) fasteners which consist of a stud, grommet, and a stud anchor, shown in figure 62. The stud is a bullet-



① Assembled.



② Disassembled.

FIGURE 62.—Flush fastener (Dzus).

shaped body with a relatively large, flat head. In the body near the head is a shallow groove. The grommet is pressed around the cowling, expanding into the groove to give a positive anchorage of the stud to the cowling. The nose or protruding end of the stud body has a spiraling slot which makes a one-quarter turn. At the base of this slot is a recess into which the stud anchor locks. The stud anchor is a steel wire coiled at each end similar to the coil spring of a bed mattress, permitting a limited range of movement in and out. It is fitted on supports at the point of cowling attachment. The stud is pressed against the anchor matching the groove, and turned until the anchor locks in the recess at the end of the slot, thus holding the cowling snug against the cowling support.

53. Fairing.—Fairing is generally used to refine or streamline contour of the airplane, although it may be used to protect some minor piece of equipment and in some cases simply to improve appearance of the airplane. The units may be made in sections or stamped in one piece. Fairing pieces are sometimes attached the same as cowling, but are generally bolted or screwed into place and not removed except for inspections or repair.

54. Maintenance.—Care must be exercised in handling all cowling or fairing when off the airplane so that it is not bent or distorted. Many pieces, especially long strips or large sections, are not sufficiently rigid to support their shape unaided. On the other hand, the smaller parts, although formed so that they are rigid as a unit when installed, are constructed of light gage material and may be damaged easily. Cracks often open up and become evident after fairing is off the airplane. These should be patched or the fairing replaced before reassembly. The finish of cowling or fairing must be kept intact and, if marred during assembly, should be touched up as soon as practicable. All fasteners must be kept in working condition and replaced at the first sign of looseness or excessive wear. Where motion is necessary between pieces of installed cowling, chafing strips of fabric or fiber are used. These should be renewed whenever wear might permit metal parts to rub together.

Section XIV

SHIELDING AND BONDING

55. General.—In order that radio equipment can be operated efficiently in aircraft, ignition and other electrical equipment and related circuits must be shielded properly and the airplane bonded.

56. Shielding.—Shielding is the method of preventing radiation of electrostatic waves by surrounding electrical equipment and related wiring with grounded covers or shields of low-resistance electrical-conducting material.

57. Bonding.—*a.* Bonding is the term applied to interconnecting electrically isolated metal parts of the airplane by means of good electrical conductors, including connecting shielding to the airplane structure. The principal reasons for bonding airplanes are to—

(1) Increase electrical capacity between metal mass of the airplane and radio antenna.

(2) Prevent electrically isolated metal parts from absorbing and thus nullifying some of the energy radiated by radio transmitting set.

(3) Eliminate danger of sparks arcing between unconnected metal members.

(4) Eliminate electrical disturbances resulting from rubbing and vibrating contacts of metal parts.

(5) Lower resistance of shielding so as effectively to localize and ground electrical disturbances.

(6) Prevent reradiation of disturbances which results when large masses of metal are isolated from main mass of the airplane.

b. Bonding connections are attached to flexible braid only by soldering. Metal braid consisting of at least 120 strands of No. 36 (B & S

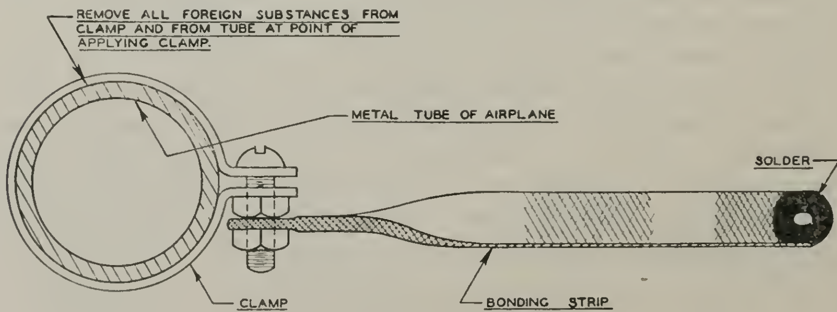


FIGURE 63.—Bonding strip connection.

gage) tinned copper wire is used for bonding strips. Electrical connections of bonds (fig. 63) may be soldered, bolted, or clamped.

c. The following instructions should be followed in making bonding connections:

(1) Surfaces of all metal parts serving as electrical conductors must be free from protective coating or other insulating materials at point of contact. Required protective coatings are applied at such points only after joining or connecting of parts has been completed.

(2) Care must always be exercised when applying solder to bonding to prevent possible burning of adjacent insulation. The soldering iron must be sufficiently hot that the solder melts and flows at touch of the iron. In no case is it permissible to use an open flame for soldering insulated parts, or for installation or repair work on aircraft.

(3) To minimize corrosion, resin flux is used whenever possible for soldering in place of soldering acids.

(4) Each end of the braid in which a hole must be made to form a terminal connection is tinned to prevent fraying of strands. Lock washers are never placed next to the bonding when the connection is bolted unless a plain washer is placed next to the bonding strip.

d. Parts requiring shielding and bonding may be determined from latest technical publications on this subject.

SECTION XV

TOWING, MOORING, AND HANDLING

58. General.—It is important that operating personnel have a thorough understanding of proper methods of towing, handling, and mooring airplanes. If these operations are not properly performed considerable damage may be done to structural units, cowling, fairing, etc., through creation of unusual stresses in these parts.

59. Towing and handling.—Most military airplanes are equipped with towing rings or similar devices for this purpose, and towlines always will be attached to these devices as shown in figure 64. However, when towing airplanes not equipped with towing rings, the towlines should be attached to the structural unit of the landing gear in such a manner that no damage will be done to any part of the airplane. Length of the towropes should be at least three and one-half times tread of the airplane. In the case of large airplanes equipped with dual wheels on each landing gear leg, a separate source of motive power may be necessary for each landing gear leg to avoid chafing of the wheels, or setting up side stresses on the landing gear structure. During the towing operation there should always be one man in the cockpit to operate the brakes, one or more men as required on the tail wheel steering handle, and a man at each wing tip when maneuvering near hangars, airplanes, or other obstacles. The airplane should never be moved by pushing or pulling on the control surfaces, stabilizers, trim tabs or flaps, but only by means of the reinforced portion of the airplane structure. For lifting the tail all airplanes are provided with reinforced lift points which are marked plainly. Under no circumstances will the tail of an airplane be lifted by means of the horizontal stabilizer.

60. Mooring.—*a*. Activities having hangars or concrete aprons employ a standard arrangement of permanent anchorage points suited to the types of airplanes being moored. Where no fixed mooring anchorage is provided the standard airplane mooring kit can be used. To use this mooring kit, the anchor rod is screwed into the arrow, and the driving rod slipped over the anchor rod and into the socket of the arrow, as shown in figure 65. The cam on the driving rod must be turned so that the prongs of the arrow will not be spread while driving. If the ground is hard, the hardened surface will first be broken by using a ground-breaking pin which is also a part of the kit. The rod is alined with the point of attachment on the airplane and the arrow is driven into the ground until the driving rod handle is within 3 inches of the ground. The handle is then rotated approxi-

FIGURE 64.—Towing rings and line attachment.

mately 90° and the driving rod is given a sharp blow to spread the prongs of the arrow. The handle is then returned to the driving position and the driving rod assembly is withdrawn from the ground.

b. Arrangement of mooring points for several weight ranges of airplanes is shown in figure 66. Care must be taken to drive the mooring anchor arrows at the proper angle so that the anchor rods will be in line with the points on the airplane to which the mooring ropes are attached. After the driving operation has been completed, the eye assembly is attached to the anchor rod and the mooring rope to the eye assembly. An upward pull on the anchor will further spread and set the arrow prongs. With wheel chocks in place in front and back of each wheel the mooring ropes are then secured to the mooring points on the airplane by drawing them sufficiently taut to prevent movement of the airplane. Care should be exercised to avoid strain on structural parts of the airplane, and it should be borne in mind that rain or moisture may excessively tighten the ropes. Rudder and ailerons are then locked in neutral position and the ele-

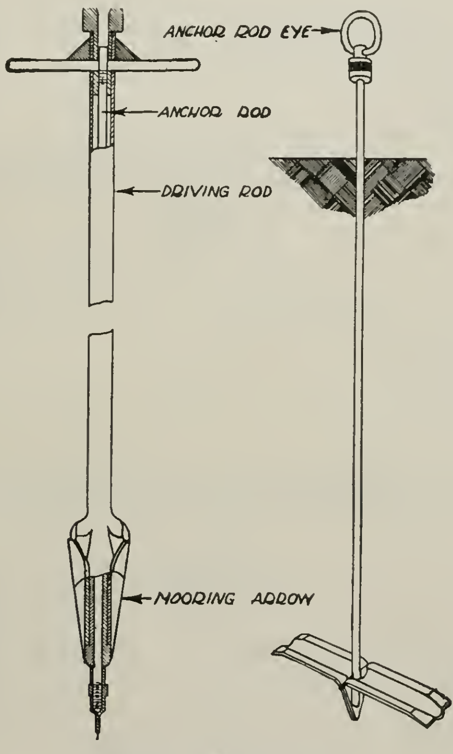


FIGURE 65.—Mooring anchor.

vators placed parallel to the ground or as near that position as possible and locked. External control surface locks are used if available, otherwise the controls in the cockpit are used for this purpose. If the airplane is equipped with an automatic pilot, it should be turned to the "On" position as outlined in the instructions pertaining to that equipment.

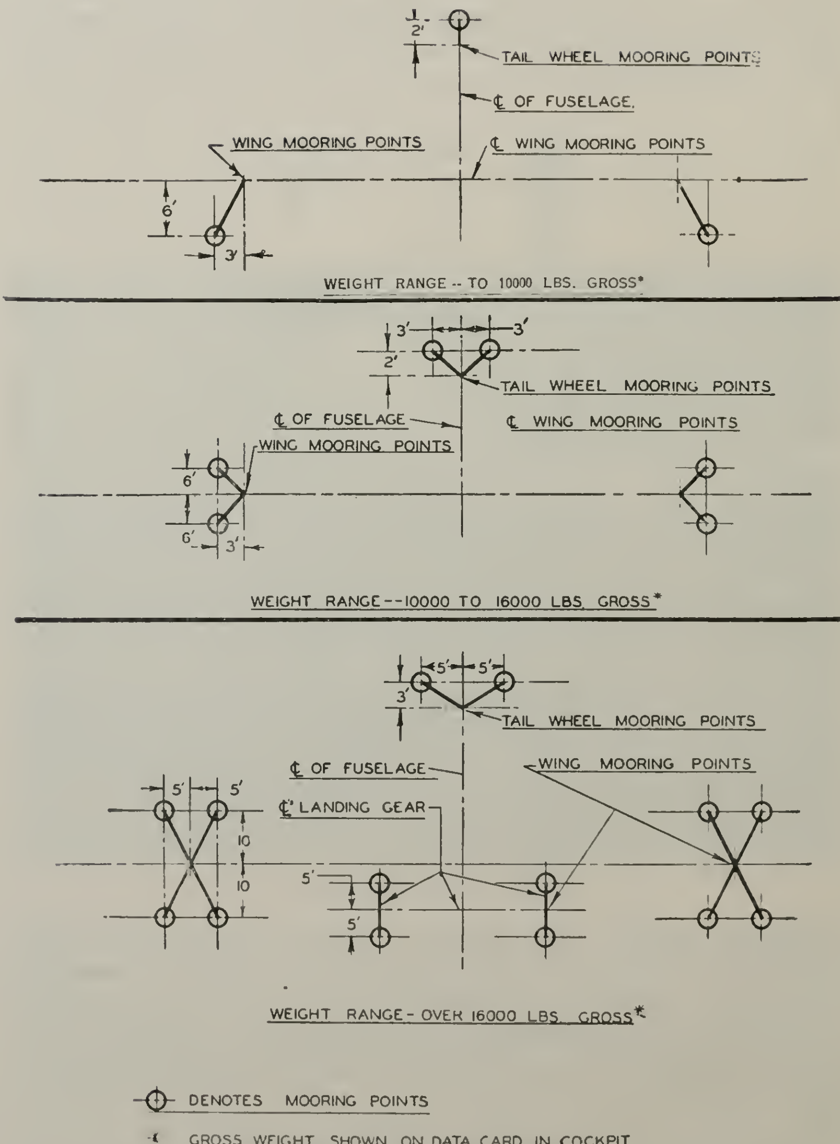


FIGURE 66.—Mooring point arrangement.

Section XVI

HYDRAULIC JACKS

61. General.—It is not feasible to outline herein detailed jacking instructions for all types of airplanes and for all conditions under which airplanes must be raised. This information can be secured from the basic handbook of instructions for each particular airplane. However, some general information on this subject is included with illustrations showing approved methods and equipment.

62. Assemblies.—*a.* A standard jack assembly used by the Air Corps is shown in figure 67. This unit is of the tripod base type, designed to use a hydraulic jack as a lifting medium and is available with rated capacities of 10,000 and 20,000 pounds. These jacks should be located under the airplane as shown in figure 68. When using these jacks, instructions given on the instruction plate should be observed. During jacking process, the locking pin should always be kept in the lowest possible hole in the sliding shaft and the lock on the height adjustment locking ring must be fully engaged, except when supporting structure for the hydraulic jacking unit is being raised or lowered.

b. The jack assembly shown in figure 69 is intended for use as a tail jack for large airplanes and as a jack for the main landing gear of small pursuit type airplanes. This jack has a double telescoping ram which gives it a very high lift in spite of its low unextended height.

63. Use.—*a.* In procedure of raising airplanes by use of jacks it must be ascertained that the jacks to be used are of sufficient capacity to support the airplane. Care must be taken that the jacks rest on a level area so that their motion will be vertical. When raising small airplanes the jacks may be placed directly on the floor or ground, and in the case of large airplanes the jacks should be placed on suitable timbers or bases so that a minimum of extension is required and as great a length of the ram remains in the cylinder as possible. All jacks must be operated simultaneously so as to maintain equal loads on them. No attempt should be made to lock the hydraulic ram in position by using clamps. If a jack should leak, it is better to allow the ram to come down slowly than to risk the possibility of its dropping suddenly when releasing a clamp. In the event it becomes necessary to leave an airplane unattended for any length of time while supported on hydraulic jacks, care should be taken to see that equipment, ladders, etc., are not located in such a position as to permit the airplane to come in contact with them in the event of leakage of the jack cylinders.

b. When airplanes in hangars are being supported by jacks, use of auxiliary cribbing or supports may be dispensed with as standard

FIGURE 67.—Tripod jack assembly.

Air Corps jacks are designed to withstand all vertical loads with large margins of safety. When the tail wheel is to remain in contact with the floor, yaw may be prevented by locking the tail wheel assembly, by securing the tail wheel with a steering fork. or by arranging

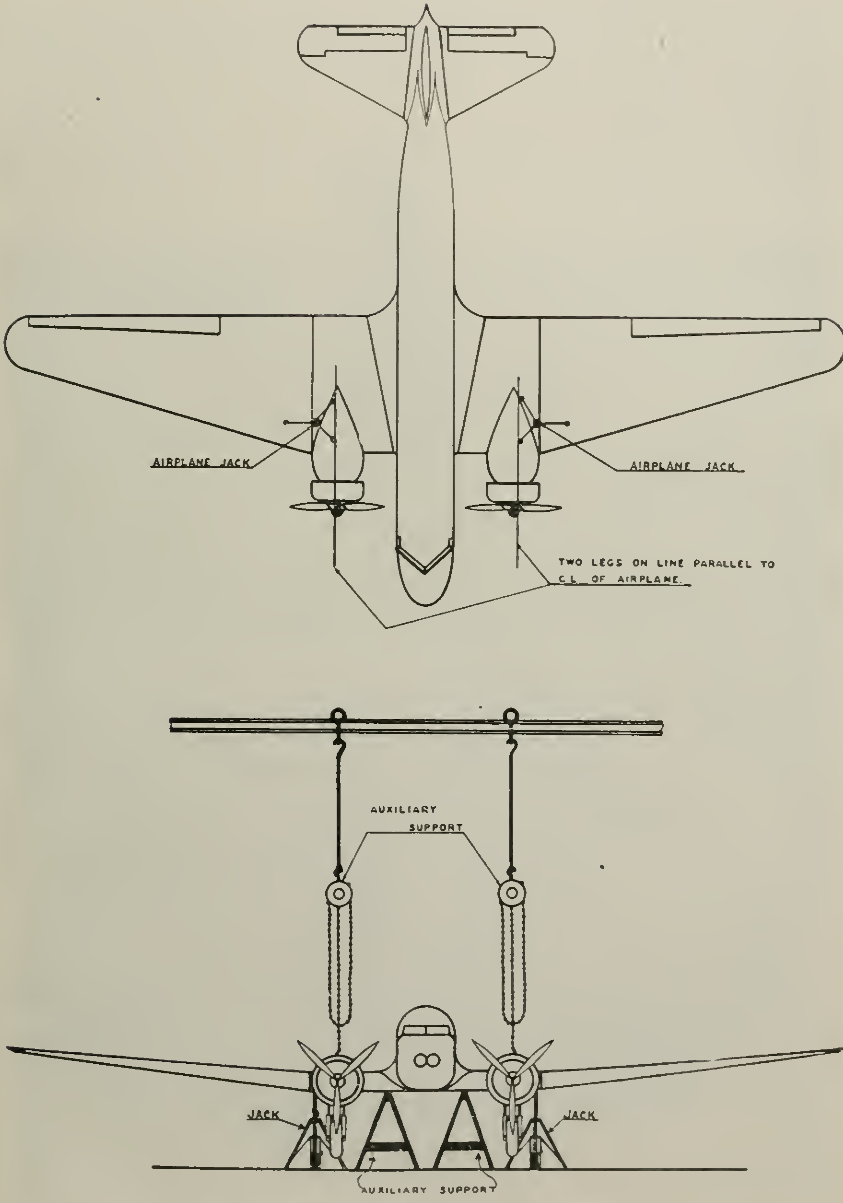


FIGURE 68.—Positions of tripod jack assembly.

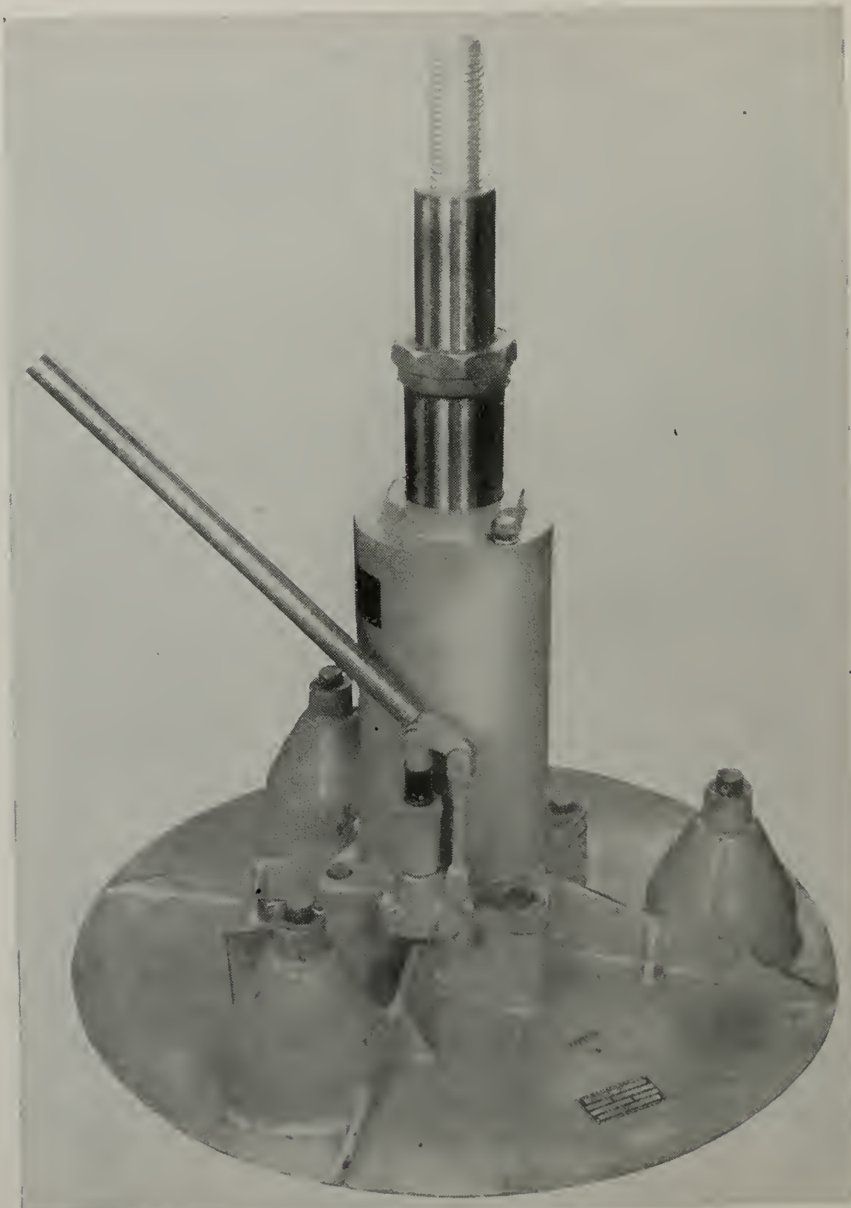


FIGURE 69.—Tail and wing jack assembly.

a rope sling around the fuselage and from this sling extending ropes from each side of the fuselage to convenient anchor points on or near the ground. However, the tail wheel must be free to roll fore and aft during raising and lowering the airplane.

c. When raising airplanes in the open they are first headed down wind and in no case raised when exposed to winds in excess of 15 miles per hour. If airplane jacking points are close together, yawing moments due to wind may cause jacks to flex and cramp alarmingly and due to the large area of vertical tail surfaces of bombardment type

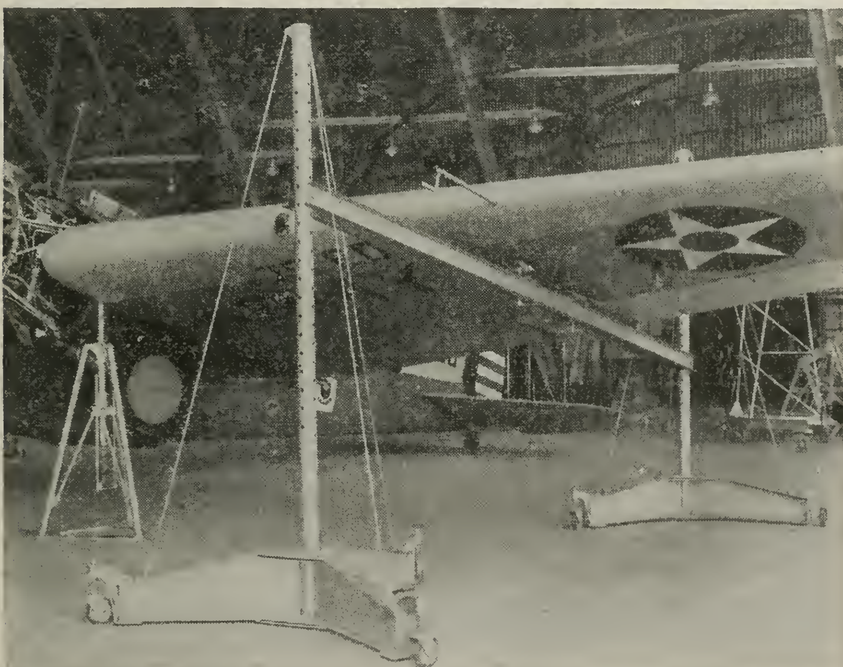


FIGURE 70.—Wing jack and auxiliary support.

airplanes, a small side wind may cause a rather severe side load on tail jacks. It is important therefore to shelter the airplane if any perceptible wind prevails. Personnel working on or under airplanes supported by jacks in the open are to be protected from injury in case of failure of the jacking equipment by one of the following means:

(1) Heavy timber cribbing, top members of which are felt-padded and snugly fitted under the wing spars extending along 3 or 4 feet of the spar.

(2) Large felt-padded timbers that fit the chordwise contour of the wing, extending several inches to the front and rear of the spars, and supported with wooden horses or stands of suitable strength.

(3) Suitable strong benches upon which sandbags have been placed to bear against the wing spars.

(4) Adjustable height steel stands bearing against such units of the primary airplane structure that are capable of supporting the airplane weight, as shown in figure 70. The center of gravity of the airplane must be aft of the point of contact of supporting stands.

(5) In no case are the timber cribbing, benches, stands, etc., specified above placed outboard of the fuselage a distance greater than one-third the semispan or beyond the minimum distance necessary to provide clearance for retracting the landing gear. Overhead hoisting equipment may be used as an auxiliary safety support where authorized by local engineering officers. Capacity of the equipment and its suspension must be checked carefully and specific authority given for its use on each particular type of airplane.

SECTION XVII

CLEANING

64. General.—*a.* The necessity for keeping airplanes clean at all times both inside and out cannot be overemphasized. During cleaning operations those so engaged should watch carefully for and report all evidence of faulty maintenance, or apparent need for inspection adjustment, or repair of any part or parts.

b. Cleaners are divided into two groups, aqueous and volatile. Due to the lower cost and noninflammability of aqueous cleaners, those listed in paragraph 65 below are used wherever practicable. Volatile cleaning fluids are used only where aqueous cleaners are found unsuitable.

65. Aqueous cleaners.—*a.* The noninflammable water solution cleaners listed below are available for use as indicated.

(1) A soft soap solution is used wherever practical for routine cleaning of painted and unpainted airplane surfaces, fuselages, etc. A suggested method of preparing the soap solution is to place 50 pounds of the soft soap in a steel drum or other suitable container and add 20 gallons of water. The soap is allowed to dissolve for 24 hours and is then mixed thoroughly. The soap solution for cleaning pur-

poses is prepared by adding 1 pint of this concentrated soap solution to 5 gallons of water. The solution may be applied with brushes, sponges, rags, or mops after which the parts being cleaned are thoroughly rinsed with clear water.

(2) Where grease spots, exhaust stains, etc., are difficult to remove with the soap solution, use of a liquid cleaner and polisher, scouring powder or dope thinner is recommended. Dope thinner is used for this purpose only on unfinished metal surfaces.

(3) The liquid cleaner and polisher is a cleaning compound consisting of a mild abrasive in a naptha water emulsion. It is intended for removal of light scratches and polishing transparent sheet, cleaning and polishing unpainted aluminum alloy surfaces of airplanes, and other purposes where a mild abrasive is required for cleaning. Most satisfactory results are usually obtained with this material by applying a small quantity of the liquid to the surface to be cleaned and then working it over a small area, using a brush or rag with a light rubbing or scrubbing action so that a thin even coating is obtained. The wet coating of cleaner and polisher is allowed to dry and the resulting white powder brushed or wiped off.

b. Liquid automobile polish or wax may be used for polishing doped or painted surfaces if desired.

66. Volatile cleaning fluids.—*a.* The following volatile materials are available for cleaning parts and surfaces of airplanes and equipment:

(1) Gasoline, unleaded. Under no circumstances will leaded (ethyl) gasoline be used for cleaning.

(2) Alcohol, denatured.

(3) Kerosene.

(4) Carbon tetrachloride-naphtha mixture.

b. Gasoline and alcohol are highly inflammable and it is necessary that the utmost precautions be exercised in their use. Kerosene burns rapidly if ignited but is moderately noninflammable. Carbon tetrachloride-naphtha mixture is also moderately noninflammable and is used only where a serious fire hazard might result from use of one of above cleaners. This mixture consists of equal parts by volume of naphtha, and carbon tetrachloride. The solvents should be mixed as required in quantities sufficient to meet daily requirements only.

c. In order to fix responsibility cleaning with inflammable cleaning fluids is done under the personal supervision of a commissioned officer, a crew chief, or a qualified civilian employee. The individual supervising such cleaning is held responsible for compliance with all instructions on cleaning. The following safety measures are absolutely necessary in use of inflammable cleaners:

(1) Adequate fire-fighting equipment will be readily available while cleaning.

(2) Inflammable solvents will be stored in small safety type containers, and kept covered when not in use. All safety type containers will be painted red and have the name of the contents marked on the outside.

(3) All sources of fire hazards such as smoking, open flames, or operations of any electrical equipment that may give off sparks is prohibited in vicinity of cleaning. Warning signs to this effect will be conspicuously posted during such cleaning.

d. While all the volatile cleaners listed above are more or less toxic, carbon tetrachloride and carbon tetrachloride-naphtha mixtures are dangerously so and the following precautions must be observed when they are used:

(1) Avoid breathing vapors. Carbon tetrachloride solutions should not be applied to heated parts, as carbon tetrachloride when heated gives off phosgene gas which is very poisonous.

(2) Keep containers tightly covered when not in use to prevent evaporation and reduce concentration of vapor.

(3) Do not place bare hands in solution.

67. Methods.—*a.* Use of suitable spray gun provides a very efficient cleaning method, especially for large parts; however, due to the extreme fire hazard resulting from high vapor concentrations produced by spraying inflammable liquids, when this method is used every possible precaution against fire must be observed. Gasoline or kerosene may be used for spray cleaning in the open air provided the equipment to be cleaned is located at a safe distance from buildings or any source of fire hazard. The equipment being cleaned must be thoroughly grounded to eliminate collection of static charges. Personnel performing the work should always stay on the windward side of the work to avoid breathing fumes. Carbon tetrachloride and carbon tetrachloride-naphtha mixtures will not be used for open air spray cleaning. The volatile fluids will not be used for indoor spraying except where special approved equipment and conditions have been provided.

b. Where portable steam pressure cleaning machines are available, routine cleaning of engines installed in aircraft and aircraft surfaces may be accomplished insofar as possible with this equipment. Care will be exercised that electrical equipment such as magnetos, generators, starters, etc., are adequately protected against moisture during cleaning procedure. This work will be accomplished by experienced personnel only.

c. The following instructions apply to airplanes operating in salt water. The treatment prescribed is applied as soon as practicable after removal of aircraft from water at close of each day's flying during which salt water take-offs and landings have been made.

(1) All traces of salt water are removed by thoroughly rinsing exterior of airplane with fresh water.

(2) A light coat of rust-preventive compound is applied to all exposed fittings on which corrosion is likely to occur such as exposed portions of landing gear, retracting pistons, control surface hinges, control cables, exposed rivets and bolts, and similar parts not protected from corrosion.

(3) Draining and flushing interior of hull compartments is accomplished at the time intervals and in the manner prescribed in the airplane handbook of instructions.

SECTION XVIII

LUBRICANTS

68. General.—*a.* These instructions generally cover classes and uses of aircraft lubricants (other than for engines), and are furnished for use as reference and information only in cases that are not covered in the handbook of instructions pertaining to particular items of equipment.

b. Grease and oil containers when left open collect grit, lint, etc., which renders the lubricant unsatisfactory for use. In certain cases the rapid wearing of parts has been traced to dirty grease. To avoid this contamination all grease and oil containers are to be kept tightly closed except when actually being used, and they should never be opened for use when sand or grit are likely to be blown into them.

69. Classification.—Lubricants stocked by the Air Corps are classified according to their specified use as—

a. Greases.—(1) *Low temperature aircraft.*—For plain or anti-friction (ball or roller) bearings operating at moderate temperatures and moderate loads.

(2) *Graphite cup.*—For plain bearings operating under heavy loads and for screws and gears when a graphited grease is specified by the manufacturer.

(3) *High melting point.*—For plain and antifriction bearings operating at high temperatures.

(4) *Aluminum soap.*—For antifriction bearings operating under moderately heavy loads.

(5) *Lead soap base.*—For plain and antifriction bearings operating under very heavy loads.

(6) *Compound, antiseize, white lead base.*—Used as a general thread lubricant.

b. Oils.—(1) *Noncompounded.*—For all antifriction bearings designed to retain a fluid lubricant, lightly loaded gear and screw mechanism of aircraft control systems, and lubrication of exposed parts which must operate at low temperatures. Those used for aircraft lubrication are as follows:

(*a*) Aircraft engine oil, grade 98 (SAE 50).

(*b*) Lubricating oil, class D, grade 20 (SAE 20).

(*c*) Aircraft instrument oil.

(2) *Compounded.*—For heavily loaded gears such as landing gear, retracting mechanism, propeller drives, and control column gears.

(*a*) Retracting mechanism gear lubricant (heavy SAE 110), equal in engine oil viscosity to SAE 70.

(*b*) Oil lubricating E. P. gear, low temperature (light SAE 80) equal in engine oil viscosity to SAE 20.

(*c*) Petrolatum.

70. Selection of grades.—In consideration of grades of lubricants summer refers to periods in which normal minimum daily temperature is above −7° C. (20° F.); winter refers to periods in which normal minimum daily temperatures range from −1° C. (30° F.) to −29° C. (−20° F.); extreme cold refers to periods during which temperatures below −29° C. (−20° F.) are likely to be encountered. Too stiff or too heavy lubricants should be avoided more than too thin or too light lubricants. Change of grade of lubricants should be made at a regular 40-hour inspection period whenever normal seasonal changes of temperature occur.

a. Summer.—(1) Medium grade of the various greases should be used except for small, well-housed antifriction bearings, for which the soft grades are satisfactory for both summer and winter.

(2) For heavily loaded gears use gear lubricant or thread lubricant, the latter only if a fluid lubricant is not retained and frequent lubrication is not convenient.

(3) Nonstructural parts such as steps, seats, and loosely fitted hinged joints will be lubricated with aluminum soap grease or graphite grease, medium.

(4) Engine oil or petrolatum will be used for oil-lubricated parts, the petrolatum when rust prevention is also desired.

(5) Hard grades of the various greases may be used for parts having limited movement or where the grease is not retained well.

b. Winter.—(1) Soft grades of the various greases are used for all structural bearings. Low temperature grease is used when available, except when high melting point grease is indicated in specific instructions. Equal parts of a medium grade grease and aircraft instrument oil thoroughly mixed at room temperature will provide a useful substitute for the soft grades, having less stiffness at low temperatures but greater leakage if the temperature rises.

(2) Gear lubricant is satisfactory for all gear lubrication at low temperatures.

(3) For oil lubrication, lubricating oil, class D, is used.

c. Extreme cold.—(1) No lubricant resistant to flow at ordinary summer temperatures will permit easy operation below −29° C. (−20° F.). For this reason all hand and electrically operated mechanisms having lightly loaded bearings, gears, and screws are lubricated with aircraft instrument oil. Those heavily loaded are lubricated with oil, lubricating, E. P. low temperature.

(2) Most ball bearings on aircraft control surfaces and pulleys on the control system are tightly inclosed or sealed except for a narrow clearance around the inner race which is filled with a soft grease. This is not changed except for extreme cold operation when the grease should be washed out with aircraft instrument oil. The aircraft instrument oil remaining in the bearing will be sufficient and satisfactory lubricant for extreme cold condition.

(3) In all cases where thinned greases or oil have been substituted for standard greases or oil for low temperature operations, the substituted lubricant is replaced with standard lubricants as soon as the temperature above those classified as extreme cold prevail.

71. Thread lubrication.—*a.* The material specified in paragraph 69*a* (6) for use on threaded parts is a lubricant which has the necessary antiseize properties to permit assembling parts to a tight fit with a minimum of torque and with a maximum freedom from seizure. Seizures in general are due to frictional flowing or yielding of the metal on contacting threaded surfaces and are particularly likely to occur whenever unlubricated threaded parts are screwed together without proper thread clearance, or when tightened or adjusted while stressed as in the case of tie rods under tension.

b. The lubricating compound should be stirred well before being applied. Care should be exercised not to apply it in excessive quantities and application should be made on the male fitting only. It is recommended for use on the following assemblies:

(1) Where aluminum or aluminum alloy pipe threads are used. In this case the male thread should be of dissimilar material as no satisfactory thread lubricant is known which will prevent thread seizure in pipe threads where both the male and female parts are aluminum or aluminum alloy. In special cases where both male and female parts are of these materials, it is not intended that they be disassembled during life of the unit.

(2) On steel threaded parts (plated or unplated) having a considerable stress imposed upon the threads, or which are subject to frequent adjustment.

(3) For assembling threaded fittings of the various piping systems except those used on vacuum pump lines.

(4) In assembling aircraft instruments and as a general purpose thread lubricant, except where a nut embodying a self-locking feature is installed.

c. Proper selection of mating threaded connections, use of the proper lubricant as specified, and proper assembly of parts will result in satisfactory service operation. No sealing compounds (resinous materials to prevent leaks in improperly fabricated or assembled joints) have been specified. Such materials are considered unnecessary and undesirable due to the possibility of plugging the lines.

SECTION XIX

INSIGNIA AND MARKINGS

72. General.—The insignia on service aircraft indicates the nation, branch of service and organization to which the aircraft belongs. Identification markings show by letters and numbers not only the branch of service and organization to which the airplane is attached, but also its type designation, the names of its assigned personnel, and other pertinent information concerning that particular airplane. The identification colors for the various systems of piping used in the service airplanes are also included in this section.

73. Insignia.—*a.* The design of wing insignia is a red circle inside a white five-pointed star inside a blue circumscribed circle. The red circle is in the center of the star; that portion of the star not covered by the red circle is white; and that portion of the circumscribed circle not covered by either the red circle or the white star is blue.

b. Rudder insignia consists of one blue stripe parallel to the rudder post and thirteen alternate red and white stripes parallel to the longitudinal axis of the airplane.

c. Organization insignia are those designs, etc., that have been approved by the War Department for use by an individual organization. Each aircraft assigned to a permanent organization, including schools, bears the insignia of that organization.

74. Markings.—*a.* The marking U. S. ARMY is painted on the lower surface of the lower wing in the case of biplanes, and on the lower surface of wings of monoplanes. The letters U. S. are painted on the right wing and the word ARMY is painted on the left wing, with the top of the letter toward the leading edge of the wing.

b. The following markings are stenciled on left side of fuselage forward of front cockpit, except that where cockpit is in nose of fuselage, markings are placed to rear of cockpit.

U. S. ARMY—(Model designation).
AIR CORPS SERIAL NO.-------------
CREW WEIGHT--------------------

Each airplane has name of home station placed immediately above foregoing technical data legend.

c. As the means of identifying the organization to which airplanes are assigned, suitable depth of front portion of engine nacelle is painted in the color combination assigned to that organization. Command airplanes are identified by painted stripes encircling fuselage immediately back of rear cockpit. These stripes are same color as organization identification color.

d. Each airplane has a distinctive designator assigned consisting of a combination of letters and numbers. The system of assigning designators uses first the wing, group, squadron, or other unit identifying number. This number is followed by a letter or letters designating type of equipment as B for bombardment, P for pursuit, etc., or if not applicable, assignment of airplane as W for wing, AB for air base, etc., followed by a number to designate particular airplane. For example, 5AB1 designates 5th Air Base Squadron, airplane No. 1. Airplane designators are painted on in a centrally located position in the following locations:

(1) On each side of vertical stabilizer, lettering appearing in two lines with individual airplane number on top line and unit or organization designator on bottom line.

(2) On upper and lower sides of left wing only (in the case of a biplane upper side of left upper and lower side of left lower wing).

Lettering will appear all on one line, with top of letters toward leading edge.

(3) In addition to above, airplane identification number is painted on engine cowling, or on forward portion of fuselage.

e. Names of permanently assigned members of the combat crew are posted on the inside of the door. In the case of open cockpit airplanes they are stenciled or painted on forward portion of left side of fuselage.

f. Code markings are the means by which number, identity, and age of protective coatings of airfoils, fuselage, etc., and other pertinent data relating to the airplane are determined. They consist of letters and numbers designating contractor or repair depot manufacturing or repairing the part; kind and number of under and finishing coats applied; date coatings were applied; and date of manufacture of frame structure. For example, AA-39-9YSPD6-10-1-39-Mfg.-8-15-39 means that a contractor whose code letters are AA applied six coats of semipigmented yellow nitrate dope on October 1, 1939, to surface of a fabric-covered frame which was manufactured August 15, 1939. The dope used was furnished in fiscal year 1939 by paint manufacturer whose code number is 9. Such code markings will not be altered, relocated, or effaced except as required by repairs or refinishing operations, in which case markings will be replaced properly.

g. Identification colors for the various pipe line systems are—

(1) *Fuel.*—Band of red paint near each union and on each side of every flexible connection.

(2) *Oil.*—Band of yellow paint near each end.

(3) *Cooling.*—(*a*) All piping used in the cooling system near each union and on each side of every flexible connection is marked—

1. Water.—Band of white paint.

2. Prestone.—Band of white paint on each side of a band of black paint.

(*b*) If the engine is cooled with any liquid except water, the cowling or structure near the filler unit is marked with letters not less than 1 inch in height designating cooling liquid required.

(4) *Fire extinguisher.*—All lines are marked with band of brown paint near each end.

(5) *Flotation equipment.*—Band of light blue paint near each union.

(6) *Oxygen.*—Band of light green paint near each union.

(7) *Air speed.*—(*a*) *Pitot pressure.*—Band of black paint on each side of all union connections.

(*b*) *Static pressure.*—Alternate bands of black and light green on each side of all union connections.

(8) *Manifold pressure.*—Alternate bands of white and light blue near each union.

(9) *Vacuum.*—Alternate bands of white and light green near each union.

(10) *Hydraulic pressure oil.*—Bands of light blue painted on each side of a band of yellow near each union.

(11) *Compressed air.*—Alternate bands of light blue and light green when pressures carried are less than 25 pounds. When over 25 pounds, alternate bands of yellow and light green near unions.

(12) *Steam.*—Alternate bands of light blue and black near unions.

(13) *Purging.*—Alternate bands of light blue and yellow near unions.

(14) *Exhaust analyzer.*—Alternate bands of light blue and brown on each side of union connections.

(15) *Anti-icing fluid.*—Alternate bands of white and red on each side of union connections.

(16) *Vent (closed compartments).*—Alternate bands of red and black near each union.

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[A. G. 062.11 (2-17-41).]

BY ORDER OF THE SECRETARY OF WAR:

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