CHAPTER 9
LANDING GEAR SYSTEMS

GENERAL

The landing gear of a fixed-wing aircraft consists of main and auxiliary units, either of which may or may not be retractable. The main landing gear forms the principal support of the aircraft on land or water and may include any combination of wheels, floats, skis, shock-absorbing equipment, brakes, retracting mechanism with controls and warning devices, cowling, fairing, and structural members necessary to attach any of the foregoing to the primary structure. The auxiliary landing gear consists of tail or nose wheel installations, outboard pontoons, skids, etc., with necessary cowling and reinforcement.

Landing Gear Arrangement

Many aircraft are equipped with a tricycle gear arrangement. This is almost universally true of large aircraft, the few exceptions being older model aircraft. Component parts of a tricycle gear arrangement are the nose gear and the main gear. Nose gear equipped aircraft are protected at the fuselage tail section with a tail skid or bumper. The nose gear arrangement has at least three advantages:

(1) It allows more forceful application of the brakes for higher landing speeds without nosing over.

(2) It permits better visibility for the pilot during landing and taxiing.

(3) It tends to prevent aircraft ground-looping by moving the aircraft c.g. forward of the main wheels. Forces acting on the c.g. tend to keep the aircraft moving forward on a straight line rather than ground-looping.

The number and location of wheels on the main gear vary. Some main gears have two wheels as shown in figure 9–1. Multiple wheels spread the aircraft's weight over a larger area in addition to providing a safety margin if one tire should fail.

Heavier aircraft may use four or more wheels. When more than two wheels are attached to one strut. the attaching mechanism is referred to as a "bogie," as shown in figure 9–2. The number of wheels that are included in the bogie is determined by the gross design weight of the aircraft and the surfaces on which the loaded aircraft may be required to land.

The tricycle arrangement of the landing gear is made up of many assemblies and parts. These consist of air/oil shock struts, main gear alignment units, support units, retraction and safety devices, auxiliary gear protective devices, nose wheel steering system, aircraft wheels, tires, tubes, and aircraft brake systems. The airframe mechanic should know all about each of these assemblies, their inspection procedures, and their relationships to the total operation of the landing gear.

Shock Struts

Shock struts are self-contained hydraulic units that support an aircraft on the ground and protect the aircraft structure by absorbing and dissipating

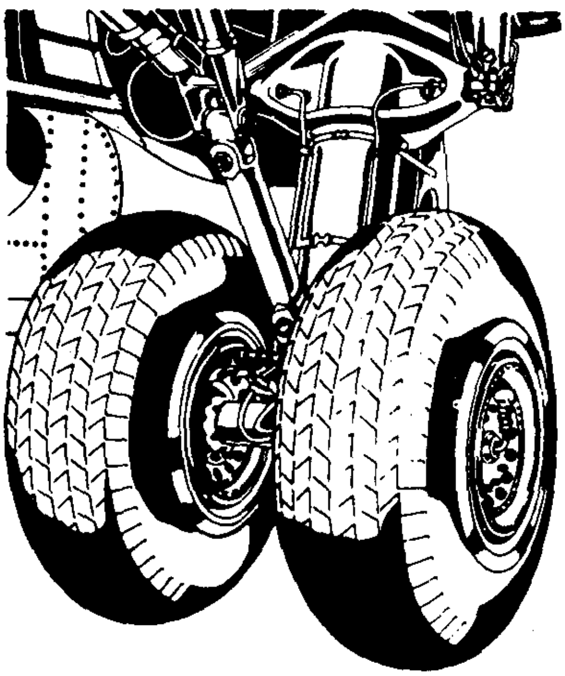


FIGURE 9–1. Dual main landing gear wheel arrangement.

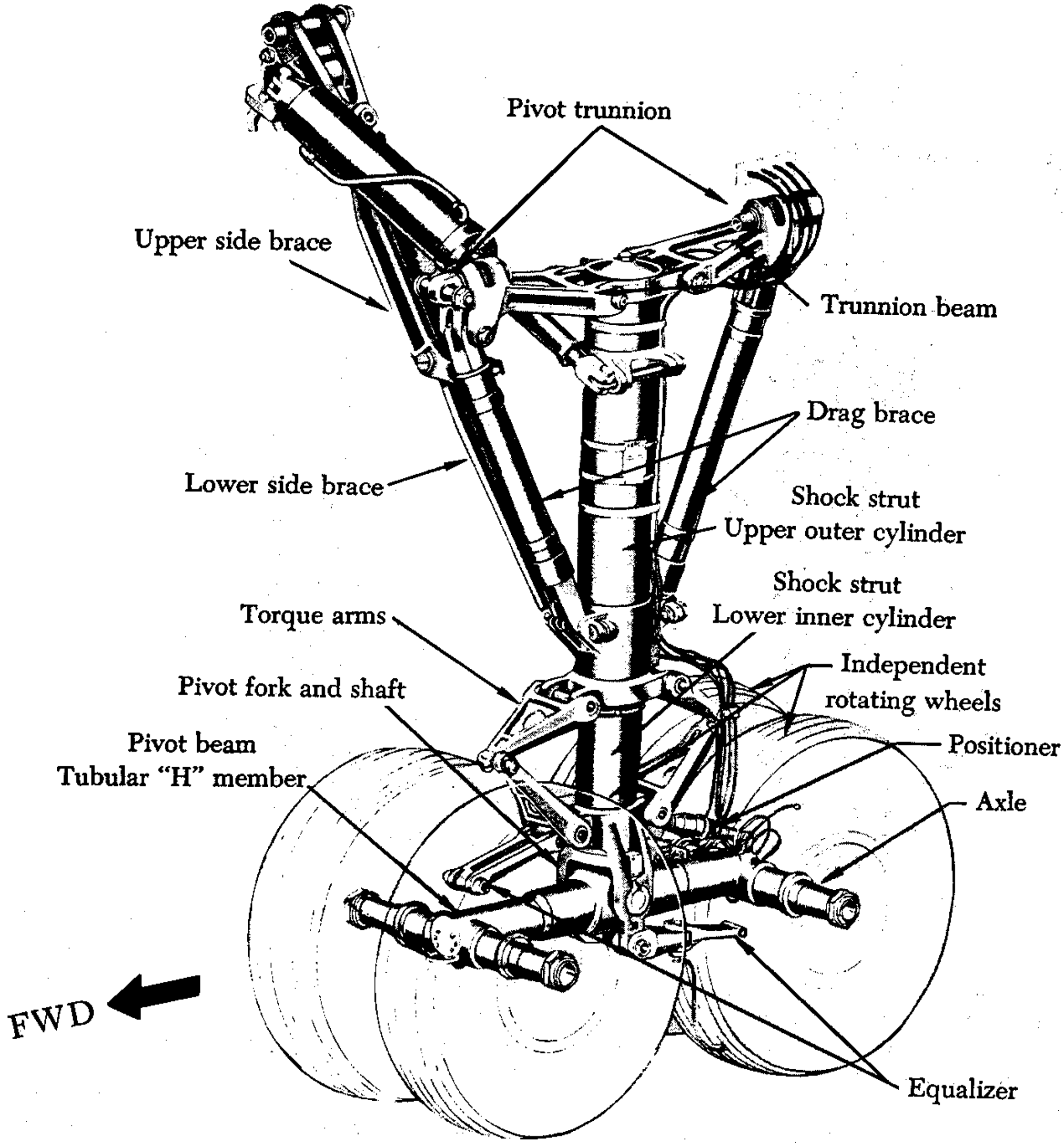


FIGURE 9–2. "Bogie" truck main landing gear assembly.

the tremendous shock loads of landing. Shock struts must be inspected and serviced regularly to function efficiently.

Since there are many different designs of shock struts, only information of a general nature is included in this section. For specific information about a particular installation, consult the applicable manufacturer's instructions.

A typical pneumatic/hydraulic shock strut (figure 9–3) uses compressed air combined with hydraulic fluid to absorb and dissipate shock loads, and is often referred to as the air/oil or oleo strut.

A shock strut is made up essentially of two telescoping cylinders or tubes, with externally closed ends (figure 9–3). The two cylinders, known as cylinder and piston, when assembled, form an upper and lower chamber for movement of the fluid. The lower chamber is always filled with fluid, while the

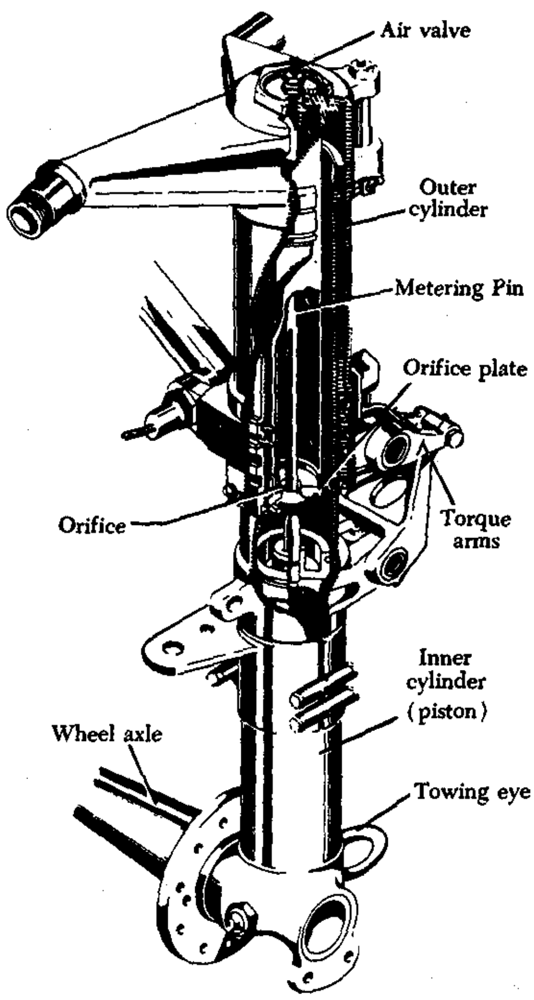


FIGURE 9–3. Landing gear shock strut of the metering pin type.

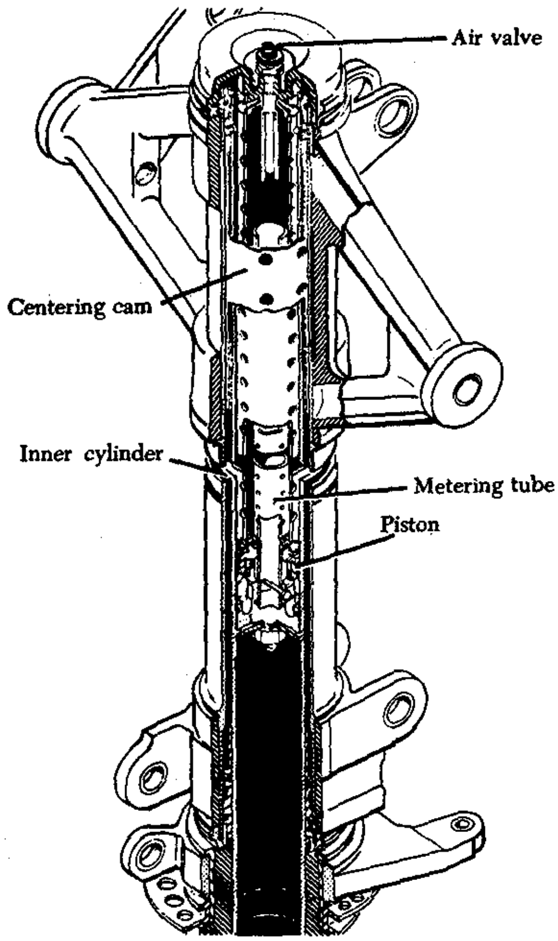


FIGURE 9–4. Landing gear shock strut of the metering tube type.

upper chamber contains compressed air. An orifice is placed between the two chambers and provides a passage for the fluid into the upper chamber during compression and return during extension of the strut.

Most shock struts employ a metering pin similar to that shown in figure 9–3 for controlling the rate of fluid flow from the lower chamber into the upper chamber. During the compression stroke, the rate of fluid flow is not constant, but is controlled automatically by the variable shape of the metering pin as it passes through the orifice.

On some types of shock struts, a metering tube replaces the metering pin, but shock strut operation is the same (figure 9–4).

Some shock struts are equipped with a damping or snubbing device consisting of a recoil valve on the piston or recoil tube to reduce the rebound during the extension stroke and to prevent too rapid extension of the shock strut. This could result in a sharp impact at the end of the stroke and possible damage to the aircraft and the landing gear.

The majority of shock struts are equipped with an axle attached to the lower cylinder to provide for installation of the wheels. Shock struts not equipped with axles have provisions on the end of the lower cylinder for easy installation of the axle assembly. Suitable connections are also provided on all shock struts to permit attachment to the aircraft.

A fitting consisting of a fluid filler inlet and air valve assembly is located near the upper end of each shock strut to provide a means of filling the strut with hydraulic fluid and inflating it with air.

A packing gland designed to seal the sliding joint between the upper and lower telescoping cylinders is installed in the open end of the outer cylinder. A packing gland wiper ring is also installed in a groove in the lower bearing or gland nut on most shock struts to keep the sliding surface of the piston or inner cylinder free from dirt, mud, ice, and snow. Entry of foreign matter into the packing gland would result in leaks.

The majority of shock struts are equipped with torque arms attached to the upper and lower cylinders to maintain correct alignment of the wheel. Shock struts without torque arms have splined piston heads and cylinders which maintain correct wheel alignment.

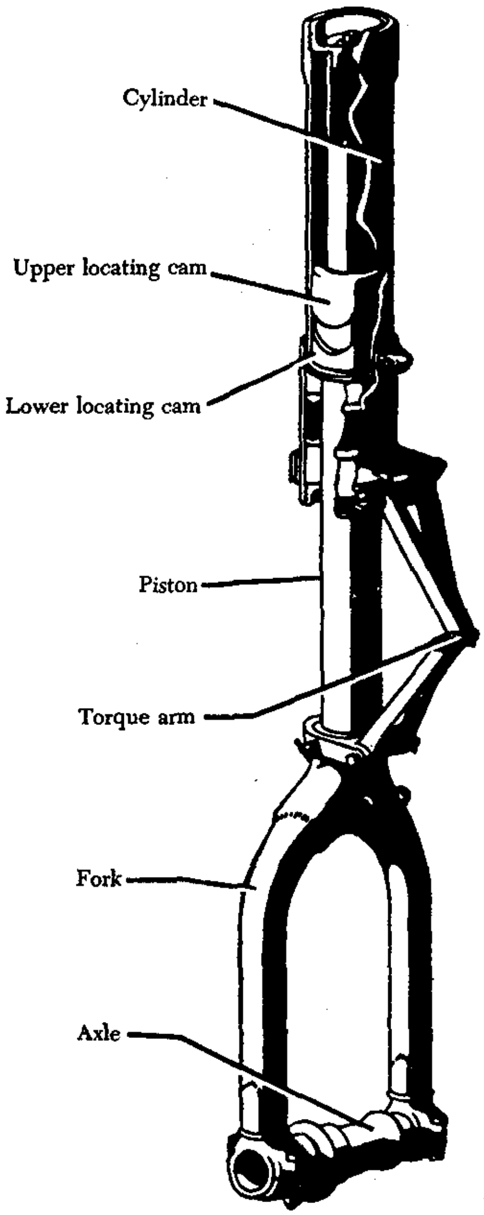


FIGURE 9–5. Nose gear shock strut.

Nose gear shock struts are provided with an upper locating cam attached to the upper cylinder and a mating lower locating cam attached to the lower cylinder (figure 9–5). These cams line up the wheel and axle assembly in the straight-ahead position when the shock strut is fully extended. This prevents the nosewheel from being cocked to one side when the nose gear is retracted, thus preventing possible structural damage to the aircraft. The mating cams also keep the nosewheel in a straight-ahead position prior to landing when the strut is fully extended. Some nose gear shock struts have attachments for installing an external shimmy damper.

Generally, nose gear struts are equipped with a locking (or disconnect) pin to enable quick turning of the aircraft when it is standing idle on the ground or in the hangar. Disengagement of this pin will allow the wheel fork spindle to rotate 360°, thus enabling the aircraft to be turned in a very small space, as in a crowded hangar.

Nose and main gear shock struts are usually provided with jacking points and towing lugs. Jacks should always be placed under the prescribed points; and when towing lugs are provided, the towing bar should be attached only to these lugs.

All shock struts are provided with an instruction plate which gives brief instructions for filling the strut with fluid and for inflating the strut. The instruction plate attached near the filler inlet and air valve assembly also specifies the correct type of hydraulic fluid to use in the strut. It is of utmost importance to become familiar with these instruction prior to filling a shock strut with hydraulic fluid or inflating it with air.

Figure 9–6 shows the inner construction of a shock strut and illustrates the movement of the fluid during compression and extension of the strut.

The compression stroke of the shock strut begins as the aircraft wheels touch the ground; the center of mass of the aircraft continues to move downward, compressing the strut and sliding the inner cylinder into the outer cylinder. The metering pin is forced through the orifice and, by its variable shape, controls the rate of fluid flow at all points of the compression stroke. In this manner the greatest possible amount of heat is dissipated through the walls of the shock strut. At the end of the downward stroke, the compressed air is further compressed, limiting the compression stroke of the strut.

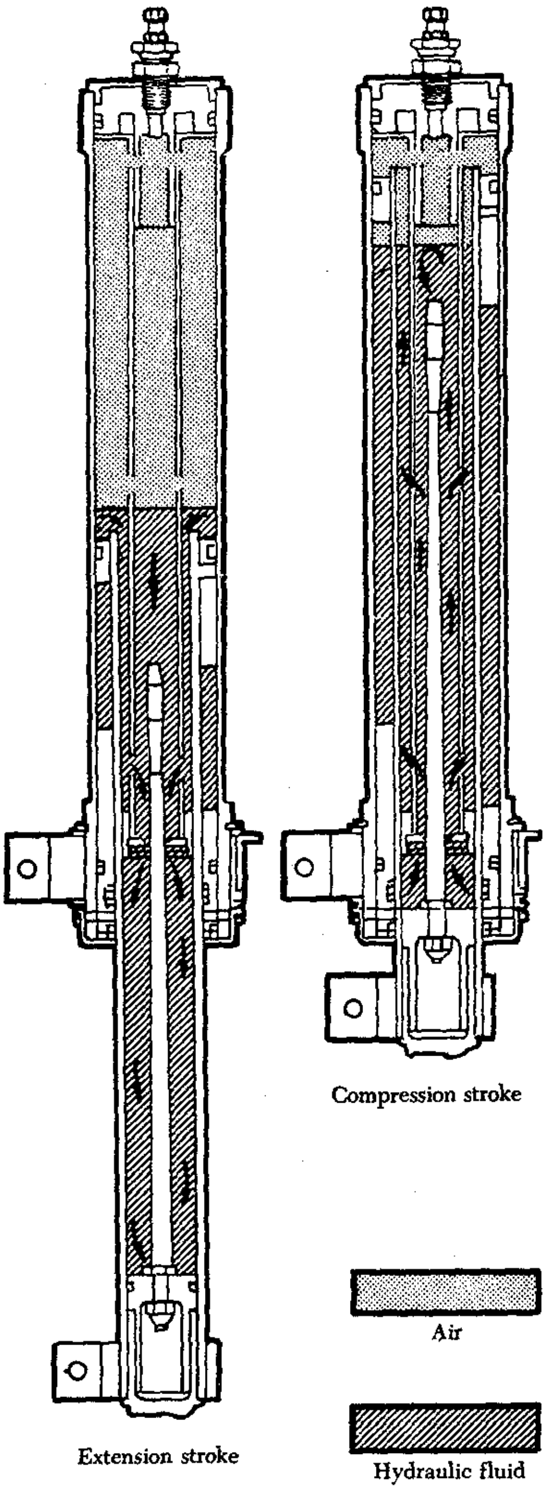


FIGURE 9–6. Shock strut operation.

If there was an insufficient amount of fluid and/or air in the strut, the compression stroke would not be limited and the strut would "bottom."

The extension stroke occurs at the end of the compression stroke as the energy stored in the compressed air causes the aircraft to start moving upward in relation to the ground and wheels. At this instant, the compressed air acts as a spring to return the strut to normal. It is at this point that a snubbing or damping effect is produced by forcing the fluid to return through the restrictions of the snubbing device. If this extension were not snubbed, the aircraft would rebound rapidly and tend to oscillate up and down, due to the action of the compressed air. A sleeve, spacer, or bumper ring incorporated in the strut limits the extension stroke.

For efficient operation of shock struts, the proper fluid level and air pressure must be maintained. To check the fluid level, the shock strut must be deflated and in the fully compressed position. Deflating a shock strut can be a dangerous operation unless servicing personnel are thoroughly familiar with high-pressure air valves. Observe all the necessary safety precautions. Refer to manufacturer's instructions for proper deflating technique.

Two of the various types of high-pressure air valves currently in use on shock struts are illustrated in figure 9–7. Although the two air valves

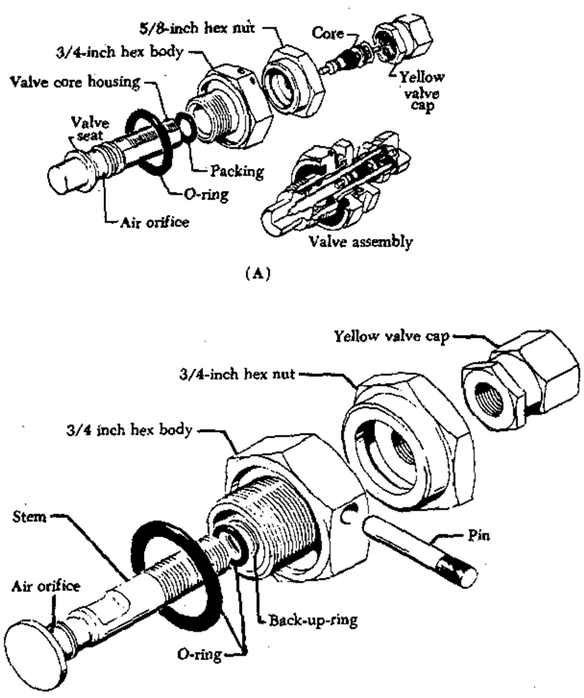


FIGURE 9–7. High-pressure air valves.

are interchangeable, there are some important differences in their construction. One valve (figure 9–7A) contains a valve core and has a 5/8-in. swivel hex nut. The other air valve (figure 9–7B) has no valve core and has a 3/4-in. swivel hex nut.

Servicing Shock Struts

The following procedures are typical of those used in deflating a shock strut, servicing with hydraulic fluid, and re-inflating (figure 9–8):

(1) Position the aircraft so the shock struts are in the normal ground operating position. Make certain that personnel, workstands, and other obstacles are clear of the aircraft. (Some aircraft must be placed on jacks to service the shock struts.)

(2) Remove the cap from the air valve (figure 9–8A).

(3) Check the swivel hex nut for tightness with a wrench (figure 9–8B).

(4) If the air valve is equipped with a valve core, release any air pressure that may be trapped between the valve core and the valve seat by depressing the valve core (figure 9–8C). Always stand to one side of the valve, since high-pressure air can cause serious injury, *e.g.*, loss of eyesight.

(5) Remove the valve core (figure 9–8D).

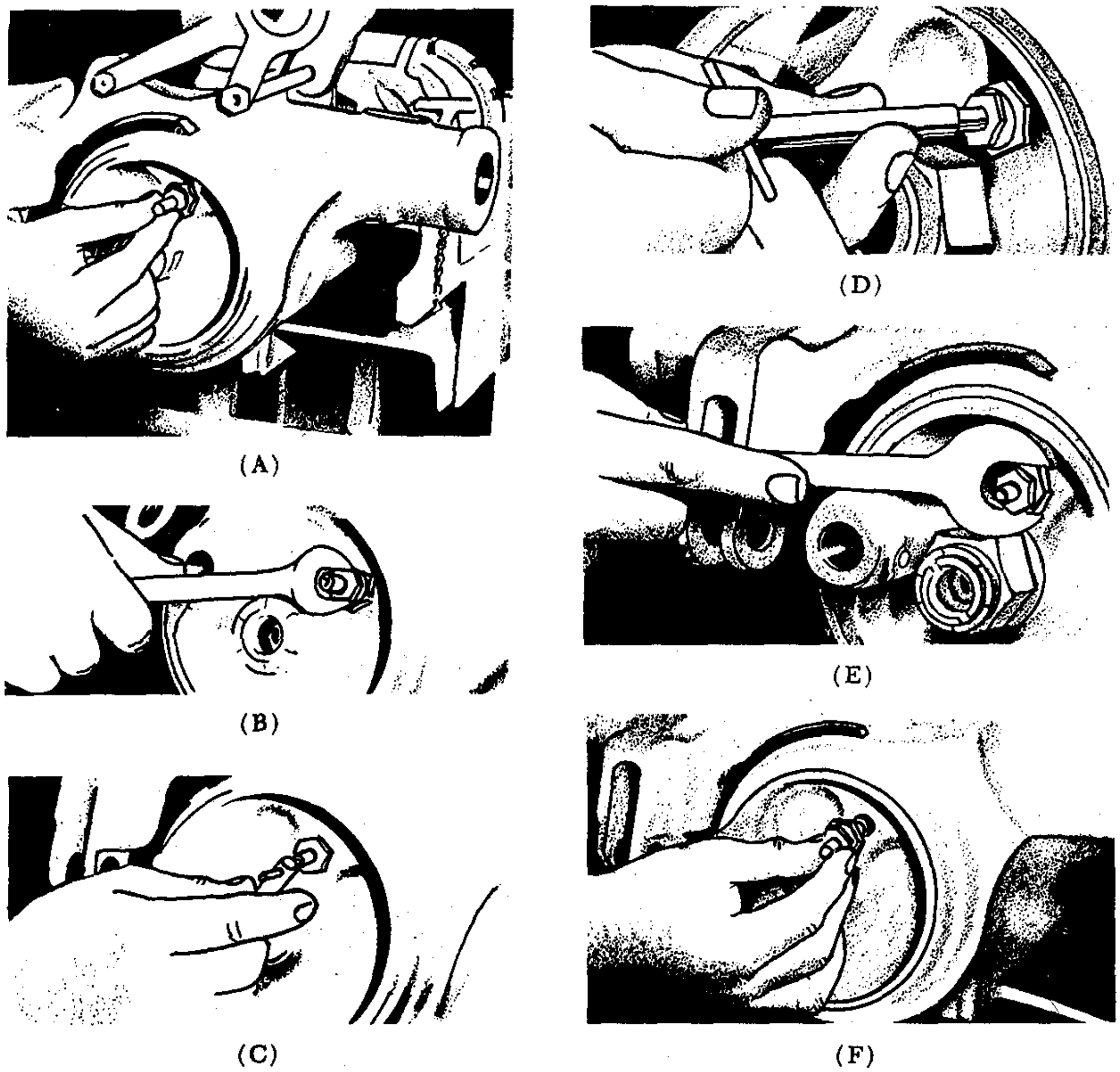


FIGURE 9–8. Steps in servicing shock struts.

(6) Release the air pressure in the strut by slowly turning the swivel nut counterclockwise (figure 9–8E).
(7) Ensure that the shock strut compresses as the air pressure is released. In some cases, it may be necessary to rock the aircraft after deflating to ensure compression of the strut.
(8) When the strut is fully compressed, the air valve assembly may be removed (figure 9–8F).
(9) Fill the strut to the level of the air valve opening with an approved type of hydraulic fluid.
(10) Re-install the air valve assembly, using a new O-ring packing. Torque the air valve assembly to the values recommended in the applicable manufacturer's instructions.
(11) Install the air valve core.
(12) Inflate the strut, using a high-pressure source of dry air or nitrogen. Bottled gas should not be used to inflate shock struts. On some shock struts the correct amount of inflation is determined by using a high-pressure air gage. On others it is determined by measuring the amount of extension (in inches) between two given points on the strut. The proper procedure can usually be found on the instruction plate attached to the shock strut. Shock struts should always be inflated slowly to avoid excessive heating and over inflation.
(13) Tighten the swivel hex nut, using the torque values specified in the applicable manufacturer's instructions.
(14) Remove the high-pressure air line chuck and install the valve cap. Tighten the valve cap fingertight.

Bleeding Shock Struts

If the fluid level of a shock strut has become extremely low, or if for any other reason air is trapped in the strut cylinder, it may be necessary to bleed the strut during the servicing operation. Bleeding is usually performed with the aircraft placed on jacks. In this position the shock struts can be extended and compressed during the filling operation, thus expelling all the entrapped air. The following is a typical bleeding procedure:

(1) Construct a bleed hose containing a fitting suitable for making an airtight connection to the shock strut filler opening. The base should be long enough to reach from the shock strut filler opening to the ground when the aircraft is on jacks.
(2) Jack the aircraft until all shock struts are fully extended.
(3) Release the air pressure in the strut to be bled.
(4) Remove the air valve assembly.
(5) Fill the strut to the level of the filler port with an approved type hydraulic fluid.
(6) Attach the bleed hose to the filler port and insert the free end of the hose into a container of clean hydraulic fluid, making sure that this end of the hose is below the surface of the hydraulic fluid.
(7) Place an exerciser jack (figure 9–9) or other suitable single-base jack under the shock strut jacking point. Compress and extend the strut fully by raising and lowering the jack until the flow of air bubbles from the strut has completely stopped. Compress the strut slowly and allow it to extend by its own weight.
(8) Remove the exerciser jack, and then lower and remove all other jacks.
(9) Remove the bleed hose from the shock strut.
(10) Install the air valve and inflate the strut.

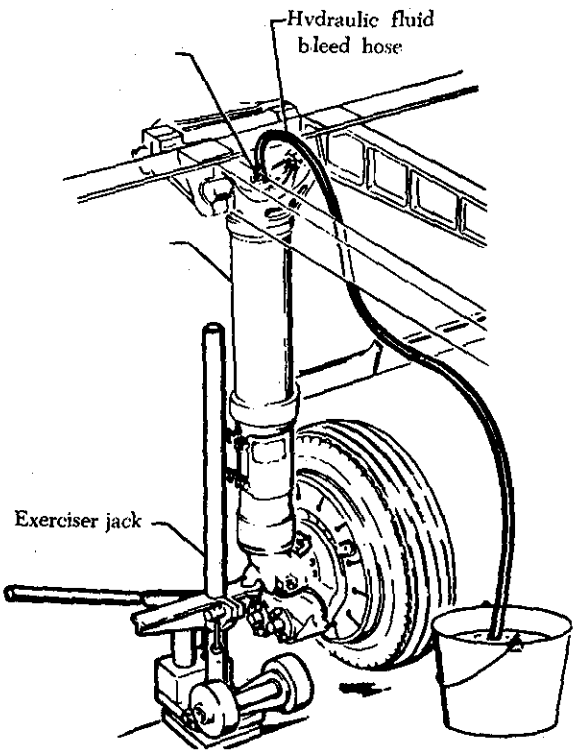


FIGURE 9–9. Bleeding a shock strut using an exerciser jack.

Shock struts should be inspected regularly for leakage of fluid and for proper extension. Exposed portions of the strut pistons should be wiped clean daily and inspected closely for scoring or corrosion.

MAIN LANDING GEAR ALIGNMENT, SUPPORT, RETRACTION

The main landing gear consists of several components that enable it to function. Typical of these are the torque links, trunnion and bracket arrangements, drag strut linkages, electrical and hydraulic gear-retraction devices, and gear indicators.

Alignment

Torque links (figure 9–10) keep the landing gear pointed in a straight-ahead direction; one torque link connects to the shock strut cylinder, while the other connects to the piston. The links are hinged at the center so that the piston can move up or down in the strut.

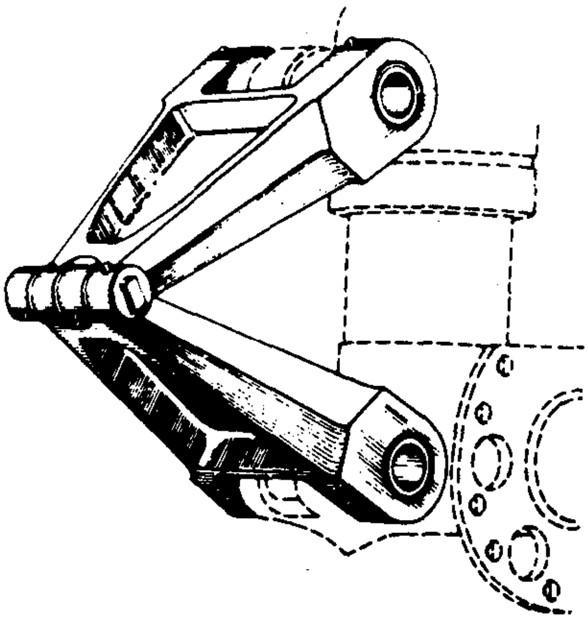


FIGURE 9–10. Torque links.

Support

To anchor the main gear to the aircraft structure, a trunnion and bracket arrangement (figure 9–11) is usually employed. This arrangement is constructed to enable the strut to pivot or swing forward or backward as necessary when the aircraft is being steered or the gear is being retracted. To restrain this action during ground movement of the aircraft, various types of linkages are used, one being the drag strut.

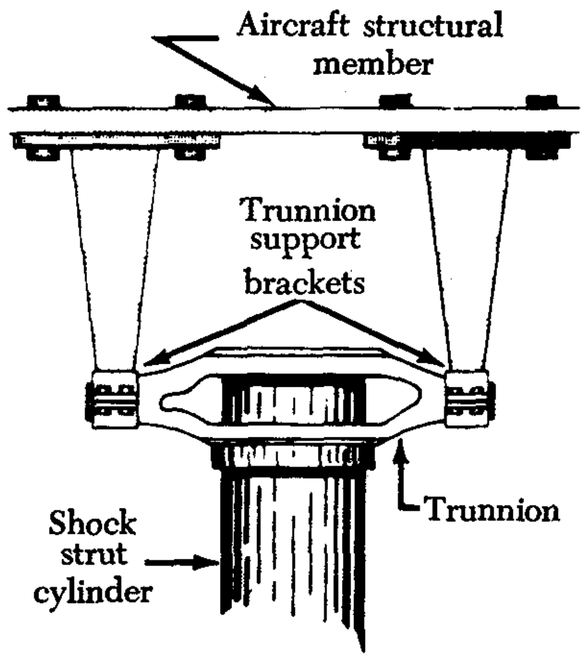


FIGURE 9–11. Trunnion and bracket arrangement.

The upper end of the drag strut (figure 9–12) connects to the aircraft structure, while the lower end connects to the shock strut. The drag strut is hinged so that the landing gear can be retracted.

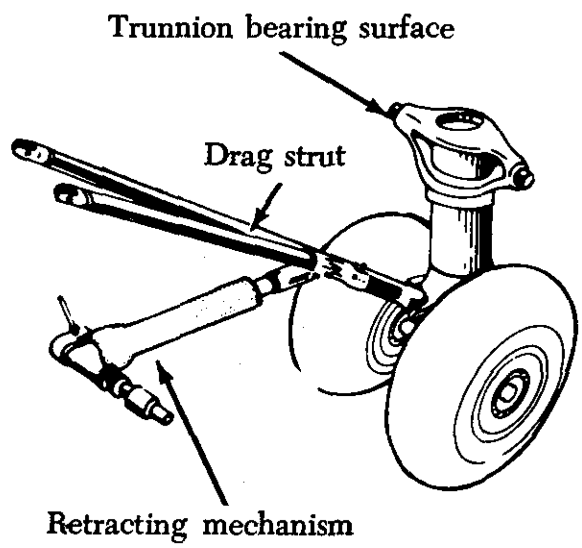


FIGURE 9–12. Drag strut linkage.

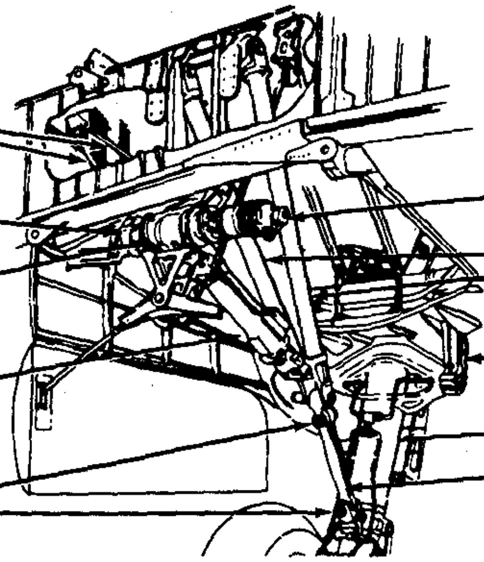


FIGURE 9–13. Electrical retraction system.

Electrical Landing Gear Retraction System

An electrical landing gear retraction system, such as that shown in figure 9–13, has the following features:

(1) A motor for converting electrical energy into rotary motion.

(2) A gear reduction system for decreasing the speed and increasing the force of rotation.

(3) Other gears for changing rotary motion (at a reduced speed) into push-pull movement.

(4) Linkage for connecting the push-pull movement to the landing gear shock struts.

Basically, the system is an electrically driven jack for raising or lowering the gear. When a switch in the cockpit is moved to the "up" position, the electric motor operates. Through a system of shafts, gears, adapters, an actuator screw, and a torque tube, a force is transmitted to the drag strut linkages. Thus, the gear retracts and locks. If the switch is moved to the "down" position, the motor reverses and the gear moves down and locks. The sequence of operation of doors and gears is similar to that of a hydraulically operated landing gear system.

Hydraulic Landing Gear Retraction Systems

Devices used in a typical hydraulically operated landing gear retraction system include actuating cylinders, selector valves, uplocks, downlocks, sequence valves, tubing, and other conventional hydraulic components. These units are so interconnected that they permit properly sequenced retraction and extension of the landing gear and the landing gear doors.

The operation of a hydraulic landing gear retraction system is of such importance that is must be covered in some detail. First, consider what happens when the landing gear is retracted. As the selector valve (figure 9–14) is moved to the "up" position, pressurized fluid is directed into the gear up line. The fluid flows to each of eight units; to sequence valves C and D, to the three gear downlocks, to the nose gear cylinder, and to the two main actuating cylinders.

Notice what happens to the fluid flowing to sequence valves C and D in figure 9–14. Since the sequence valves are closed, pressurized fluid cannot flow to the door cylinders at this time. Thus, the doors cannot close. But the fluid entering the three downlock cylinders is not delayed; therefore, the gear is unlocked. At the same time, fluid also enters the up side of each gear-actuating cylinder and the gears begin to retract. The nose gear completes

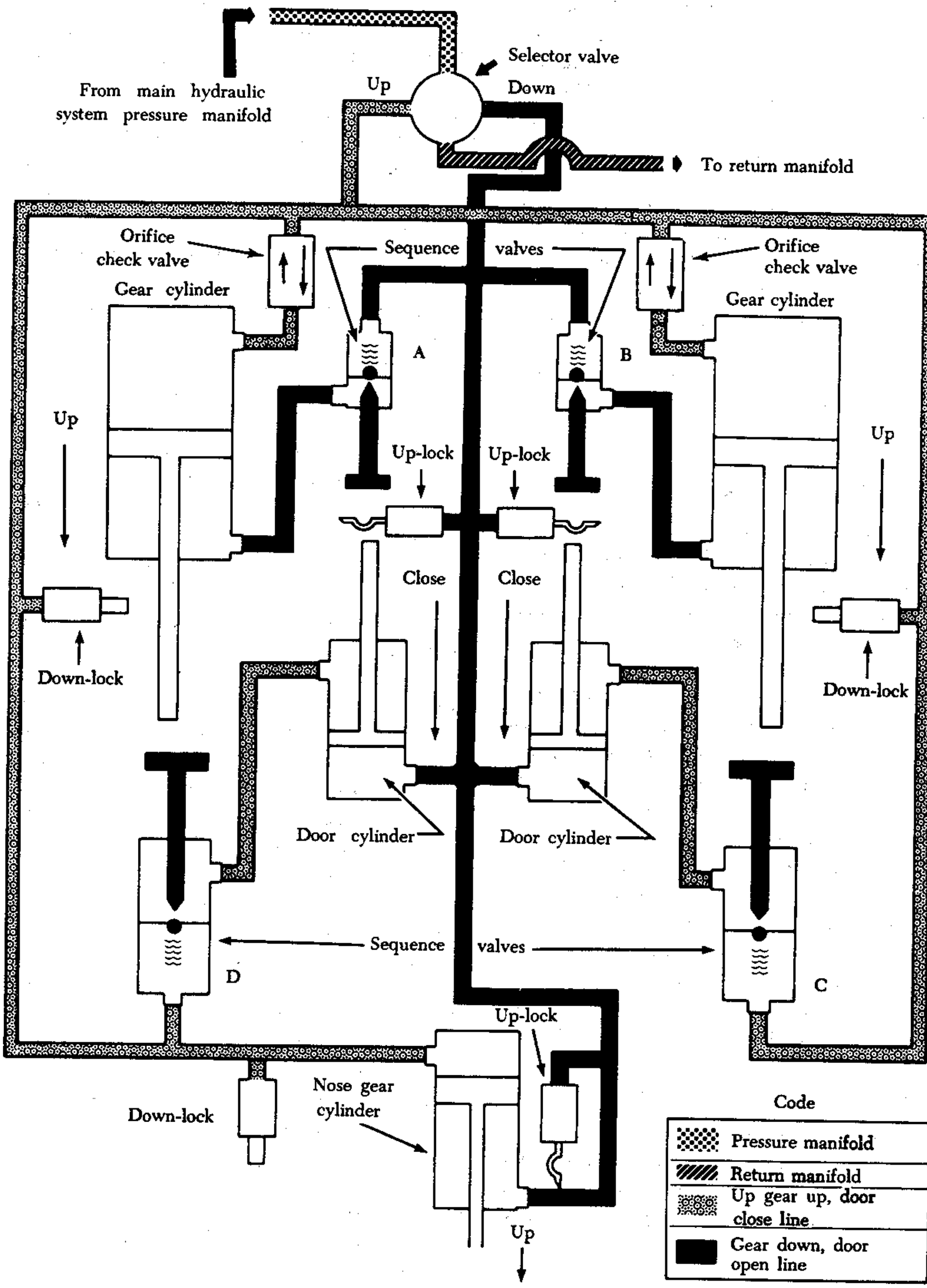


Figure 9–14. Hydraulic landing gear retraction system schematic.

retraction and engages its uplock first, because of the small size of its actuating cylinder. Also, since the nose gear door is operated solely by linkage from the nose gear, this door closes. Meanwhile, the main landing gear is still retracting, forcing fluid to leave the downside of each main gear cylinder. This fluid flows unrestricted through an orifice check valve, opens the sequence check valve A or B, and flows through the landing-gear selector valve into the hydraulic system return line. Then, as the main gear reaches the fully retracted position and engages the spring-loaded uplocks, gear linkage strikes the plungers of sequence valves C and D. This opens the sequence check valves and allows pressurized fluid to flow into the door cylinders, closing the landing gear doors.

Wing Landing Gear Operation

A typical wing landing gear operating sequence is illustrated in figure 9–15. The wing landing gear retracts or extends when hydraulic pressure is applied to the up or down side of the gear actuator. The gear actuator applies the force required to raise and lower the gear. The actuator works in conjunction with a walking beam to apply force to the wing gear shock strut, swinging it inboard and forward into the wheel well. Both the actuator and the walking beam are connected to lugs on the landing gear trunnion. The outboard ends of the actuator and walking beam pivot on a beam hanger which is attached to the aircraft structure. A wing landing gear locking mechanism located on the outboard side of the wheel well locks the gear in the "up" position. Locking of the gear in the "down" position is accomplished by a downlock bungee which positions an upper and lower jury strut so that the upper and lower side struts will not fold.

EMERGENCY EXTENSION SYSTEMS

The emergency extension system lowers the landing gears if the main power system fails. Some aircraft have an emergency release handle in the cockpit, which is connected through a mechanical linkage to the gear uplocks. When the handle is operated, it releases the uplocks and allows the gears to free-fall, or extend, under their own weight. On other aircraft, release of the uplock is accomplished using compressed air which is directed to uplock release cylinders.

In some aircraft, design configurations make emergency extension of the landing gear by gravity and airloads alone impossible or impractical. In such aircraft, provisions are included for forceful gear extension in an emergency. Some installations are designed so that either hydraulic fluid, or compressed air provides the necessary pressure; while others use a manual system for extending the landing gears under emergency conditions.

Hydraulic pressure for emergency operation of the landing gear may be provided by an auxiliary hand pump, an accumulator, or an electrically powered hydraulic pump, depending upon the design of the aircraft.

LANDING GEAR SAFETY DEVICES

Accidental retraction of a landing gear may be prevented by such safety devices as mechanical downlocks, safety switches, and ground locks. Mechanical downlocks are built-in parts of a gear-retraction system and are operated automatically by the gear-retraction system. To prevent accidental operation of the downlocks, electrically operated safety switches are installed.

Safety Switch

A landing gear safety switch (figure 9–16) in the landing gear safety circuit is usually mounted in a bracket on one of the main gear shock struts. This switch is actuated by a linkage through the landing gear torque links. The torque links spread apart or move together as the shock strut piston extends or retracts in its cylinder. When the strut is compressed (aircraft on the ground), the torque links are close together, causing the adjusting links to open the safety switch. During takeoff, as the weight of the aircraft leaves the struts, the struts and torque links extend, causing the adjusting links to close the safety switch. As shown in figure 9–16, a ground is completed when the safety switch closes. The solenoid then energizes and unlocks the selector valve so that the gear handle can be positioned to raise the gear.

Ground Locks

In addition to this safety device, most aircraft are equipped with additional safety devices to prevent collapse of the gear when the aircraft is on the ground. These devices are called ground locks. One

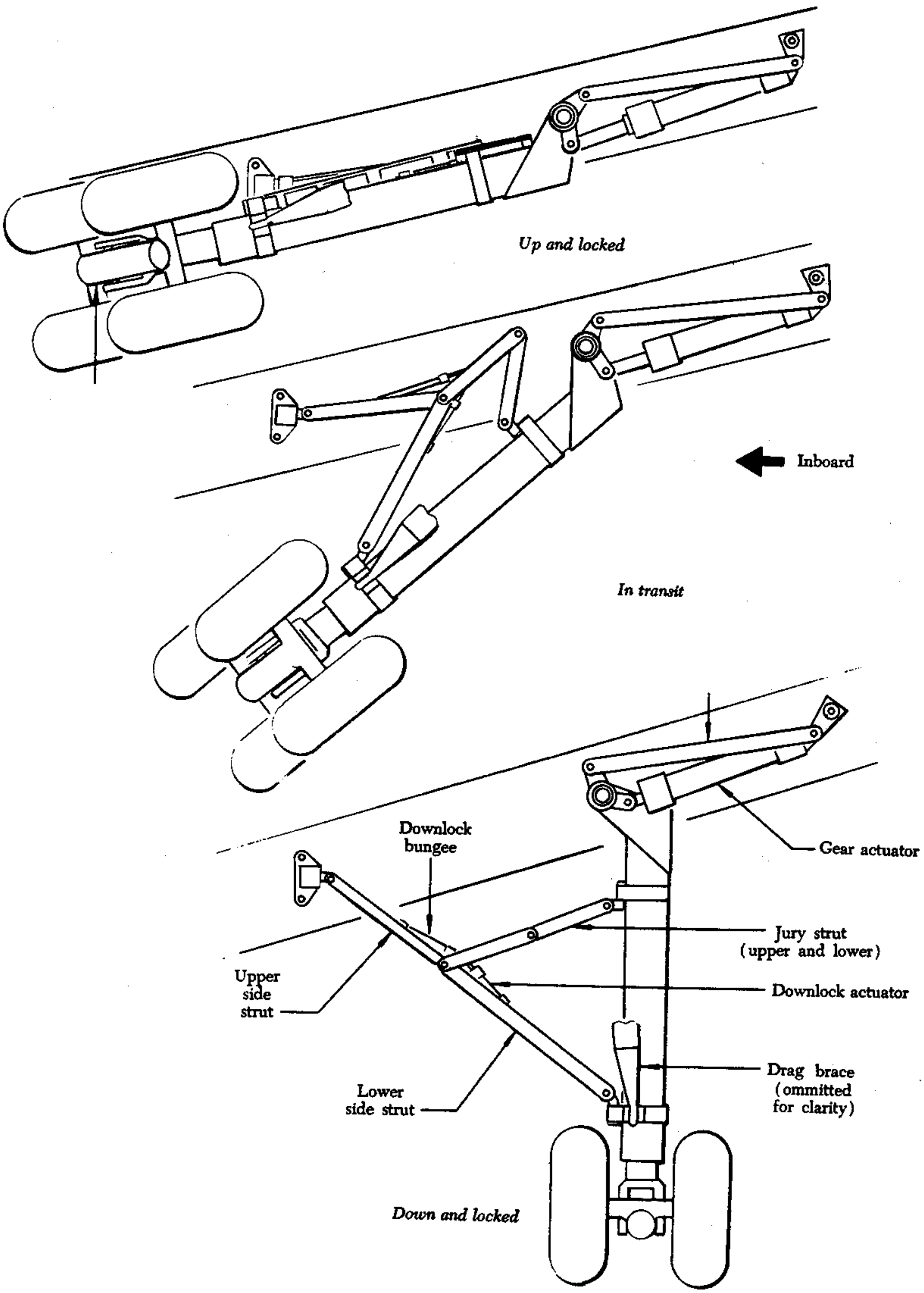


Figure 9–15. Wing landing gear operating sequence.

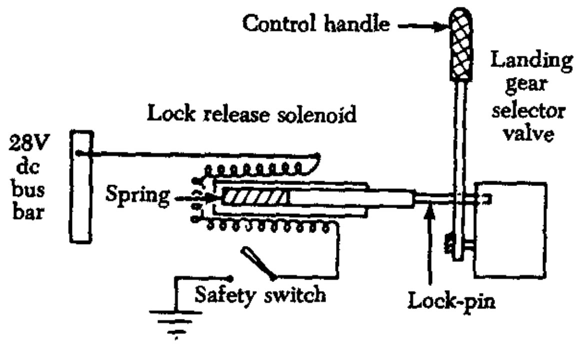


FIGURE 9–16. Typical landing gear safety circuit.

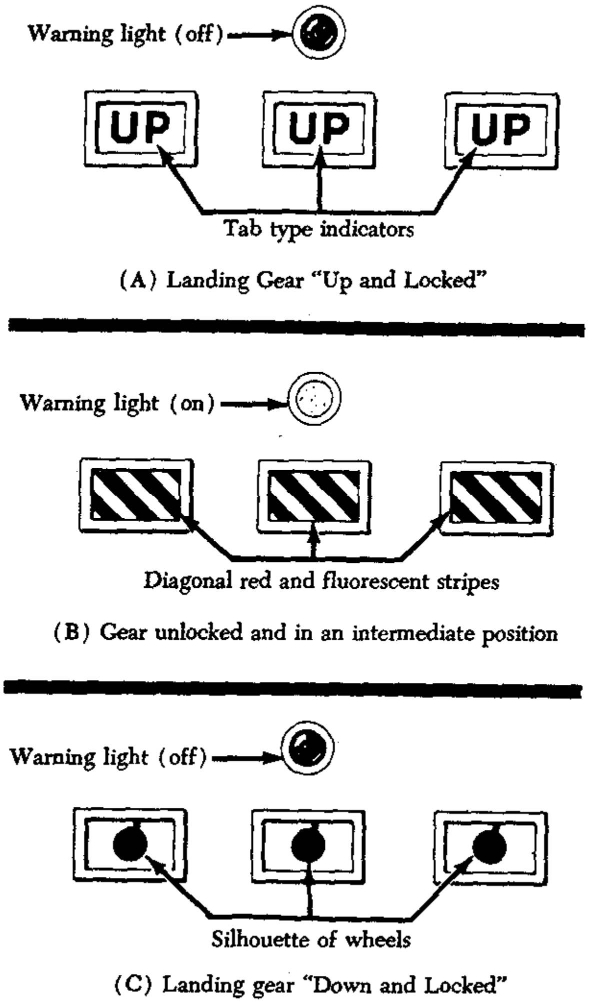


FIGURE 9–17. A typical gear position indicator and warning light.

common type is a pin installed in aligned holes drilled in two or more units of the landing gear support structure. Another type is a spring-loaded clip designed to fit around and hold two or more units of the support structure together. All types of ground locks usually have red streamers permanently attached to them to readily indicate whether or not they are installed.

Gear Indicators

To provide a visual indication of landing gear position, indicators are installed in the cockpit or flight compartment.

Gear warning devices are incorporated on all retractable gear aircraft and usually consist of a horn or some other aural device and a red warning light. The horn blows and the light comes on when one or more throttles are retarded and the landing gear is in any position other than down and locked.

Several designs of gear position indicators are available. One type displays movable miniature landing gears which are electrically positioned by movement of the aircraft gear. Another type consists of two or three green lights which burn when the aircraft gear is down and locked. A third type (figure 9–17) consists of tab-type indicators with markings "up" to indicate that the gear is up and locked, a display of red and white diagonal stripes to show when the gear is unlocked, or a silhouette of each gear to indicate when it locks in the "down" position.

Nosewheel Centering

Centering devices include such units as internal centering cams (figure 9–18) to center the nose wheel as it retracts into the wheel well. If a centering unit were not included in the system, the fuselage wheel well and nearby units could be damaged.

During retraction of the nose gear, the weight of the aircraft is not supported by the strut. The strut is extended by means of gravity and air pressure within the strut. As the strut extends, the raised area of the piston strut contacts the slopping area of the fixed centering cam and slides along it. In so doing, it aligns itself with the centering cam and rotates the nose gear piston into a straight-ahead direction.

The internal centering cam is a feature common to most large aircraft. However, other centering

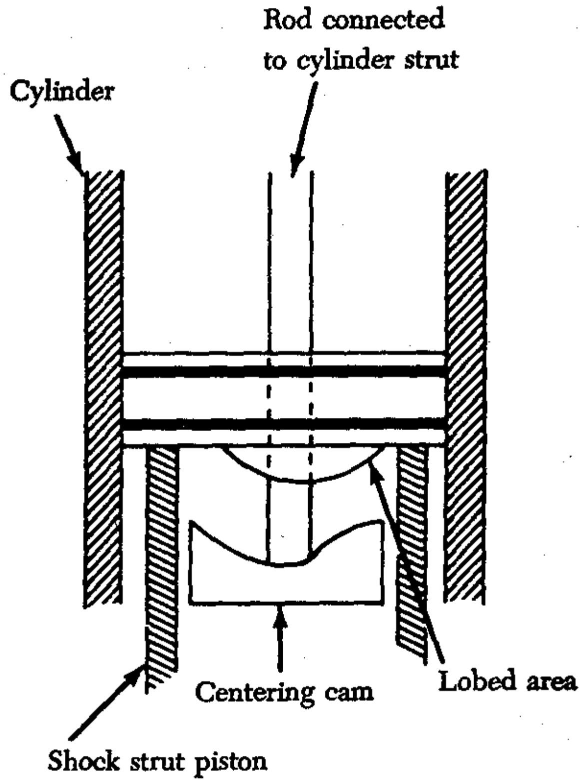


FIGURE 9–18. Cutaway view of a nose gear internal centering cam.

devices are commonly found on small aircraft. Small aircraft characteristically incorporate an external roller or guide pin on the strut. As the strut is folded into the wheel well on retraction, the roller or guide pin will engage a ramp or track mounted to the wheel well structure. The ramp/track guides the roller or pin in such a manner that the nose wheel is straightened as it enters its well.

In either the internal cam or external track arrangement, once the gear is extended and the weight of the aircraft is on the strut, the nose wheel may be turned for steering.

NOSEWHEEL STEERING SYSTEM

Light Aircraft

Light aircraft are commonly provided nosewheel steering capabilities through a simple system of mechanical linkage hooked to the rudder pedals. Most common applications utilize push-pull rods to connect the pedals to horns located on the pivotal portion of the nosewheel strut.

Heavy Aircraft

Large aircraft, with their larger mass and a need for positive control, utilize a power source for nosewheel steering. Even though large aircraft nosewheel steering system units differ in their construction features, basically all of these systems work in approximately the same manner and require the same sort of units. For example, each steering system (figure 9–19) usually contains:

(1) A cockpit control, such as a wheel, handle, lever, or switch to allow starting, stopping, and to control the action of the system.

(2) Mechanical, electrical, or hydraulic connections for transmitting cockpit control movements to a steering control unit.

(3) A control unit, which is usually a metering or control valve.

(4) A source of power, which is, in most instances, the aircraft hydraulic system.

(5) Tubing for carrying fluid to and from various parts of the system.

(6) One or more steering cylinders, together with the required linkages, for using pressurized fluid to turn the nose gear.

(7) A pressurizing assembly to keep fluid in each steering cylinder always under pressure, thereby preventing shimmy.

(8) A followup mechanism, consisting of gears, cables, rods, drums, and/or bellcranks, for returning the steering control unit to NEUTRAL and thus holding the nose gear at the correct angle of turn.

(9) Safety valves to allow the wheels to trail or swivel, in the event of hydraulic failure.

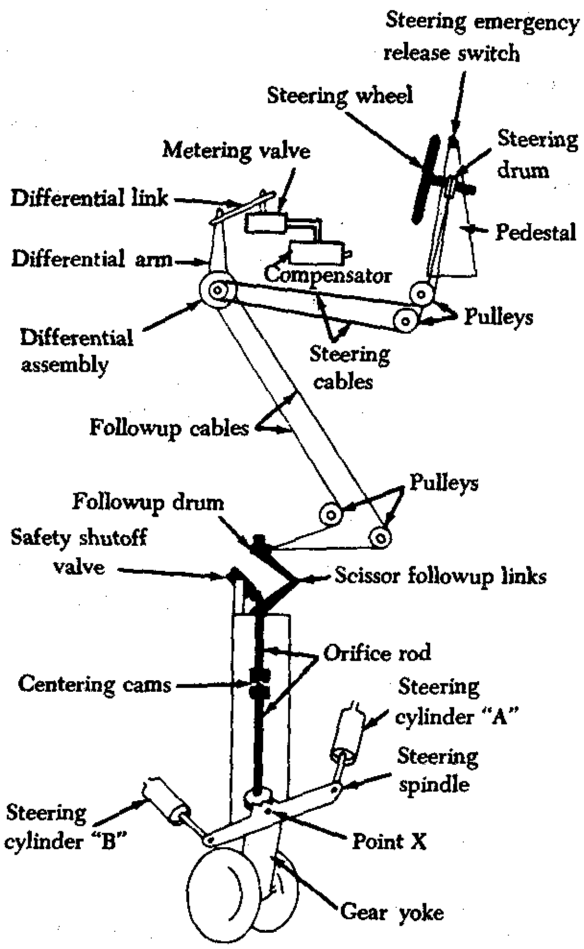


FIGURE 9–19. Nosewheel system mechanical and hydraulic units.

Nosewheel Steering Operation

The nosewheel steering wheel connects through a shaft to a steering drum located inside the cockpit control pedestal. The rotation of this drum transmits the steering signal by means of cables and pulleys to the control drum of the differential assembly. Movement of the differential assembly is transmitted by the differential link to the metering valve assembly, where it moves the selector valve to the selected position. Then hydraulic pressure provides the power for turning the nose gear.

As shown in figure 9–20, pressure from the aircraft hydraulic system is directed through the opened safety shutoff valve and into a line leading to the metering valve. This metering valve then routes pressurized fluid out of port A, through the right-turn alternating line, and into steering cylinder A. This is a one-port cylinder, and pressure forces the piston to start extending. Since the rod of this piston connects to the nose steering spindle, which pivots at point X, the extension of the piston turns the steering spindle gradually toward the right. This action turns the nose gear slowly toward the right, because the spindle is connected to the nose gear shock strut. As the nose gear turns right, fluid is forced out of cylinder B, through the left-turn alternating line, and into port B of the metering valve. The metering valve sends this return fluid into a compensator, which routes the fluid into the aircraft system return manifold.

Thus, hydraulic pressure starts the nose gear turning. However, the gear should not be turned too far. The nose gear steering system contains devices to stop the gear at the selected angle of turn and hold it there.

Followup Linkage

As already pointed out, the nose gear is turned by the steering spindle as the piston of cylinder A (figure 9–20) extends. But the rear of the spindle has gear teeth which mesh with a gear on the bottom of the orifice rod. Thus, as the nose gear and its spindle turn, the orifice rod also turns, although in the opposite direction. This rotation is transmitted by the two sections of the orifice rod to the scissor followup links (figure 9–19), located at the top of the nose gear strut. As the followup links return, they rotate the connected followup drum, which transmits the movement by cables and pulleys to the differential assembly. Operation of the differential assembly causes the differential arm and links to move the metering valve back toward the neutral position.

The compensator unit (figure 9–21) which is a part of the nosewheel system keeps fluid in the steering cylinders pressurized at all times. This hydraulic unit consists of a three-port housing, which encloses a spring-loaded piston and poppet. The left port is an air vent, which prevents trapped air at the rear of the piston from interfering with movements of the piston. The second port, located at the top of the compensator, connects through a line to the metering valve return port. The third port is located at the right side of the compensator. This port, which is connected to the hydraulic return

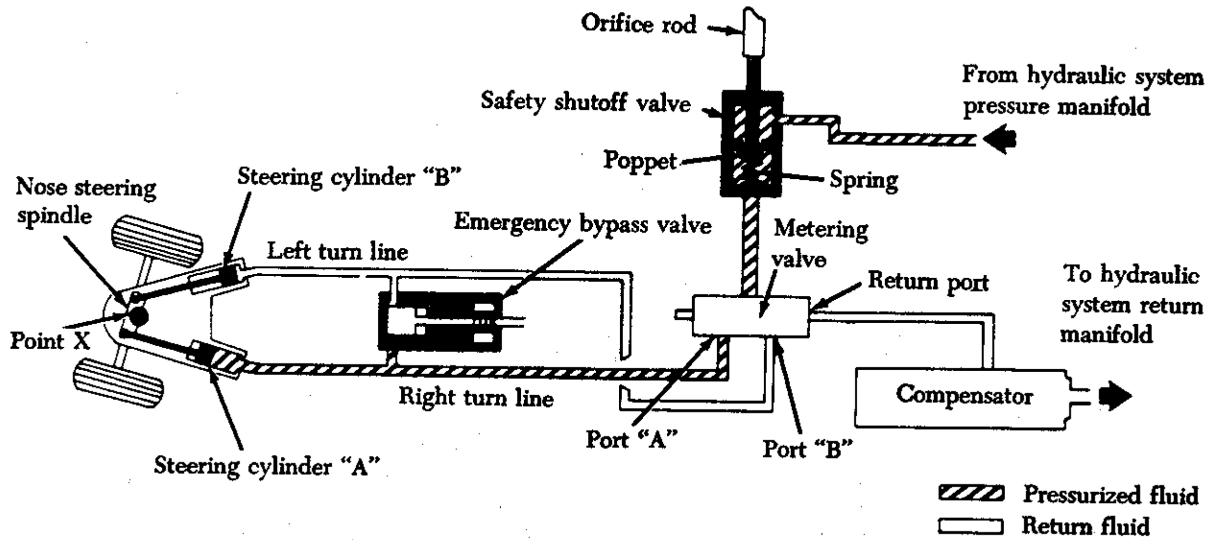


FIGURE 9–20. Nosewheel steering hydraulic flow diagram.

manifold, routes the steering system return fluid into the manifold when the poppet valve is open.

The compensator poppet opens when pressure acting on the piston becomes high enough to compress the spring. This requires 100 p.s.i.; therefore, fluid in the metering valve return line contains fluid trapped under that pressure. Now, since pressure in a confined fluid is transmitted equally and undiminished in all directions (Pascal's law), 100 p.s.i. also exists in metering valve passage H and in chambers E, D, G, and F (figure 9–21). This same pressure is also applied in the right- and left-turn alternating lines as well as in the steering cylinders themselves.

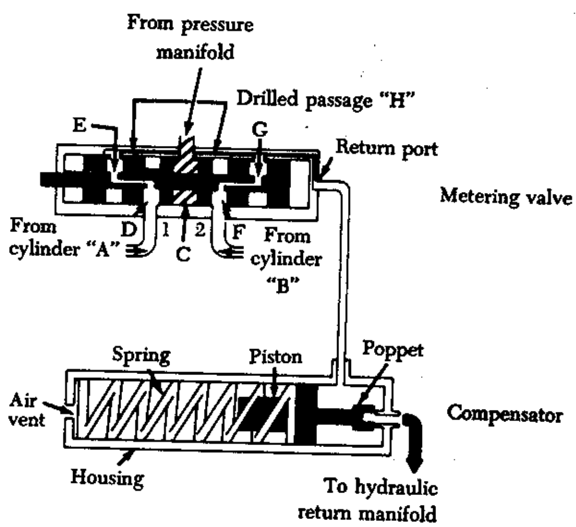


FIGURE 9–21. Cutaway view of metering valve and compensator.

SHIMMY DAMPERS

A shimmy damper controls vibration, or shimmy, through hydraulic damping. The damper is either attached to or built integrally with the nose gear and prevents shimmy of the nosewheel during taxiing, landing, or takeoff. There are three types of shimmy dampers commonly used on aircraft: (1) The piston type, (2) vane type, and (3) features incorporated in the nosewheel power steering system of some aircraft.

Piston-Type Shimmy Damper

The piston-type shimmy damper shown in figure 9–22 consists of two major components: (1) The cam assembly and (2) the damper assembly. The shimmy damper is mounted on a bracket at the lower end of the nose gear shock strut outer cylinder.

The cam assembly is attached to the inner cylinder of the shock strut and rotates with the nosewheel. Actually, the cam consists of two cams that are mirror images of each other. Lobes on the cams are so placed that the damping effect offers the greatest resistance to rotation when the wheel is centered. The cam follower crank is a U-shaped casting which incorporates the rollers that follow the cam lobes to restrict rotation. The arm of the crank connects to the operating piston shaft.

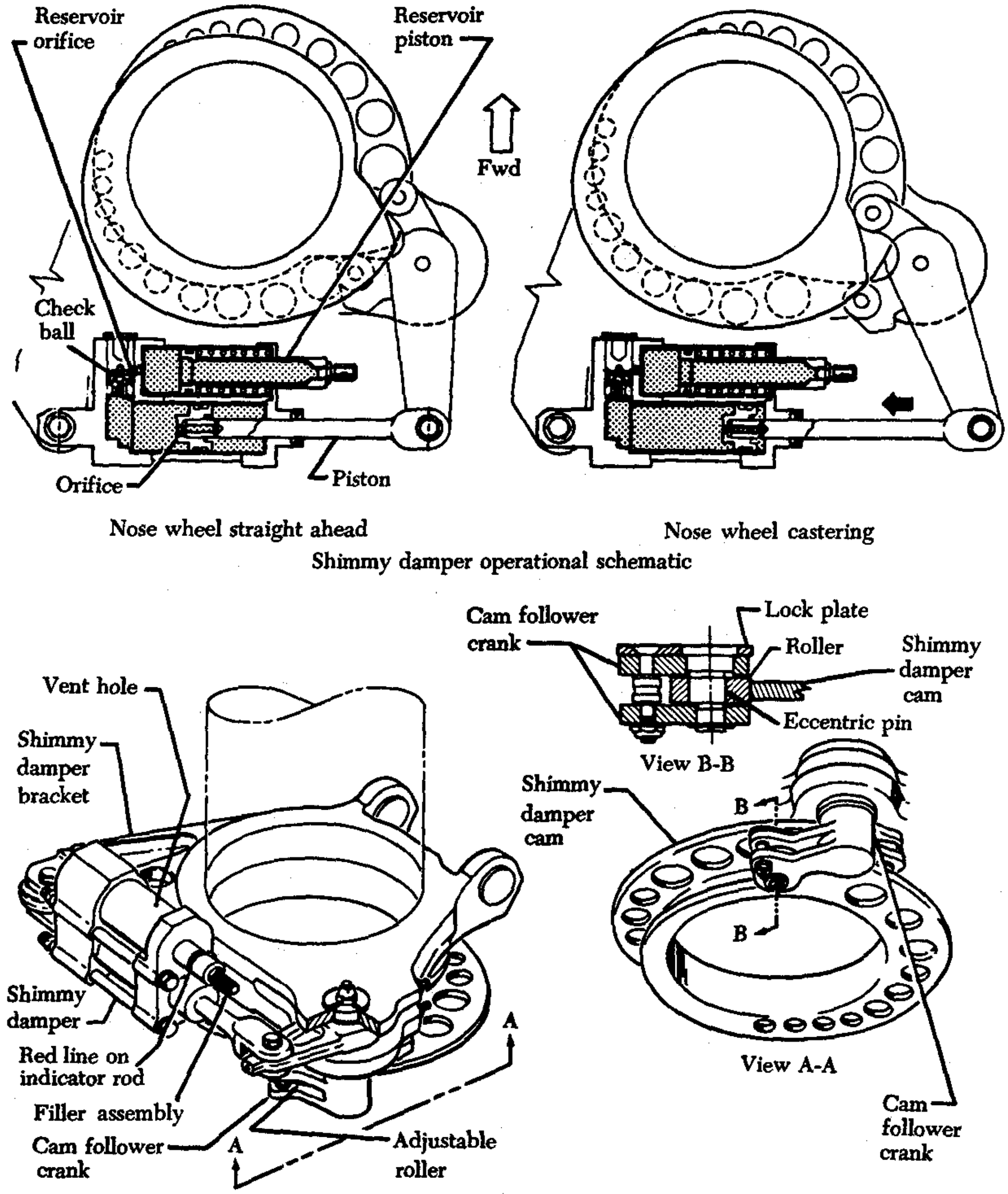


Figure 9–22. Typical piston-type shimmy damper.

The damper assembly consists of a spring-loaded reservoir piston to maintain the confined fluid under constant pressure, and an operating cylinder and piston. A ball check permits the flow of fluid from the reservoir to the operating cylinder to make up for any fluid loss in the operating cylinder. Because of the rod on the operating piston, its stroke away from the filler end of the piston displaces more fluid than its stroke toward the filler end. This difference is taken care of by the reservoir orifice, which permits a small flow both ways between the reservoir and operating cylinder.

A red mark (figure 9–22) on the reservoir indicator rod indicates the fluid level in the reservoir. When the piston goes into the reservoir so far that the mark is not visible, the reservoir must be serviced. The operating cylinder houses the operating piston. A small orifice in the piston head allows fluid to flow from one side of the piston to the other. The piston shaft is connected to the arm of the cam follower crank.

As the nosewheel fork rotates in either direction (figure 9–22), the shimmy damper cam displaces the cam follower rollers, causing the operating piston to move in its chamber. This movement forces fluid through the orifice in the piston. Since the orifice is very small, rapid movements of the piston, which commonly occur during landing and takeoff, are restricted, and nosewheel shimmy is eliminated. Gradual rotation of the nosewheel fork is not resisted by the damper. This enables the aircraft to be steered at slow speeds. If the fork rotates in either direction until the rollers are over the high spots on their portions of the cam, further movement of the nosewheel is practically unrestricted.

The piston-type shimmy damper generally requires a minimum of servicing and maintenance; however, it should be checked periodically for evidence of hydraulic leaks around the damper assembly, and the reservoir fluid level must be properly maintained at all times. The cam assembly should be checked for evidence of binding and for worn, loose, or broken parts.

Vane-Type Shimmy Damper

The vane-type shimmy damper is located on the nosewheel shock strut just above the nosewheel fork and may be mounted either internally or externally. If mounted internally, the housing of the shimmy damper is fitted and secured inside the shock strut, and the shaft is splined to the nosewheel fork. If mounted externally, the housing of the shimmy damper is bolted to the side of the shock strut, and the shaft is connected by mechanical linkage to the nosewheel fork.

The housing (figure 9–23) is divided into three

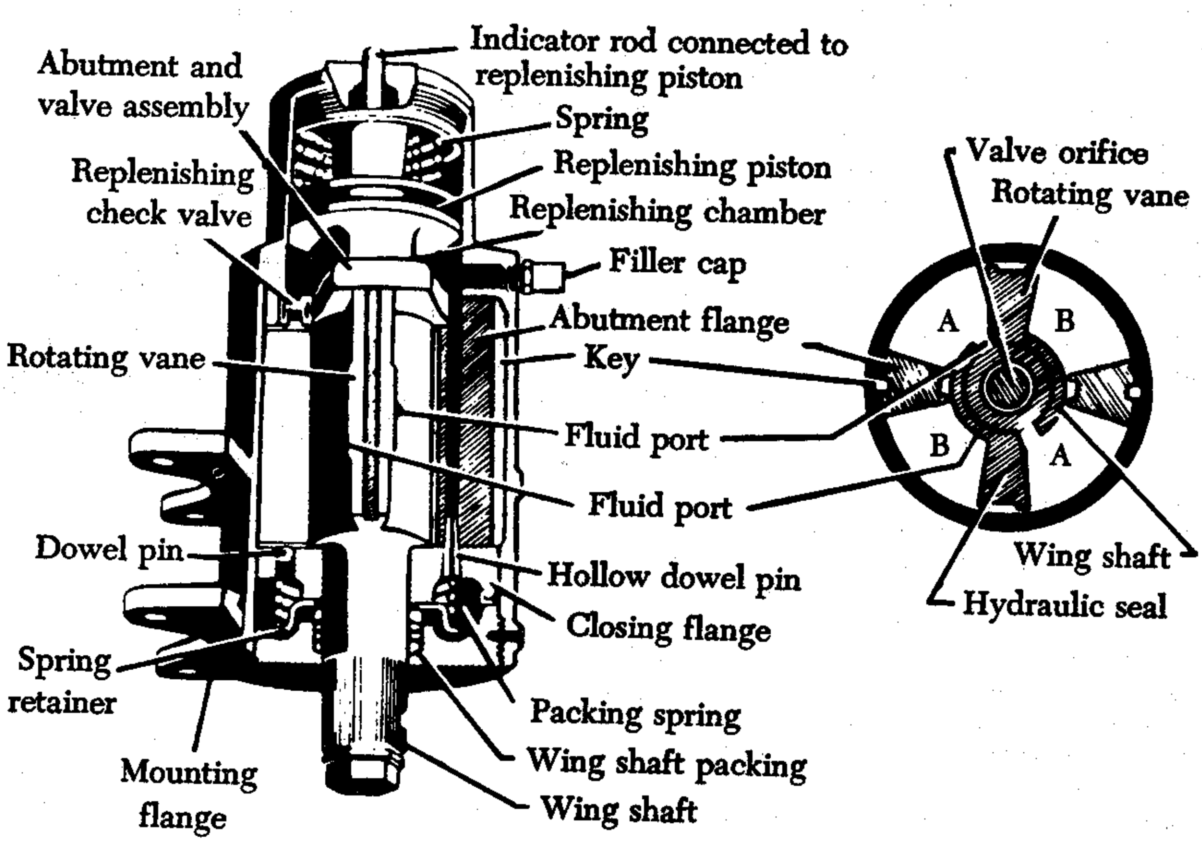


FIGURE 9–23. Typical vane-type shimmy damper.

main parts: (1) The replenishing chamber, (2) the working chamber, and (3) the lower shaft packing chamber.

The replenishing chamber is in the top part of the housing and stores a supply of fluid under pressure. Pressure is applied to the fluid by the spring-loaded replenishing piston and piston shaft which extends through the upper housing and serves as a fluid level indicator. The area above the piston contains the piston spring and is open to atmosphere to prevent a hydraulic lock. Fluid is prevented from leaking past the piston by O-ring packings. A grease fitting provides the means for filling the replenishing chamber with fluid.

The working chamber is separated from the replenishing chamber by the abutment and valve assembly. The working chamber contains two one-way ball check valves, which will allow fluid to flow from the replenishing chamber to the working chamber only. This chamber is divided into four sections by two stationary vanes called abutment flanges, which are keyed to the inner wall of the housing, and two rotating vanes, which are an integral part of the wing shaft. The shaft contains the valve orifice through which the fluid must pass in going from one chamber to another.

Turning the nosewheel in either direction causes the rotating vanes to move in the housing. This results in two sections of the working chamber growing smaller, while the opposite two chambers grow larger. The rotating vane can move only as fast as the fluid can be displaced from one chamber to the other. All of the fluid being displaced must pass through the valve orifice in the shaft. Resistance to the flow of fluid through the orifice is proportional to the velocity of flow. This means that the shimmy damper offers little resistance to slow motion, such as that encountered during normal steering of the nose gear or ground handling, but offers high resistance to shimmy on landing, takeoff, and high-speed taxiing. An automatic orifice adjustment compensates for temperature changes. A bimetallic thermostat in the shaft opens and closes the orifice as the temperature and viscosity change. This results in a constant resistance over a wide temperature range. In case an exceptionally high pressure is suddenly built up in the working chamber by a severe twisting force on the nosewheel, the closing flange moves down, compressing the lower shaft packing spring, allowing fluid to pass around the lower ends of the vanes, preventing structure damage.

Maintaining the proper fluid level is necessary to the continued functioning of a vane-type shimmy damper. If a shimmy damper is not operating properly, the fluid level is the first item which should be checked by measuring the protrusion of the indicator rod from the center of the reservoir cover. Inspection of a shimmy damper should include a check for evidence of leakage and a complete examination of all fittings and connections between the moving parts of the shock strut and the damper shaft for loose connections.

Fluid should be added only when the indicator rod protrudes less than the required amount. The distance the rod should protrude varies with different models. A shimmy damper should not be overfilled. If the indicator rod is above the height specified on the nameplate, fluid should be bled out of the damper.

Steer Damper

A steer damper is hydraulically operated and accomplishes the two separate functions of steering and/or eliminating shimmying. The type discussed here is designed for installation on nose gear struts and is connected into the aircraft hydraulic system. A typical steer damper is shown in figure 9–24.

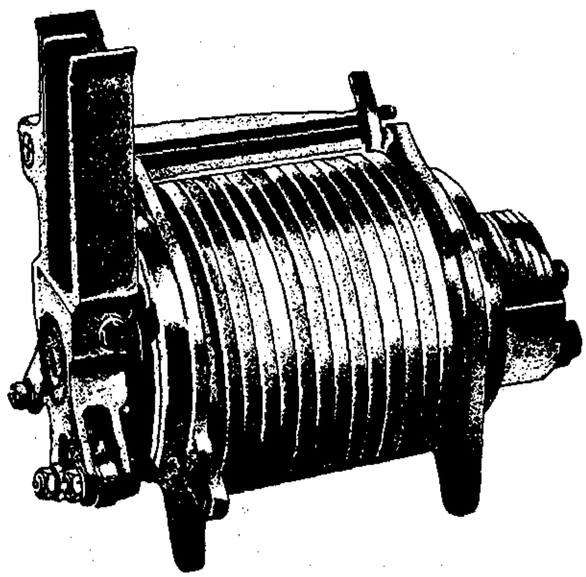


FIGURE 9–24. Typical steer damper.

Basically, a steer damper consists of a closed cylinder containing rotary vane-type working chambers (similar to the vane-type shimmy damper) and a valving system.

Steer dampers may contain any even number of working chambers. A steer damper with one vane on the wing shaft and one abutment leg on the abutment flange would have two chambers. Similarly, a unit with two vanes on the wingshaft and two abutment legs on the abutment flange would have four chambers. The single- or double-vaned units are the ones most commonly used.

A mechanical linkage is connected from the protruding splined portion of the wing shaft to the wheel fork and is used as a means for transmitting force. The linkage on the steer damper may be connected to a heavy coil spring on the outside of the reservoir for automatic wheel centering.

The steer damper accomplishes two separate functions: one is steering the nosewheel and the other is shimmy damping. Only the damping function of the steer damper is discussed in this section.

The steer damper automatically reverts to damping when, for any reason, the flow of high-pressure fluid is removed from the inlet of the steer damper. This high pressure, which activates the steer damper valving system, is removed from the control passages by one of two methods, depending on the installation. When the inlet line is supplied with a three-way solenoid valve and the high-pressure supply is shut off, the fluid bleeds out of the unit through the outlet port of the valve to the discharge line. When a two-way solenoid valve is furnished, high-pressure fluid leaves the control passages through an orifice specially provided for this type of installation which is located in the center of the return line plunger.

Effective damping is assured by maintaining unaerated hydraulic fluid in the working chambers. This is accomplished by allowing air and a very small amount of hydraulic fluid to leave the working chambers through strategically located vent grooves while unaerated fluid is allowed to enter through replenishing valves from the hydraulic return line. Excessive pressure in the unit due to temperature changes is prevented by the thermal relief valve in the inlet flange.

Daily inspection of a steer damper should include a check for leakage and a complete inspection of all hydraulic connections, steer damper mounting bolts for tightness, and all fittings and connections between the moving parts of the shock strut and the steer damper wing shaft.

BRAKE SYSTEMS

Proper functioning of the brakes is of utmost importance on aircraft. The brakes are used for slowing, stopping, holding, or steering the aircraft. They must develop sufficient force to stop the aircraft in a reasonable distance; brakes must hold the aircraft for normal engine turnup; and brakes must permit steering of the aircraft on the ground. Brakes are installed in each main landing wheel and they may be actuated independently of each other. The right-hand landing wheel is controlled by applying toe pressure to the right rudder pedal and the left-hand wheel is controlled by the left rudder pedal.

For the brakes to function efficiently, each component in the brake system must operate properly, and each brake assembly on the aircraft must operate with equal effectiveness. It is therefore important that the entire brake system be inspected frequently and an ample supply of hydraulic fluid be maintained in the system. Each brake assembly must be adjusted properly and friction surfaces kept free of grease and oil.

Three types of brake systems are in general use: (1) Independent systems, (2) power control systems, and (3) power boost systems. In addition, there are several different types of brake assemblies in widespread use.

Independent Brake Systems

In general, the independent brake system is used on small aircraft. This type of brake system is termed "independent" because it has its own reservoir and is entirely independent of the aircraft's main hydraulic system.

Independent brake systems are powered by master cylinders similar to those used in the conventional automobile brake system. The system is composed of a reservoir, one or two master cylinders,

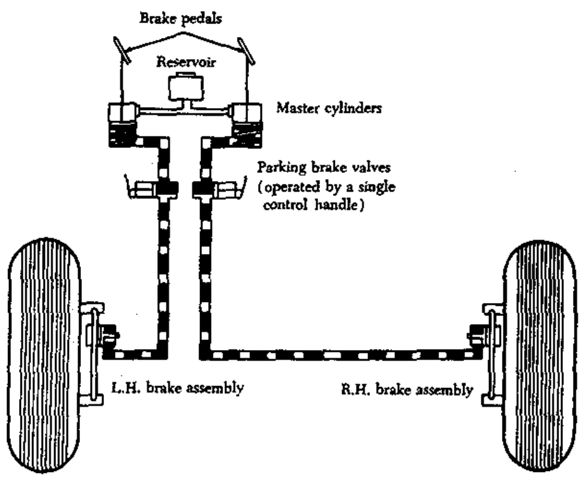


FIGURE 9–25. Typical independent brake system.

mechanical linkage which connects each master cylinder with its corresponding brake pedal, connecting fluid lines, and a brake assembly in each main landing gear wheel (figure 9–25).

Each master cylinder is actuated by toe pressure on its related pedal. The master cylinder builds up pressure by the movement of a piston inside a sealed, fluid-filled cylinder. The resulting hydraulic pressure is transmitted to the fluid line connected to the brake assembly in the wheel. This results in the friction necessary to stop the wheel.

When the brake pedal is released, the master cylinder piston is returned to the "off" position by a return spring. Fluid that was moved into the brake assembly is then pushed back to the master cylinder by a piston in the brake assembly. The brake assembly piston is returned to the "off" position by a return spring in the brake. Some light aircraft are equipped with a single master cylinder which is hand-lever operated and applies brake action to both main wheels simultaneously. Steering on this system is accomplished by nosewheel linkage.

The typical master cylinder has a compensating port or valve that permits fluid to flow from the brake chamber back to the reservoir when excessive pressure is developed in the brake line due to temperature changes. This ensures that the master cylinder won't lock or cause the brakes to drag.

Various manufacturers have designed master cylinders for use on aircraft. All are similar in operation, differing only in minor details and construction. Two well-known master cylinders—the Goodyear and the Warner—are described and illustrated in this section.

In the Goodyear master cylinder (figure 9–26) fluid is fed from an external reservoir by gravity to the master cylinder. The fluid enters through the cylinder inlet port and compensating port and fills the master cylinder casting ahead of the piston and the fluid line leading to the brake actuating cylinder.

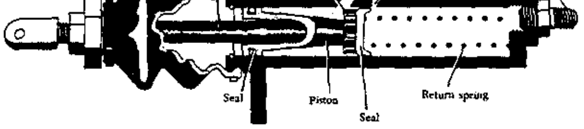


Figure 9–26. Goodyear master brake cylinder.

Application of the brake pedal, which is linked to the master cylinder piston rod, causes the piston rod to push the piston forward inside the master cylinder casting. A slight forward movement blocks the compensating port, and the buildup of pressure begins. This pressure is transmitted to the brake assembly.

When the brake pedal is released and returns to the "off" position, the piston return spring pushes the front piston seal and the piston back to full "off" position against the piston return stop. This again clears the compensating port. Fluid that was moved into the brake assembly and brake connecting line is then pushed back to the master cylinder by the brake piston which is returned to the "off" position by the pressure of the brake piston return springs. Any pressure or excess volume of fluid is relieved through the compensating port and passes back to the fluid reservoir. This prevents the master cylinder from locking or causing the brakes to drag.

If any fluid is lost back of the front piston seal due to leakage, it is automatically replaced from the fluid reservoir by gravity. Any fluid lost in front of the piston from leaks in the line or at the brake assembly is automatically replaced through the piston head ports, and around the lip of the front piston seal when the piston makes the return stroke to the full "off" position. The front piston seal functions as a seal only during the forward stroke.

These automatic fluid replacement arrangements always keep the master cylinder, brake connecting line, and brake assembly fully supplied with fluid as long as there is fluid in the reservoir.

The rear piston seal seals the rear end of the cylinder at all times to prevent leakage of fluid, and the flexible rubber boot serves only as a dust cover.

The brakes may be applied for parking by a ratchet-type lock built into the mechanical linkage between the master cylinder and the foot pedal. Any change in the volume of fluid due to expansion while the parking brake is on is taken care of by a spring incorporated in the linkage. The brakes are unlocked by application of sufficient pressure on the brake pedals to unload the ratchet.

Brake systems employing the Goodyear master cylinder must be bled from the top down. In no case should bleeding be attempted from the bottom up, because it is impossible to remove the air behind the piston seal.

The Warner master cylinder (figure 9–27) incorporates a reservoir, pressure chamber, and compensating device in a single housing. The reservoir is vented to the atmosphere through the filler plug, which also contains a check valve. A fluid level tube is located in the side of the reservoir housing.

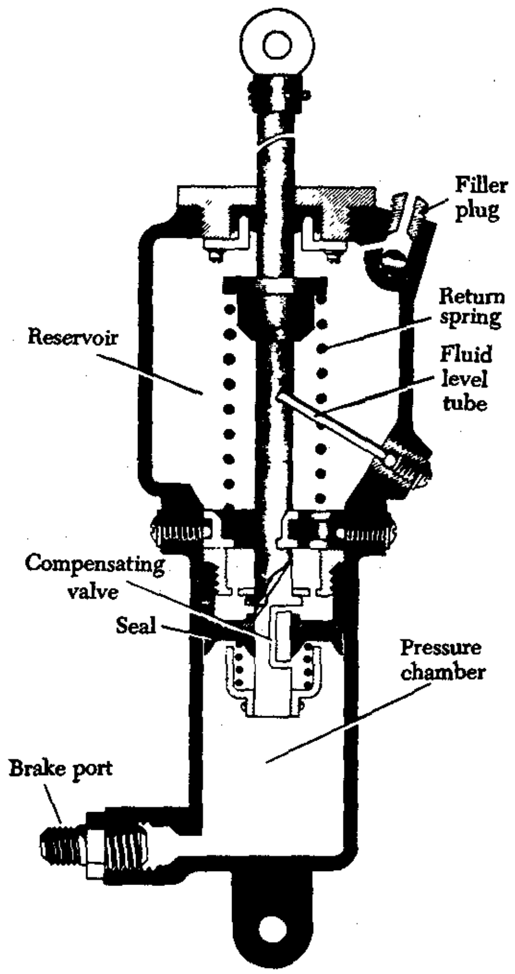


FIGURE 9–27. Warner master brake cylinder.

Toe pressure on the brake pedal is transferred to the cylinder piston by mechanical linkage. As the piston moves downward, the compensating valve closes and pressure is trapped in the pressure chamber. Further movement of the piston forces fluid into the brake assembly, creating the braking action. When toe pressure is removed from the brake pedal, the piston return spring returns the piston to the "off" position. The compensating device allows fluid to flow to and from the reservoir and pressure chamber when the brakes are in the "off" position and the entire system is under atmospheric pressure.

Certain models of the Warner master cylinder have a parking feature which consists of a ratchet and spring arrangement. The ratchet locks the unit in the "on" position, and the spring compensates for expansion and contraction of fluid.

Power Brake Control Systems

Power brake control valve systems (figure 9–28) are used on aircraft requiring a large volume of fluid to operate the brakes. As a general rule, this applies to many large aircraft. Because of their weight and size, large wheels and brakes are required. Larger brakes mean greater fluid displacement and higher pressures, and for this reason independent master cylinder systems are not practical on heavy aircraft.

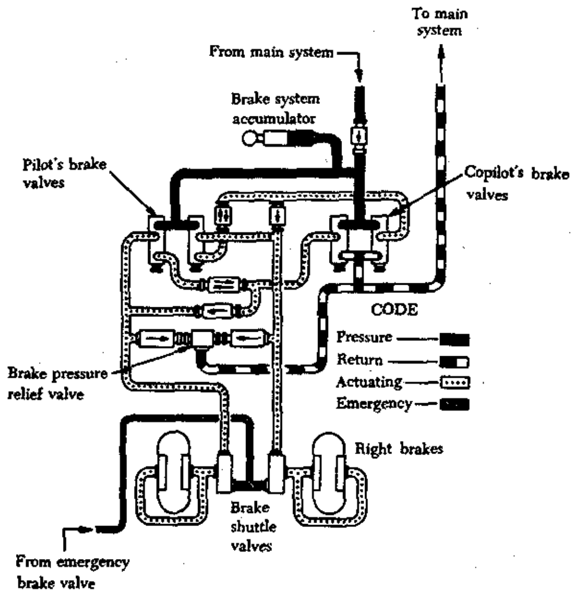


FIGURE 9–28. Typical power brake control valve system.

In this system a line is tapped off from the main hydraulic system pressure line. The first unit in this line is a check valve which prevents loss of brake system pressure in case of main system failure.

The next unit is the accumulator which stores a reserve supply of fluid under pressure. When the brakes are applied and pressure drops in the accumulator, more fluid enters from the main system and is trapped by the check valve. The accumulator also acts as a surge chamber for excessive loads imposed upon the brake hydraulic system.

Following the accumulator are the pilot's and copilot's control valves. The control valves regulate and control the volume and pressure of the fluid which actuates the brakes.

Four check valves and two orifice check valves are installed in the pilot's and copilot's brake actuating lines. The check valves allow the flow of fluid in one direction only. The orifice check valves allow unrestricted flow of fluid in one direction from the pilot's brake control valve; flow in the opposite direction is restricted by an orifice in the poppet. Orifice check valves help prevent chatter.

The next unit in the brake actuating lines is the pressure relief valve. In this particular system, the pressure relief valve is preset to open at 825 p.s.i. to discharge fluid into the return line, and closes at 760 p.s.i. minimum.

Each brake actuating line incorporates a shuttle valve for the purpose of isolating the emergency brake system from the normal brake system. When brake actuating pressure enters the shuttle valve, the shuttle is automatically moved to the opposite end of the valve. This closes off the hydraulic brake system actuating line. Fluid returning from the brakes travels back into the system to which the shuttle was last open.

Pressure Ball-Check Brake Control Valve

A pressure ball-check power brake control valve (figure 9–29) releases and regulates main system pressure to the brakes and relieves thermal expansion when the brakes are not being used. The main parts of the valve are the housing, piston assembly, and tuning fork. The housing contains three chambers and ports: pressure inlet, brake, and return.

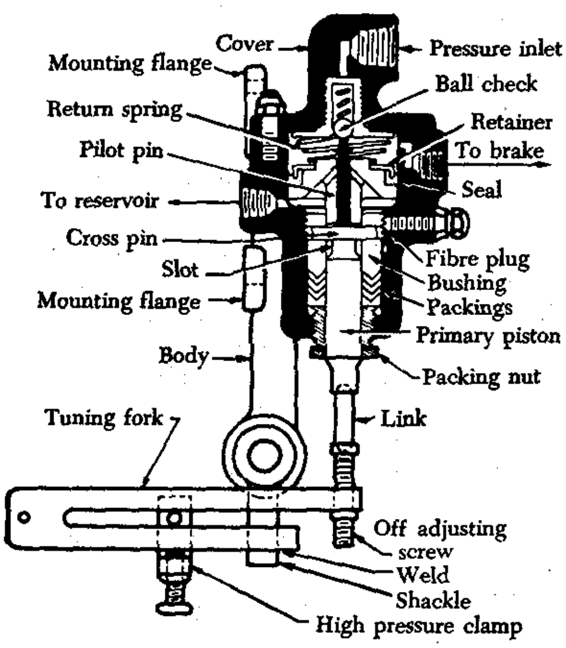


FIGURE 9–29. Pressure ball-check power brake control valve.

When toe pressure is applied to the brake pedal, the motion is transmitted through linkage to the tuning fork. The tuning fork swivels, moving the piston upward in the cylinder. The first movement upward causes the piston head to contact a flange on the pilot pin, closing the return fluid passage. Further movement upward unseats the ball-check valve allowing main system pressure to flow into the brake line. As the pressure increases in the brake actuating cylinder and line, the pressure also increases on the top side of the piston. When the total force on top of the piston is greater than the force applied at the brake pedal, the piston is forced downward against the bar spring tension. This allows the ball-check valve to seat, closing off system pressure. In this position, the pressure and return ports are both closed and the power brake valve is balanced. This balancing action cuts system pressure down to brake pressure by closing off the pressure from the main system when the desired brake pressure is attained. As long as the valve is balanced, fluid under pressure is trapped in the brake assembly and line.

Power Brake Control Valve (Sliding Spool Type)

A sliding spool power brake control valve (figure 9–30) basically consists of a sleeve and spool installed in a housing. The spool moves inside the sleeve, opening or closing either the pressure or return port of the brake line. Two springs are provided. The large spring, referred to in figure 9–30 as the plunger spring, provides "feel" to the brake pedal. The small spring returns the spool to the "off" position.

When the plunger is depressed the large spring moves the spool closing the return port and opening the pressure port to the brake line. When the pressure enters the valve, fluid flows to the opposite end of the spool through a hole when the pressure pushes the spool back far enough toward the large spring to close the pressure port, but does not open the return port. The valve is then in the static condition. This movement partially compresses the large spring, giving "feel" to the brake pedal. When the brake pedal is released the small spring moves the spool back and opens the return port. This allows fluid pressure in the brake line to flow out through the return port.

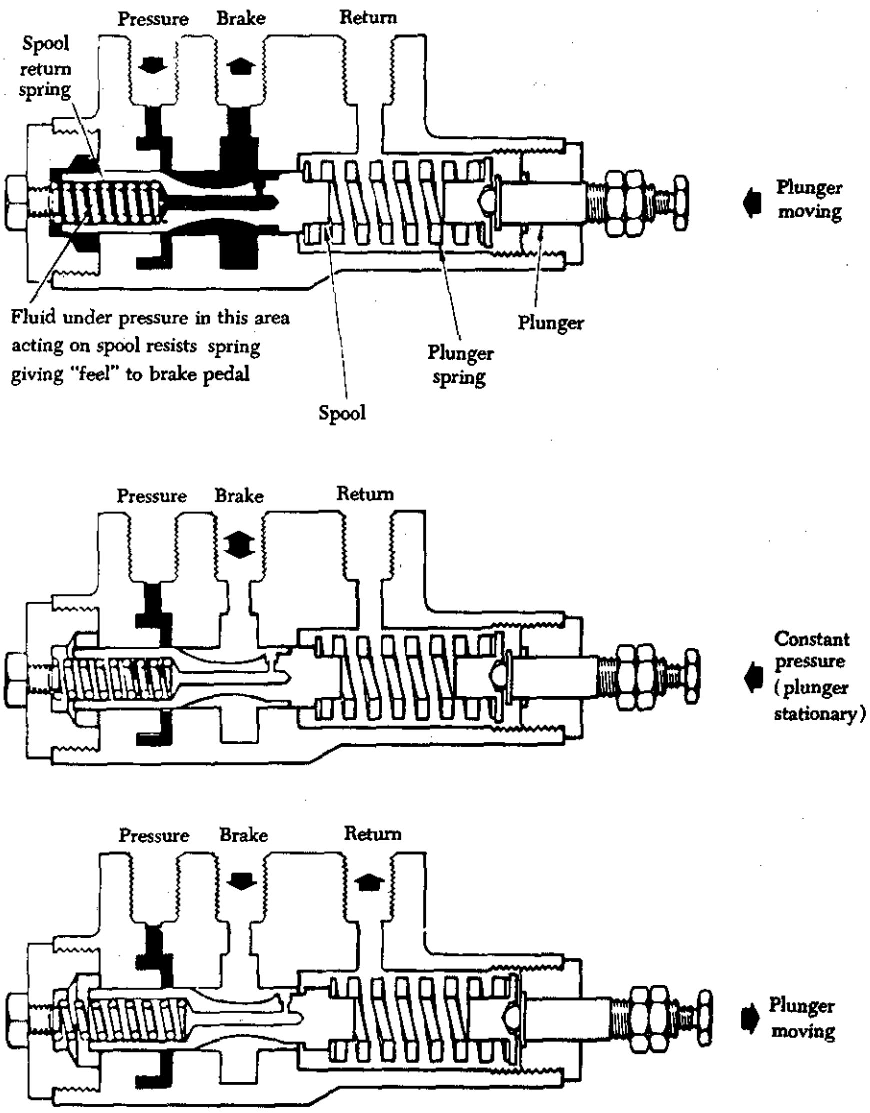


FIGURE 9–30. Sliding spool power brake control valve.

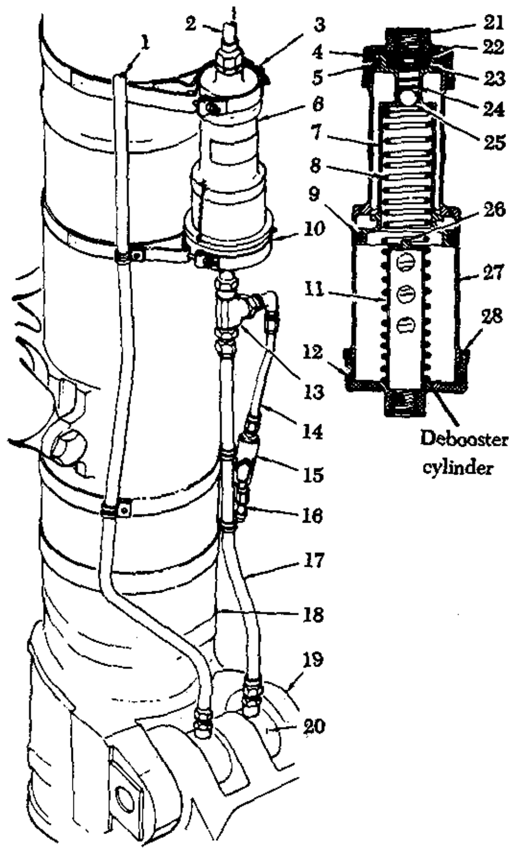
Brake Debooster Cylinders

In some power brake control valve systems, debooster cylinders are used in conjunction with the power brake control valves. Debooster units are generally used on aircraft equipped with a high-pressure hydraulic system and low-pressure brakes. Brake debooster cylinders reduce the pressure to the brake and increase the volume of fluid flow. Figure 9–31 shows a typical debooster cylinder installation, mounted on the landing gear shock strut in the line between the control valve and the brake.

As shown in the schematic diagram of the unit, the cylinder housing contains a small chamber and a large chamber, a piston with a small head and a large head, a spring-loaded ball-check valve, and a piston return spring.

In the "off" position, the piston assembly is held at the inlet (or small) end of the debooster by the piston return spring. The ball-check valve is held on its seat in the small piston head by a light spring. Fluid displaced by thermal expansion in the brake unit can easily push the ball-check valve off its seat to escape through the debooster back to the power control valve.

When the brakes are applied, fluid under pressure enters the inlet port to act on the small end of the piston. The ball check prevents the fluid from passing through the shaft. Force is transmitted through the small end of the piston to the large end of the piston. As the piston moves downward in the housing a new flow of fluid is created from the



1. Emergency system pressure line
2. Main brake pressure line
3. Upper support clamp
4. Packing
5. Packing
6. Debooster cylinder assembly
7. Piston
8. Piston spring
9. Packing
10. Lower support clamp
11. Riser tube
12. Packing
13. Tee fitting
14. Brake line (to pressure relief valve)
15. Brake pressure relief valve
16. Overflow line
17. Brake line (debooster to shuttle valve)
18. Shock strut
19. Torque link
20. Brake shuttle valve
21. Upper end cap
22. Snapring
23. Spring retainer
24. Valve spring
25. Ball
26. Ball pedestal
27. Barrel
28. Lower end cap

FIGURE 9–31. Brake debooster cylinder.

large end of the housing through the outlet port to the brakes. Because the force from the small piston head is distributed over the greater area of the large piston head, pressure at the outlet port is reduced. At the same time, a greater volume of fluid is displaced by the large piston head than that used to move the small piston head.

Normally, the brakes will be fully applied before the piston has reached the lower end of its travel. However, if the piston fails to meet sufficient resistance to stop it (due to a loss of fluid from the brake unit or connecting lines), the piston will continue to move downward until the riser unseats the ball-check valve in the hollow shaft. With the ball-check valve unseated, fluid from the power control valve will pass through the piston shaft to replace the lost fluid. Since the fluid passing through the piston shaft acts on the large piston head, the piston will move up, allowing the ball-check valve to seat when pressure in the brake assembly becomes normal.

When the brake pedals are released pressure is removed from the inlet port, and the piston return spring moves the piston rapidly back to the top of the debooster. The rapid movement causes a suction in the line to the brake assembly, resulting in faster release of the brakes.

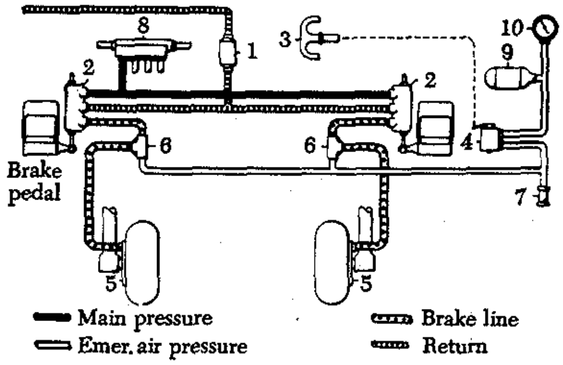
Power Boost Brake Systems

As a general rule, power boost brake systems are used on aircraft that land too fast to employ the independent brake system, but are too light in weight to require power brake control valves.

In this type of system, a line is tapped off the main hydraulic system pressure line, but main hydraulic system pressure does not enter the brakes. Main system pressure is used only to assist the pedals through the use of power boost master cylinders.

A typical power boost brake system (figure 9–32) consists of a reservoir, two power boost master cylinders, two shuttle valves, and the brake assembly in each main landing wheel. A compressed air bottle with a gage and release valve is installed for emergency operation of the brakes. Main hydraulic system pressure is routed from the pressure manifold to the power master cylinders. When the brake pedals are depressed, fluid for actuating the brakes is routed from the power boost master cylinders through the shuttle valves to the brakes.

When the brake pedals are released, the main system pressure port in the master cylinder is closed. Fluid that was moved into the brake assem-



1. Brake reservoir
2. Power boost master cylinder
3. Emergency brake control
4. Air release valve
5. Wheel brake
6. Shuttle valve
7. Air vent
8. Main system pressure manifold
9. Emergency air bottle
10. Emergency air gage

FIGURE 9–32. Power boost master cylinder brake system.

bly is forced out the return port by a piston in the brake assembly, through the return line to the brake reservoir. The brake reservoir is connected to the main hydraulic system reservoir to assure an adequate supply of fluid to operate the brakes.

Nose Wheel Brakes

Many transport type aircraft such as the B–727 have brakes installed on the nose wheel. Movement of either right or left brake pedal will actuate the corresponding right or left main gear brake metering valve.

Movement of both brake pedals together will apply both main gear brakes and the nose gear brakes after approximately half the pedal stroke. Actuation of one brake pedal for directional control braking will not actuate the nose gear brakes until nearly the end of the pedal stroke. Nose gear brake application is controlled through the brake differential linkage.

When the brake pedals are depressed the differential directs the force through linkage to the main gear metering valve first. After this valve is opened, continued movement of the brake pedals is directed to the nose gear metering valve, opening it and activating the brakes. Nose wheel braking is available above 15 mph from straight ahead to approximately 6° of steering. At this point the nose wheel steering brake cutoff switch activates the anti skirt valve and shuts off nose wheel braking. There is no nose wheel braking below 15 mph.

BRAKE ASSEMBLIES

Brake assemblies commonly used on aircraft are the single-disk, dual-disk, multiple-disk, segmented rotor, or expander tube types. The single- and dual-disk types are more commonly used on small aircraft; the multiple-disk type is normally used on medium-sized aircraft; and the segmented rotor and expander tube types are commonly found on heavier aircraft.

Single-Disk Brakes

With the single-disk brake, braking is accomplished by applying friction to both sides of a rotating disk which is keyed to the landing gear wheel. There are several variations of the single-disk brake; however, all operate on the same principle and differ mainly in the number of cylinders and the type of brake housing. Brake housings may be either the one-piece or divided type. Figure 9–33 shows a single-disk brake installed on an aircraft, with the wheel removed. The brake housing is attached to the landing gear axle flange by mounting bolts.

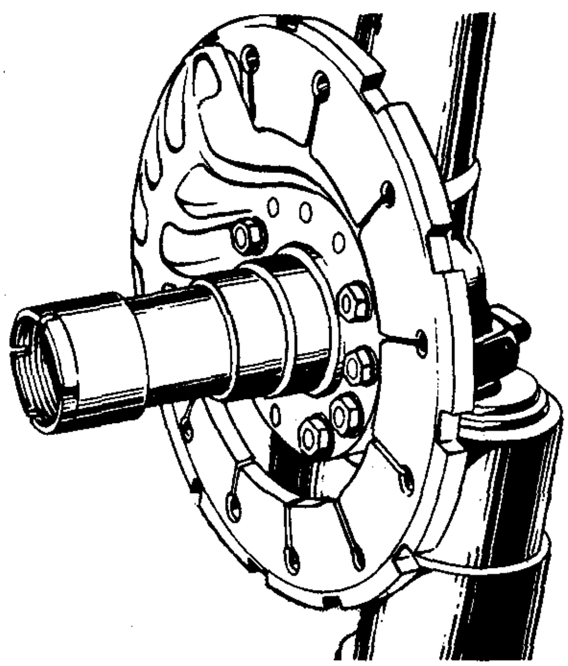
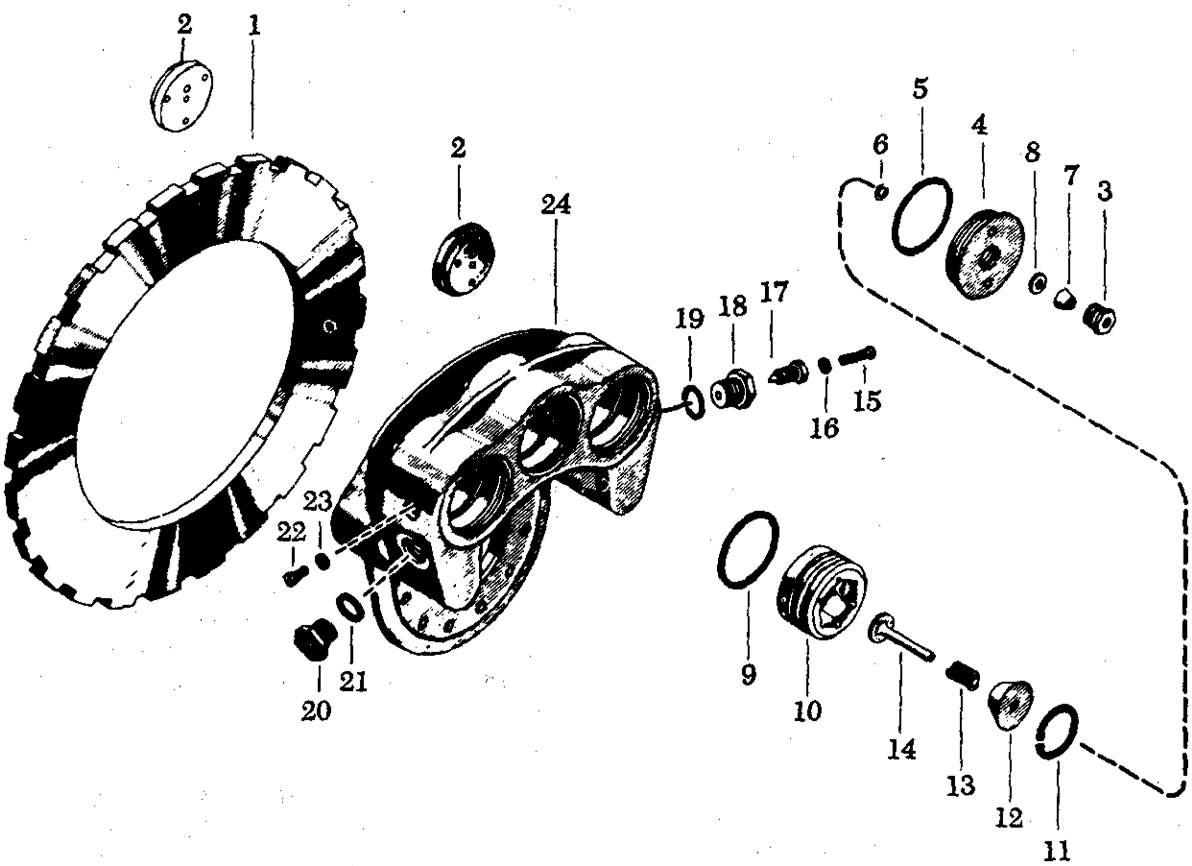


FIGURE 9–33. Typical single-disk brake installation.

Figure 9–34 shows an exploded view of a typical single-disk brake assembly. This brake assembly has a three-cylinder, one-piece housing. Each cylinder



1. Brake disk
2. Lining puck
3. Adjusting pin nut
4. Cylinder head
5. O-ring gasket
6. O-ring packing
7. Adjusting pin grip
8. Washer
9. O-ring packing
10. Piston
11. Internal retainer ring
12. Spring guide
13. Brake return spring
14. Adjusting pin
15. Bleeder screw
16. Washer
17. Bleeder valve
18. Bleeder adapter
19. Gasket
20. Fluid inlet bushing
21. Gasket
22. Screw
23. Washer
24. Brake housing

FIGURE 9–34. Exploded view of single-disk brake assembly.

in the housing contains a piston, a return spring, and an automatic adjusting pin.

There are six brake linings, three on the inboard side of the rotating disk and three on the outboard side of the rotating disk. These brake linings are often referred to as "pucks." The outboard lining pucks are attached to the three pistons and move in and out of the three cylinders when the brakes are operated. The inboard lining pucks are mounted in recesses in the brake housing and are therefore stationary.

Hydraulic pressure from the brake control unit enters the brake cylinders and forces the pistons and their pucks against the rotating disk. The rotating disk is keyed to the landing gear wheel so that it is free to move laterally within the brake cavity of the wheel. Thus, the rotating disk is forced into contact with the inboard pucks mounted in the housing. The lateral movement of the rotating disk ensures equal braking action on both sides of the disk.

When brake pressure is released, the return springs force the pistons back to provide a preset clearance between the pucks and the disk. The self-adjusting feature of the brake will maintain the desired puck-to-disk clearance, regardless of lining wear.

When the brakes are applied, hydraulic pressure moves each piston and its puck against the disk. At the same time, the piston pushes against the adjusting pin (through the spring guide) and moves the pin inboard against the friction of the adjusting pin grip. When pressure is relieved, the force of the return spring is sufficient to move the piston away from the brake disk but not enough to move the adjusting pin, which is held by the friction of the pin grip. The piston moves away from the disk until it stops against the head of the adjusting pin. Thus, regardless of the amount of wear, the same travel of the piston will be required to apply the brake.

Maintenance of the single-disk brake may include bleeding, performing operational checks, checking lining wear, checking disk wear, and replacing worn linings and disks.

A bleeder valve is provided on the brake housing for bleeding the single-disk brake. Always bleed brakes in accordance with the applicable manufacturer's instructions.

Operational checks are made during taxiing. Braking action for each main landing gear wheel should be equal, with equal application of pedal pressure and without any evidence of soft or spongy action. When pedal pressure is released, the brakes should release without any evidence of drag.

Dual-Disk Brakes

Dual-disk brakes are used on aircraft when more braking friction is desired. The dual-disk brake is very similar to the single-disk type, except that two rotating disks instead of one are used.

Multiple-Disk Brakes

Multiple-disk brakes are heavy-duty brakes, designed for use with power brake control valves or power boost master cylinders. Figure 9–35 is an exploded view of the complete multiple-disk brake assembly. The brake consists of a bearing carrier, four rotating disks called rotors, three stationary disks called stators, a circular actuating cylinder, an automatic adjuster, and various minor components.

Regulated hydraulic pressure is applied through the automatic adjuster to a chamber in the bearing carrier. The bearing carrier is bolted to the shock strut axle flange and serves as a housing for the

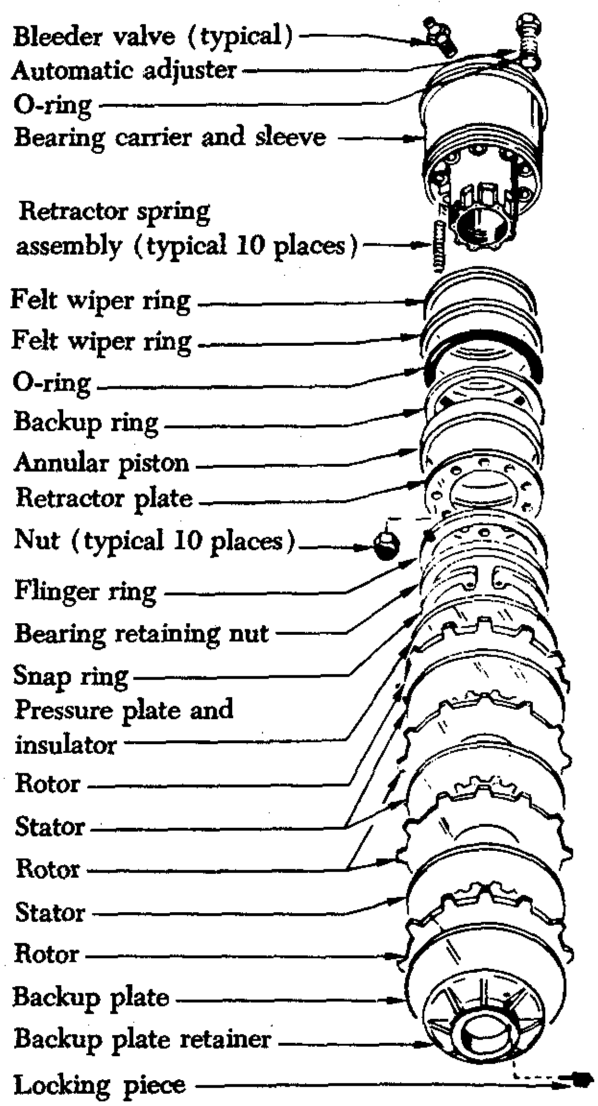


FIGURE 9–35. Multiple-disk brake.

annular actuating piston. Hydraulic pressure forces the annular piston to move outward, compressing the rotating disks, which are keyed to the landing wheel and compressing the stationary disks, which are keyed to the bearing carrier. The resulting friction causes a braking action on the wheel and tire assembly.

When the hydraulic pressure is relieved, the retracting springs force the actuating piston to retract into the housing chamber in the bearing carrier. The hydraulic fluid in the chamber is forced out by the returning of the annular actuating piston, and is bled through the automatic adjuster to the return line. The automatic adjuster traps a predetermined amount of fluid in the brake, an amount just sufficient to give correct clearances between the rotating disks and stationary disks.

Maintenance of the multiple-disk brake may include bleeding, checking disks for wear, replacing disks, and performing operational checks.

Bleeder valves are provided, making it possible to bleed the brake in any position. Bleeding should be accomplished according to the instructions for the specific aircraft.

The disks are checked for wear using a gage equipped with a movable slide, a stop pin, and an anvil.

Segmented Rotor Brakes

Segmented rotor brakes are heavy-duty brakes, especially adapted for use with high-pressure hydraulic systems. These brakes may be used with either power brake control valves or power boost master cylinders. Braking is accomplished by means of several sets of stationary, high-friction type brake linings making contact with rotating (rotor) segments. A cutaway view of the brake is shown in figure 9-36.

The segmented rotor brake is very similar to the multiple-disk type described previously. The brake

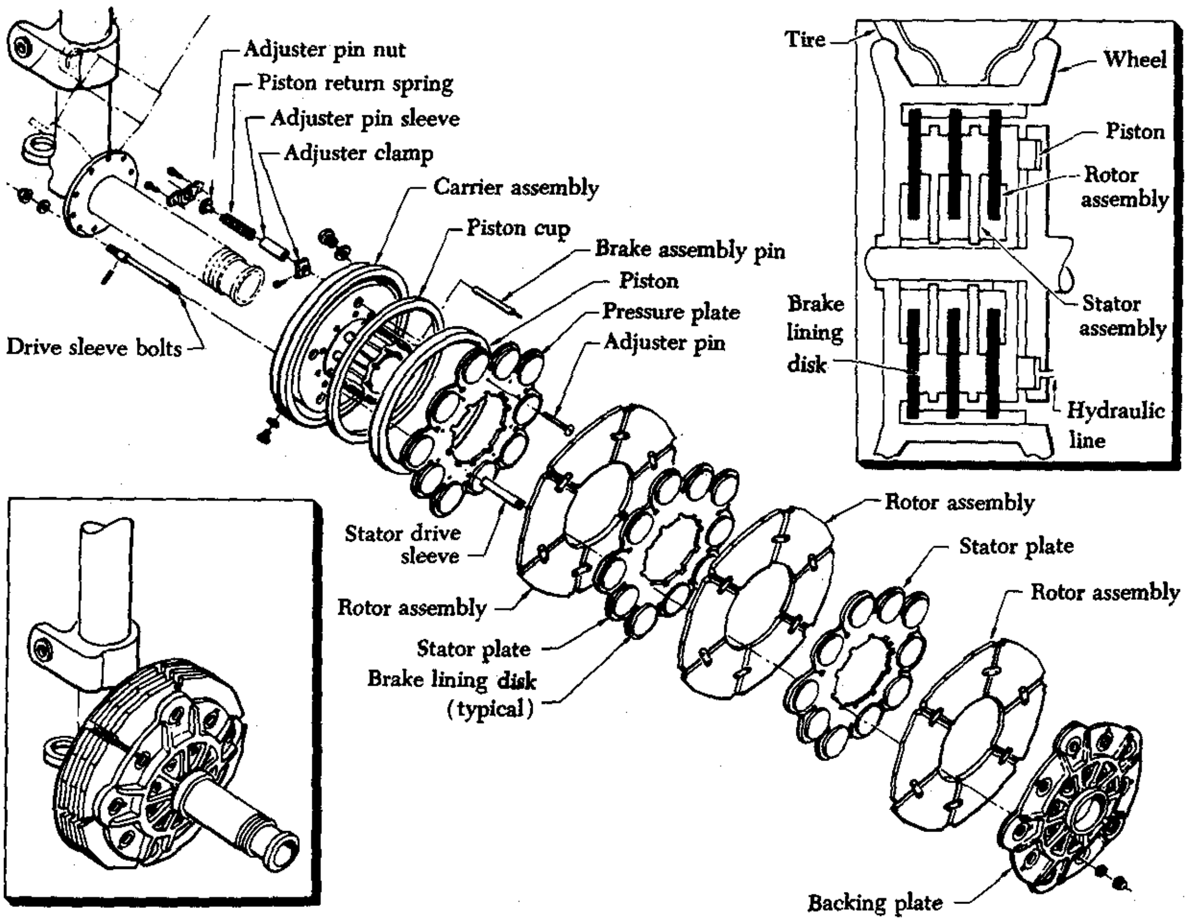


FIGURE 9-36. Segmented rotor brake assembly units.

assembly consists of a carrier, two pistons and piston cup seals, a pressure plate, an auxiliary stator plate, roto segments, stator plates, a compensating shim, automatic adjusters, and a backing plate.

The carrier assembly is the basic unit of the brake. It is the part which is attached to the landing gear shock strut flange upon which the other components are assembled. Two grooves, or cylinders, are machined in the carrier to receive the piston cups and pistons. Hydraulic fluid is admitted to these cylinders through a line which is attached to a threaded boss on the outside of the carrier.

The automatic adjusters are threaded into equally spaced holes (figure 9–36) located in the face of the carrier. The adjusters compensate for lining wear by maintaining a fixed running clearance with the brake in the "off" position. Each automatic adjuster is composed of an adjuster pin, adjuster clamp, return spring, sleeve, nut, and clamp hold-down assembly.

The pressure plate is a flat, circular, nonrotating plate, notched on the inside diameter to fit over the stator drive sleeves.

Following the pressure plate is the auxiliary stator plate. This is also a nonrotating plate, notched on the inside diameter. Brake lining is riveted to one side of the auxiliary stator plate.

The next unit in the assembly is the first of several rotor segments. Each rotor plate is notched on the outside circumference. This enables it to be keyed to the landing gear wheel and rotate with it. This particular model of the segmented rotor brake has four sets of these rotor segments.

Mounted between each of the rotor segments is a stator plate (figure 9–37). The stator plates are non-rotating plates and have brake linings riveted to both sides. The linings are in the form of multiple blocks, separated to aid in the dissipation of heat.

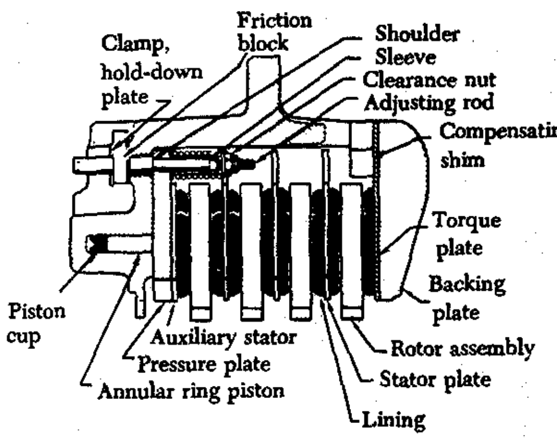


FIGURE 9–37. Cross section of a segmented rotor brake.

Following the last rotor segment is the compensating shim. The compensating shim is provided so that all the brake lining available for wear can be used. Without the shim, only about one-half of the lining could be used due to the limited travel of the pistons. After approximately one-half of the brake lining has been used, the shim is removed. The adjuster clamp is then re-positioned on the automatic adjuster pin, restoring piston travel so that the remaining lining can be used.

The backing plate (figure 9–38) is the final unit in the assembly and is a non-rotating plate with brake linings riveted to one side. The backing plate receives the ultimate hydraulic force resulting from brake application.

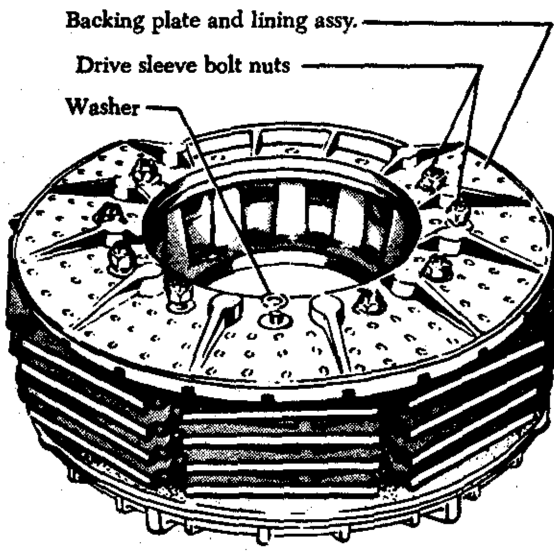


FIGURE 9–38. Backing plate installed.

Hydraulic pressure released from the brake control unit enters the brake cylinders and acts on the piston cups and pistons forcing them outward from the carrier. The pistons apply force against the pressure plate, which in turn pushes against the auxiliary stator. The auxiliary stator contacts the first rotor segment, which in turn engages the first stator plate. Lateral movement continues until all the braking surfaces are in contact. The auxiliary stator plate, the stator plates, and the backing plate are prevented from rotating by the stator drive sleeves. Thus, the non-rotating linings are all forced in contact with the rotors, creating enough friction to stop the wheel to which the rotors are keyed.

The function of the automatic adjuster is dependent upon the correct friction between the adjuster pin and the adjuster clamp. Adjustment of brake running clearance is governed by the distance obtained between the adjuster washer and the end of the adjuster nut when the brake is assembled.

During brake application, the pressure plate moves toward the rotors. The washer moves with the pressure plate, causing the spring to compress. As piston travel increases and as the pressure plate moves farther, the lining then comes in contact with the rotor segments. As the linings wear, the pressure plate continues to move and eventually comes into direct contact with the adjuster sleeve through the adjuster washer. Thus, no further force is applied to the spring. Additional travel of the pressure plate caused by lining wear will force the adjuster pin to slide through the adjuster clamp.

When hydraulic pressure in the brake is released, the return spring forces the pressure plate to return until it bottoms on the shoulder of the adjuster pin. As this cycle is repeated during brake application and release, the adjuster pin will advance through the adjuster clamp due to lining wear, but the running clearance will remain constant.

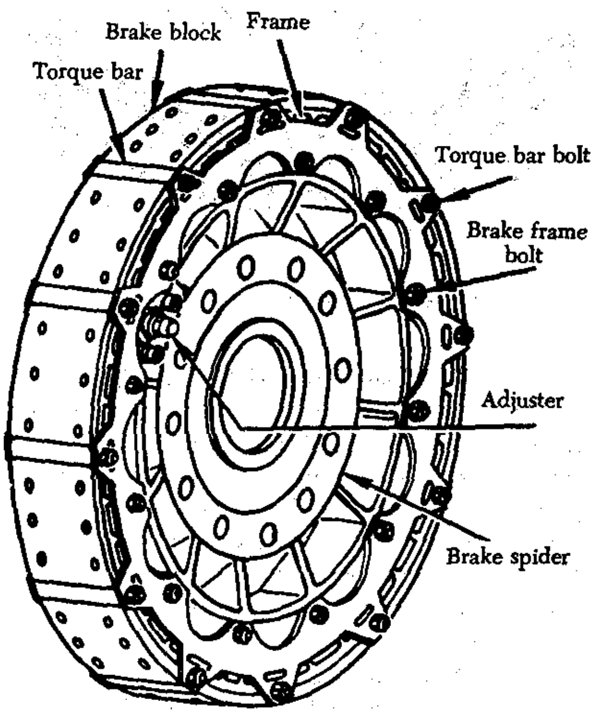


FIGURE 9–39. Assembled expander tube brake.

Expander Tube Brakes

The expander tube brake (figure 9–39) is a low-pressure brake with 360° of braking surface. It is light in weight, has few moving parts, and may be used on large aircraft as well as on small aircraft.

An exploded view of the expander tube brake is shown in figure 9–40. The main parts of the brake are the frame, expander tube, brake blocks, return springs, and clearance adjuster.

The brake frame is the basic unit around which the expander tube brake is built. The main part of the frame is a casting which is bolted to the torque flange of the landing gear shock strut. Detachable metal sides form a groove around the outer circumference into which moving parts of the brake are fitted.

The expander tube is made of neoprene reinforced with fabric, and has a metal nozzle through which fluid enters and leaves the tube.

The brake blocks are made of special brake lining material, the actual braking surface being strengthened by a backing plate of metal. The brake blocks are held in place around the frame and are prevented from circumferential movement by the torque bars.

The brake return springs are semi-elliptical or half-moon in shape. One is fitted between each separation in the brake blocks. The ends of the return springs push outward against the torque bars, while the bowed center section pushes inward, retracting the brake blocks when the brakes are released.

When hydraulic fluid under pressure enters the expander tube the tube expands. Since the frame prevents the tube from expanding inward and to the sides, all movement is outward. This forces the brake blocks against the brake drum, creating friction. The tube shields prevent the expander tube from extruding out between the blocks, and the torque bars prevent the blocks from rotating with the drum. Friction created by the brake is directly proportional to brake line pressure.

The clearance adjuster (figure 9–40) consists of a spring-loaded piston acting behind a neoprene diaphragm. It closes off the fluid passage in the inlet manifold when the spring tension is greater than the fluid pressure in the passage. Tension on the spring may be increased or decreased by turning the adjustment screw. Some of the older models of the expander tube brake are not equipped with clearance adjusters.

For brakes equipped with adjusters, clearance between the brake blocks and drum is usually set to a

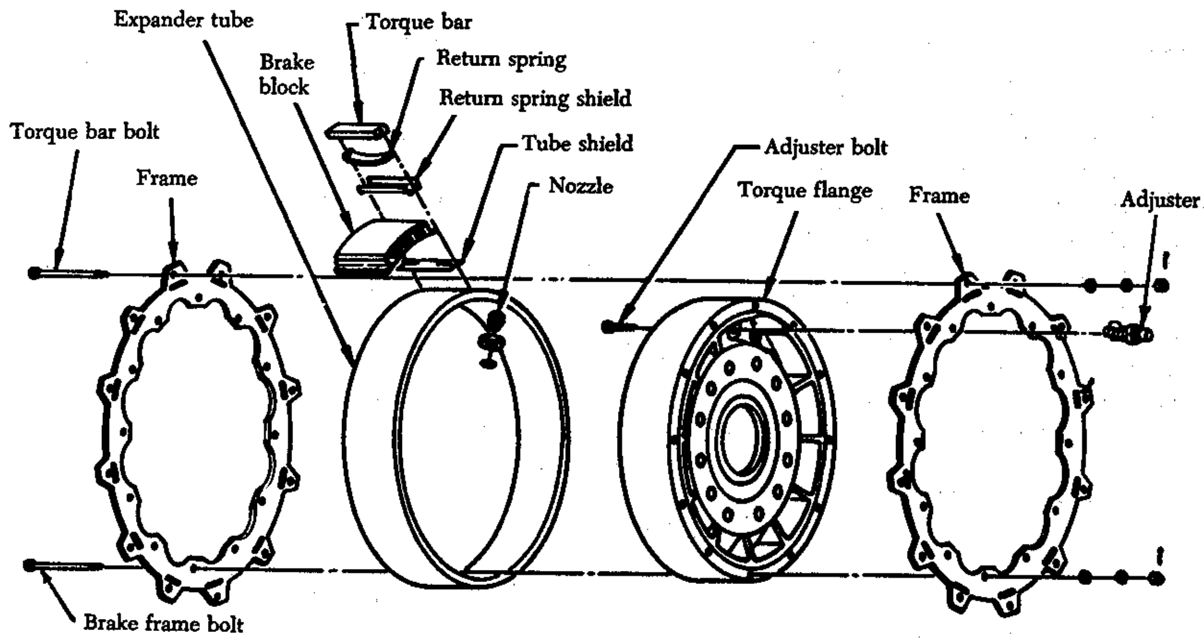


FIGURE 9–40. Exploded view of expander tube brakes.

minimum of 0.002 to 0.015 in., the exact setting depending on the particular aircraft concerned. All brakes on the same aircraft should be set to the same clearance.

To decrease clearance, turn the adjuster knob clockwise; to increase clearance, turn the adjuster knob counterclockwise. It should be kept in mind, however, that turning the adjuster knob alone does not change the clearance. The brakes must be applied and released after each setting of the adjuster knob to change the pressure in the brake and thereby change the brake clearance.

INSPECTION AND MAINTENANCE OF BRAKE SYSTEMS

Proper functioning of the brake system is of the utmost importance. Hence, conduct inspections at frequent intervals, and perform needed maintenance promptly and carefully.

When checking for leaks, make sure the system is under operating pressure. However, tighten any loose fittings with the pressure off. Check all flexible hoses carefully for swelling, cracking, or soft spots, and replace if evidence of deterioration is noted.

Maintain the proper fluid level at all times to prevent brake failure or the introduction of air into the system. Air in the system is indicated by a spongy action of the brake pedals. If air is present in the system, remove it by bleeding the system.

There are two general methods of bleeding brake systems—bleeding from the top downward (gravity method) and bleeding from the bottom upward (pressure method). The method used generally depends on the type and design of the brake system to be bled. In some instances it may depend on the bleeding equipment available. A general description of each method follows.

Gravity Method of Bleeding Brakes

In the gravity method, the air is expelled from the brake system through one of the bleeder valves provided on the brake assembly (figure 9–41).

A bleeder hose is attached to the bleeder valve, and the free end of the hose is placed in a recepta-

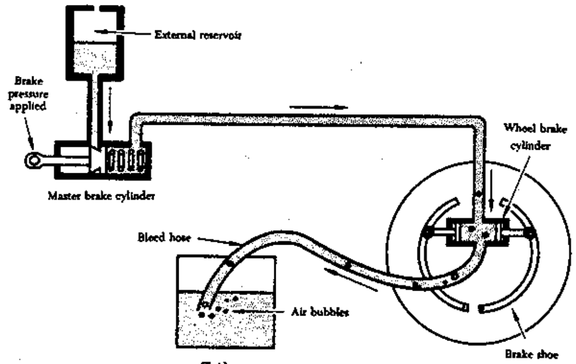


FIGURE 9–41. Gravity method of bleeding brakes.

cle containing enough hydraulic fluid to cover the end of the hose. The air-laden fluid is then forced from the system by operating the brake. If the brake system is a part of the main hydraulic system, a portable hydraulic test stand may be used to supply the pressure. If the system is an independent master cylinder system, the master cylinder will supply the necessary pressure. In either case, each time the brake pedal is released the bleeder valve must either be closed or the bleeder hose pinched off; otherwise, more air will be drawn back into the system. Bleeding should continue until no more air bubbles come through the bleeder hose into the container.

Pressure Method of Bleeding Brakes

In the pressure method, the air is expelled through the brake system reservoir or other specially provided location. Some aircraft have a bleeder valve located in the upper brake line. In using this method of bleeding, pressure is applied using a bleed tank (figure 9–42). A bleed tank is a portable tank containing hydraulic fluid under pressure. The bleeder tank is equipped with an air valve, air gage, and a connector hose. The connector hose attaches to the bleeder valve on the brake assembly and is provided with a shutoff valve.

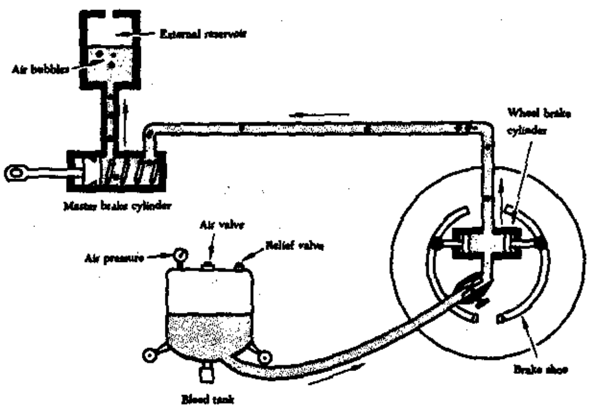


FIGURE 9–42. Pressure method of bleeding brakes.

Perform this method of bleeding strictly in accordance with the specific manufacturer's instructions for the aircraft concerned.

Although the bleeding of individual systems presents individual problems, observe the following precautions in all bleeding operations:

(1) Be certain that the bleeding equipment to be used is absolutely clean and is filled with the proper type of hydraulic fluid.
(2) Maintain an adequate supply of fluid during the entire operation. A low fluid supply will allow air to be drawn into the system.
(3) Bleeding should continue until no more air bubbles are expelled from the system, and a firm brake pedal is obtained.
(4) After the bleeding operation is completed, check the reservoir fluid level. With brake pressure on, check the entire system for leaks.

Brakes which have become overheated from excessive braking are dangerous and should be treated accordingly. Excessive brake heating weakens the tire and wheel structure and increases tire pressure.

AIRCRAFT LANDING WHEELS

Aircraft wheels provide the mounting for tires which absorb shock on landing, support the aircraft on the ground and assist in ground control during taxi, takeoff and landing. Wheels are usually made from either aluminum or magnesium. Either of these materials provides a strong, light weight wheel requiring very little maintenance.

1. Split wheel—the most popular type. (Figures 9–43 and 9–44 Heavy aircraft wheel, Figures 9–45 and 9–46 Light aircraft wheel.)
2. Removable flange type Figure 9–47.
3. Drop center fixed flange type Figure 9–48.

The split wheel is used on most aircraft today. Illustrations of wheels used on light civilian type and heavy transport type aircraft are shown to illustrate the similarities and differences.

Split Wheels

Figures 9–43 and 9–44 and the description that follows were extracted from the B.F. Goodrich maintenance manual on wheels. The wheel illustrated in figure 9–43 is used on the Boeing B–727 transport aircraft.

Description—The numbers in parenthesis refer to figures 9–43 and 9–44.

A. The main landing gear wheel is a tubeless, split-type assembly made of forged aluminum.
B. The inner and outer wheel half assemblies are fastened together by 18 equally spaced tie bolts (11), secured with nuts (9). A tubeless tire valve assembly installed in the web of the inner wheel half (48), with the valve stem (7) protruding through a vent hole in the outer wheel half (30), is used to inflate the tubeless tire used with

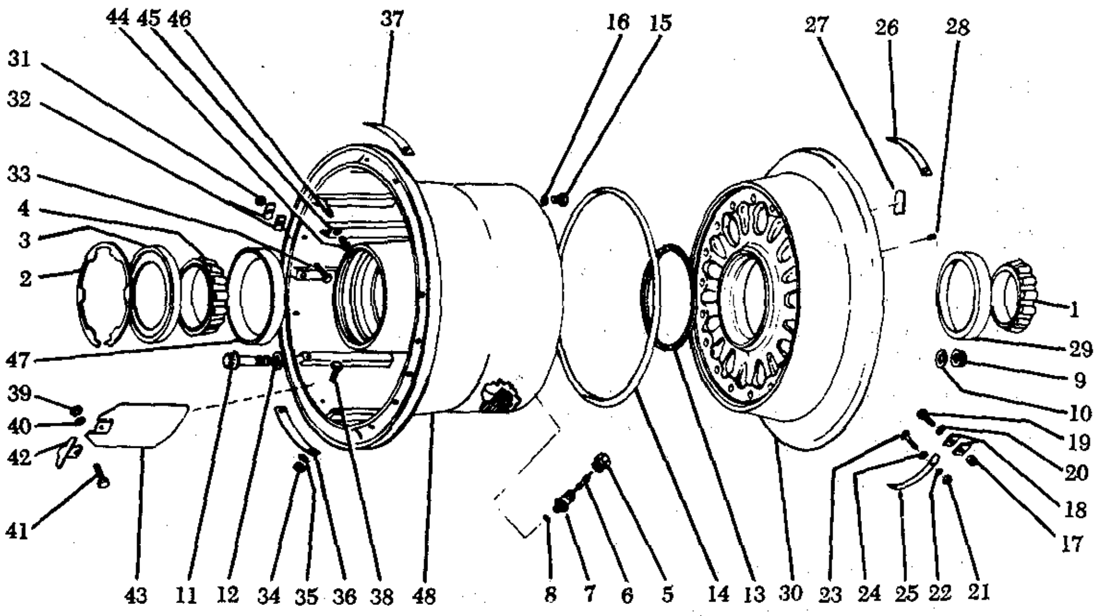


FIGURE 9–43. Split wheel—heavy aircraft.

Index No.	Description		
	WHEEL, LANDING GEAR, 49 x 17, TUBELESS, MAIN		
1	CONE BEARING	25	IDENTIFICATION PLATE
2	RING, RETAINING	26	INSTRUCTION PLATE
3	SEAL	27	PLATE, IDENTIFICATION
4	CONE, BEARING	28	INSERT, HELI-COIL
	VALVE ASSY, TUBELESS TIRE	29	CUP, BEARING
5	CAP, VALVE	30	WHEEL HALF, OUTER
6	VALVE, INSIDE		WHEEL HALF, ASSY, INNER
7	STEM, VALVE	31	NUT
8	GROMMET, RUBBER (TIRE AND RIM ASSOC.)	32	WEIGHT, WHEEL BALANCE, 1/4 oz.
9	NUT	33	BOLT, MACHINE
10	WASHER	34	NUT
11	BOLT	35	WASHER, FLAT
12	WASHER	36	IDENTIFICATION PLATE
13	PACKING, PREFORMED	37	INSTRUCTION PLATE
14	PACKING, PREFORMED	38	BOLT, MACHINE
15	PLUG, MACHINE THD, THERMAL PRESSURE	39	NUT
	RELIEF, ASSY OF	40	WASHER, FLAT
16	PACKING, PREFORMED	41	BOLT, MACHINE
	WHEEL HALF ASSY, OUTER	42	BRACKET
17	NUT	43	SHIELD, HEAT
18	WEIGHT, WHEEL BALANCE, 1/4 oz.	44	SCREW
19	BOLT, MACHINE	45	INSERT
20	WASHER	46	INSERT, HELI-COIL
21	NUT	47	CUP, BEARING
22	WASHER, FLAT	48	WHEEL HALF, INNER
23	BOLT, MACHINE		
24	WASHER, FLAT		

FIGURE 9–44. Parts list—split wheel, heavy aircraft.

this wheel. Leakage of air from the tubeless tire through the wheel half mating surfaces is prevented by a rubber packing (14) mounted on the register surface of the inner wheel half. Another packing (13) mounted on the inner register surface of the inner wheel half seals the hub area of the wheel against dirt and moisture.

C. A retaining ring (2) installed in the hub of the inner wheel half holds the seal (3) and bearing cone (4) in place when wheel is removed from axle. The seal retains the bearing lubricant and keeps out dirt and moisture. Tapered roller bearings (1, 4, 29, 47) in the wheel half hubs support the wheel on the axle.

D. Inserts (45) installed over bosses in the inner wheel half (48) engage the drive slots in the brake disks, rotating the disks as the wheel turns. A heat shield (43), mounted underneath and between the inserts, keeps excessive heat, generated by the brake, from the wheel and the tire. Two alignment brackets (42), 160° apart, are attached with the heat shield to the wheel half. The brackets prevent brake disk misalignment during wheel installation.

E. Three thermal relief plugs (15), equally spaced and mounted in the web of the inner wheel half directly under the mating surfaces, protect against excessive brake heat expanding the air pressure in the tire and causing a blowout. The inner core of the thermal relief plug is made of fusible metal that melts at a predetermined temperature, releasing the air in the tire. A packing (16) is installed underneath the head of each thermal relief plug to prevent leakage of air from the tires.

Figures 9–45 and 9–46 were extracted from the B.F. Goodrich maintenance manual on wheels. The wheel illustrated is typical of split wheels used on light aircraft.

Description—Numbers in parentheses refer to figures 9–45 and 9–46.

A. This main wheel is a tubeless split-type assembly made of forged aluminum.

B. The inner (24) and outer (16) wheel half assemblies are fastened together by 8 equally spaced tie bolts (11), secured with nuts (9). A tubeless tire valve assembly installed in the outer wheel half (16) is used to inflate the 6.50–8 tubeless tire used with this wheel. Leakage of air from the tubeless tire through the wheel half mating surfaces is prevented by a rubber packing (12) mounted in the mating surface of the outer wheel half.

C. A seal (1) retains grease in the bearing (2) which is installed into bearing cup (23) inner wheel half, and (15) outer wheel half. Tapered bearings (2) installed in the bearing cups in the wheel halves support the wheel on the axle.

D. Torque keys (19) installed in cutouts in the inner rim of the wheel engage the drive tabs in the brake disks, rotating the disks as the wheel turns.

Removable Flange Wheels

The drop-center and flat base removable flange wheels (figure 9–47) have a one-piece flange held in place by a retainer snap ring. Wheels of the removable-flange type are used with low-pressure casings and may have either the drop center or a flat base. A flat-base rim may be removed quickly from the tire by removing the retaining lock ring that holds the one-piece removable flange in place, and lifting the flange from the seat. When a brake drum of the conventional type is installed on each side of the wheel, this provides a dual-brake assembly.

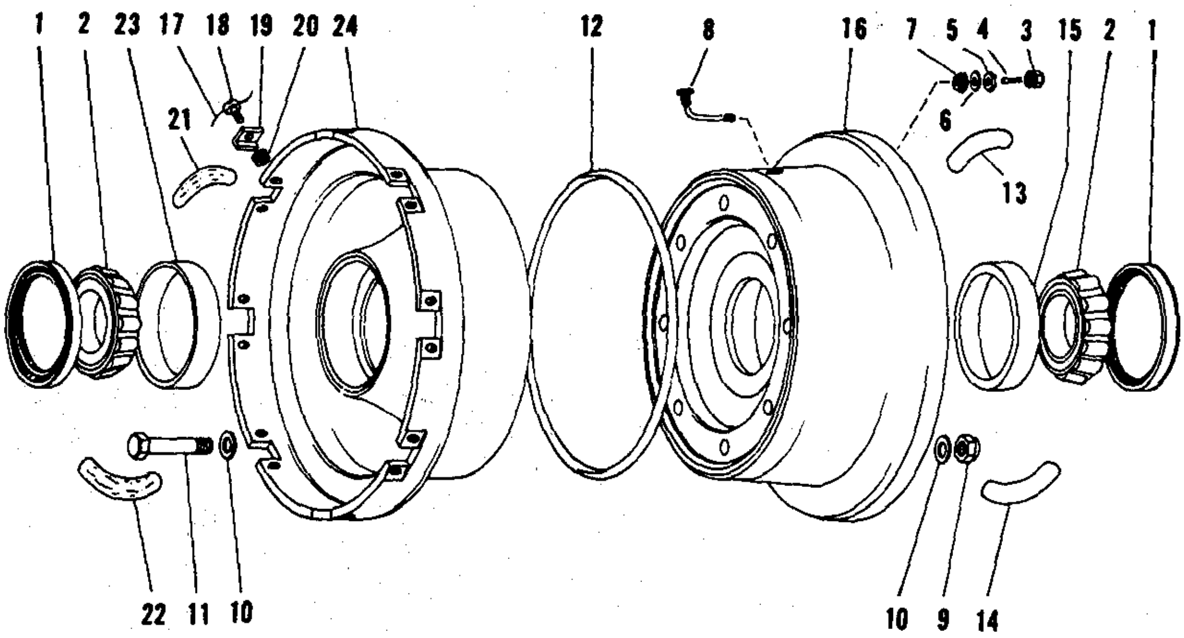


FIGURE 9–45. Split wheel—light aircraft.

Index No.	Description
1	WHEEL ASSEMBLY (With Valve Assy)
2	SEAL ASSY
	CONE, Bearing
	VALVE ASSY, Tubeless tire
3	CAP, Valve
4	CODE, Valve
5	NUT
6	SPACER
7	GROMMET
8	STEM, Valve
9	NUT
10	WASHER
11	BOLT
12	PACKING
13	WHEEL-HALF ASSY, Outer
14	PLATE, Identification
15	PLATE, Instruction
16	CUP, Bearing
	WHEEL-HALF ASSY, Inner
17	WIRE, Lock
18	SCREW
19	KEY, Torque
20	INSERT, Heli-coil
21	PLATE, Identification
22	PLATE, Instruction
23	CUP, Bearing
24	WHEEL-HALF, Inner

FIGURE 9-46. Parts list—split wheel, light aircraft.

A brake-drum liner may be held in place by means of steel bolts projecting through the casting with lock nuts on the inner side. These can be tightened easily through spokes in the wheel.

The bearing races are usually shrink-fitted into the hub of the wheel casting and provide the surfaces on which the bearings ride. The bearings are the tapered roller type. Each bearing is made up of a cone and rollers. Bearings should be cleaned and repacked with grease periodically in accordance with applicable manufacturer's instructions.

Fixed Flange Wheels

Drop center fixed flange aircraft wheels (figure 9-48) are special use wheels such as military, for high pressure tires. Some may be found installed on older type aircraft.

Outboard radial ribs are provided generally to give added support to the rim at the outboard bead seat. The principal difference between wheels used for streamline tires and those used for smooth contour tires is that the latter are wider between the flanges.

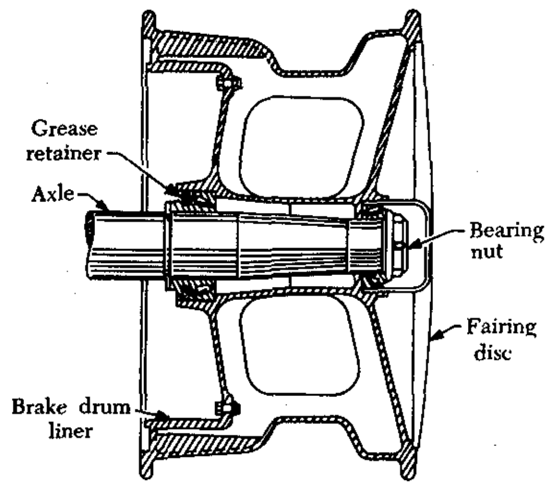
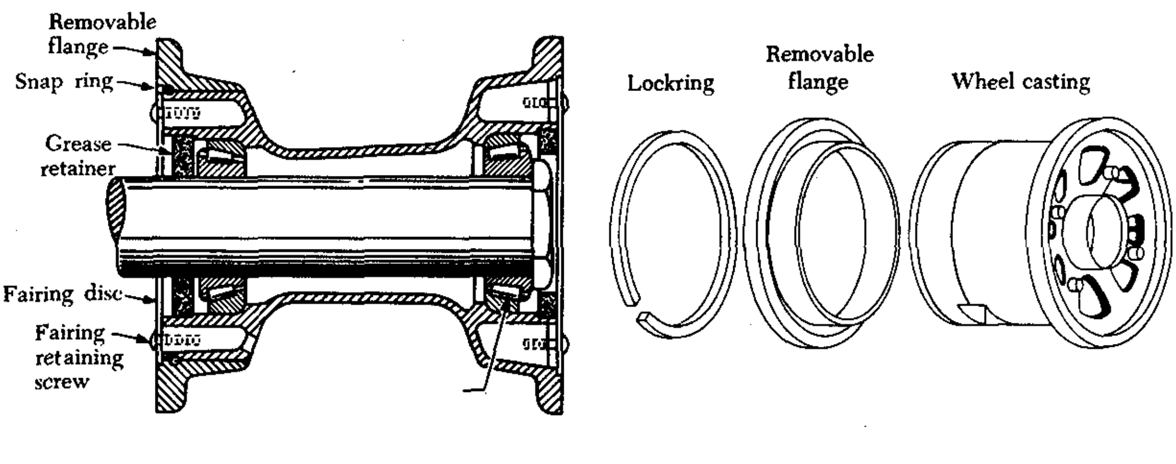


FIGURE 9-48. Fixed flange, drop center wheel.

Wheel Bearings

The bearings of an airplane wheel are of the tapered roller type and consist of a bearing cone, rollers with a retaining cage, and a bearing cup, or outer race. Each wheel has the bearing cup, or race, pressed into place and is often supplied with a hub cap to keep dirt out of the outside bearing.



A. Drop center. B. Flat base.

FIGURE 9-47. Removable flange wheels.

Suitable retainers are supplied inboard of the inner bearing to prevent grease from reaching the brake lining. Felt seals are provided to prevent dirt from fouling multiple-disk brakes. Seals are also supplied on amphibian airplanes to keep out water.

AIRCRAFT TIRES

Aircraft tires, tubeless or tube type, provide a cushion of air that helps absorb the shocks and roughness of landings and takeoffs: they support the weight of the aircraft while on the ground and provide the necessary traction for braking and stopping aircraft on landing. Thus, aircraft tires must be carefully maintained to meet the rigorous demands of their basic job . . . to accept a variety of static and dynamic stresses dependably—in a wide range of operating conditions.

Aircraft Tire Construction

Dissect an aircraft tire and you'll find that it's one of the strongest and toughest pneumatic tires made. It must withstand high speeds and very heavy static and dynamic loads. For example, the main gear tires of a four-engine jet transport are required to withstand landing speeds up to 250 mph, as well as static and dynamic loads as high as 22 and 33 tons respectively. Typical construction is shown in figure 9–49.

Tread

Made of rubber compound for toughness and durability, the tread is patterned in accordance with aircraft operational requirements. The circumferential ribbed pattern is widely used today because it provides good traction under widely varying runway conditions.

Tread Reinforcement

One or more layers of reinforced nylon cord fabric strengthens the tread for high speed operation. Used mainly for high speed tires.

Breakers

Not always used, these extra layers of reinforcing nylon cord fabric are placed under the tread rubber to protect casing plies and strengthen tread area. They are considered an integral part of the carcass construction.

Casing Plies/Cord Body

Diagonal layers of rubber-coated nylon cord fabric (running at opposite angles to one another) provide the strength of a tire. Completely encompassing the tire body, the carcass plies are folded around the wire beads and back against the tire sidewalls (the "ply turnups").

Beads

Made of steel wires embedded in rubber and wrapped in fabric, the beads anchor the carcass plies and provide firm mounting surfaces on the wheel.

Flippers

These layers of fabric and rubber insulate the carcass from the bead wires and improve the durability of the tire.

Chafers

Layers of fabric and rubber that protect the carcass from damage during mounting and demounting. They insulate the carcass from brake heat and provide a good seal against movement during dynamic operations.

Bead Toe

The inner bead edge closest to the tire center line.

Bead Heel

The outer bead edge which fits against the wheel flange.

Innerliner

On tubeless tires, this inner layer of less permeable rubber acts as a built-in tube, it prevents air from seeping through casing plies. For tube type tires, a thinner rubber liner is used to prevent tube chafing against the inside ply.

Tread Reinforcing Ply

Rubber compound cushion between tread and casing plies, provides toughness and durability. It adds protection against cutting and bruising throughout the life of the tread.

Sidewall

Sidewalls are primarily covers over the sides of the cord body to protect the cords from injury and exposure. Little strength is imparted to the cord body by the sidewalls. A special sidewall construction, the "chine tire," is a nose wheel tire designed with built-in deflector to divert runway water to the side, thus reducing water spray in the area of rear mounted jet engines.

Apex Strip

The apex strip is additional rubber formed around the bead to give a conture for anchoring the ply turnups.

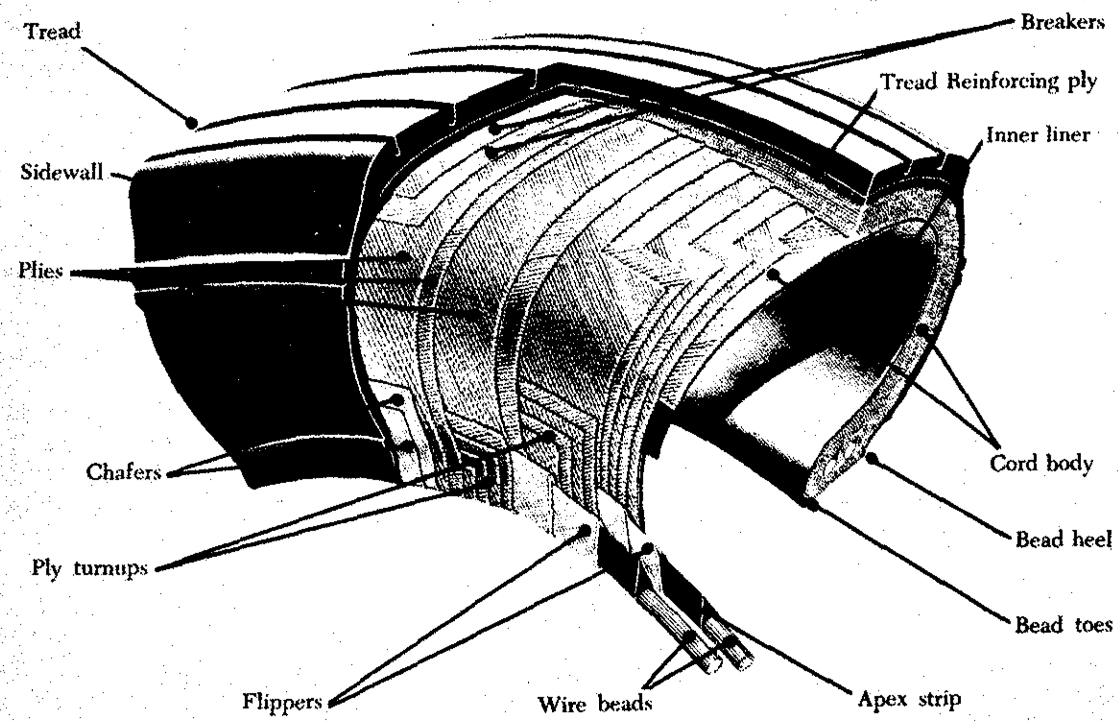


FIGURE 9–49. Aircraft tire construction.

Aircraft Tire Care

Tires are as vital to the operation of aircraft as they are to the operation of an automobile. During ground operation tires can be considered as ground control surfaces. The same rules of safe driving and careful inspection apply on the runway as on the highway.

They include control of speed, braking, and cornering, and inspection for proper inflation, cuts, bruises, and signs of tread wear. Contrary to what most people think—including many beginning pilots—the toughest demand on aircraft tires is rapid heat buildup during lengthy ground operations, not the impact of hard landings.

Aircraft tires are designed to flex more than automotive tires—over twice as much. This flexing causes internal stress and friction as tires roll on the runway. High temperatures are generated, damaging the body of the tire.

The best safeguards against heat buildup in aircraft tires are short ground rolls, slow taxi speeds, minimum braking, and proper tire inflation.

Excessive braking increases tread abrasion. Likewise, fast cornering accelerates tread wear. Proper inflation assures the correct amount of flexing and keeps heat buildup to a minimum, increasing tire life and preventing excessive tread wear.

Inflation pressure should always be maintained as specified in the aircraft maintenance manual or according to information available from a tire dealer.

Even though using a tire gage is the only accurate way to spot-check inflation, a quick visual inspection of the tread can reveal if air pressure has been consistently high or low. Excessive wear in the shoulder area of the tire is an indication of under inflation. Excessive wear in the center of the tire suggests over inflation.

Tires should also be carefully inspected for cuts or bruises. The best way to avoid aircraft tire cuts and bruises is to slow down when unsure of runway or taxiing surface conditions.

Since airplane tires have to grip the runway in the same way car tires grip the road, tread depth is also important. Tread grooves must be deep enough to permit water to pass under the tires, minimizing the danger of skidding or hydroplaning on wet runways. Tire treads should be inspected visually or with an approved depth gage according to manufacturers' specifications.

Another inspection goal is detection and removal of any traves of gasoline or oil on the tires. Such mineral fluids damage rubber, reducing tire life. Likewise, tires should be inspected for ozone or weather checking. Electricity changes oxygen in the air to ozone, which also prematurely ages rubber.

MATCHING DUAL TIRES

Matching tires on dual wheels, or dual wheels on a multi-wheel gear configuration, is necessary so that each tire will have the same contact area with the ground and thereby carry an equal share of the load. Only those tires having inflated diameters within the tolerances listed below should be paired together on dual wheels.

Tires should not be measured until they have been mounted and kept fully inflated for at least 12 hours, at normal room temperatures.

O. D. Range of Tires	Maximum Tolerance Permissable
Up to 24"	1/4"
25" to 32"	5/16"
33" to 40"	3/8"
41" to 48"	7/16"
49" to 55"	1/2"
56" to 65"	9/16"
66" and up	5/8"

FIGURE 9–50. Matching tires on dual wheel installations.

Aircraft tires should be stored in a cool dry place away from electric motors. The manufacturers specifications should be followed at all times when performing tire maintenance.

Tires on dual wheel aircraft will have a longer operational life if matched as suggested in figure 9–50.

AIRCRAFT TIRE MAINTENANCE

All aircraft tire manufacturers publish maintenance manuals and instruction manuals.

The following discussion on aircraft tires is excerpted from the B.F. Goodrich publication Care and Maintenance of Aircraft Tires, Fourth Edition, and is published with their permission.

Proper Inflation For Satisfactory Service

Proper inflation is undoubtedly the most necessary maintenance function for safe, long service from aircraft tires.

Tire pressures should be checked with an accurate gage at least once a week or oftener, and it is recommended that they be checked before each flight. Otherwise, if a slow leak should develop, it could cause severe loss of air within two or three days, with resulting damage to the tire and tube. Air pressures should only be checked when tires are cool. Wait at least two hours after a flight before checking pressures (three hours in hot weather).

For New Mountings

A newly mounted tire and/or tube should be checked at least daily for several days, after which the regular inflation control schedule may be followed. This is necessary because air is usually trapped between the tire and tube at the time of mounting, giving a false pressure reading. As this trapped air seeps out under the beads of the tire and around the valve hole in the wheel, the tire may become severely under inflated within a day or two.

Allow For Nylon Stretch

All aircraft tires are now made with nylon cord, and the initial 24-hour stretch of a newly mounted nylon tire may result in a 5 percent to 10 percent drop in air pressure. Thus, such a tire should not be placed in service until it has been left to stand at least 12 hours after being mounted and inflated to regular operating pressure. The air pressure should then be adjusted to compensate for the decrease in pressure caused by the stretching of the cord body.

Tubeless Air Diffusion Loss

Maximum allowable diffusion is 5 percent for any 24-hour period. However, no accurate tests can be made until after the tire has been mounted and inflated for at least 12 hours, and air added to compensate for pressure drop due to normal nylon cord body expansion, and any changes in tire temperature. A pressure drop of over 10 percent during this initial period should be sufficient reason to not place the tire and wheel assembly into service.

For Duals: Equalize Pressures

Differences of air pressure in tires mounted as duals, whether main or nose, should be cause for concern, as it ordinarily means that one tire is carrying more of the load than the other. If there is a difference of more than 5 lbs., it should be noted in the log. The log-book should then be referred to on each subsequent inflation check. Impending tire or tube failure can often be detected by this method. Should a pressure difference be found, check the valve core by spreading a little water over the end of the valve. If no bubble appears, it can be assumed that the valve core is holding pressure satisfactorily.

Sources of Pressure Data

Inflation of nose wheel tires should follow the recommendations of the aircraft manufacturers, because they take into consideration both the extra load transferred to the nose wheel by the braking effect and by the static load. Air pressure in the nose wheel tire, based on the static load only, would result in under inflation for the load carried when the brakes are applied. Tail wheel tires, however, should be inflated in accordance with the axle static load.

When tires are inflated under load, the recommended pressure should be increased by 4 percent. The reason is that the deflected portion of the tire causes the volume of the air chamber to be reduced, and increases the inflation pressure reading, which must then be offset in accordance with the above rule.

Effects of Under Inflation

Under inflation results in harmful and potentially dangerous effects. Aircraft tires which are under inflated are much more likely to creep or slip on the wheels on landing or when brakes are applied. Tube valves can shear off, and the complete tire, tube and wheel assembly can be destroyed under such conditions. Too-low pressures can also cause rapid or uneven wear at or near the edge of the tread.

Under inflation provides more opportunity for the sidewalls or the shoulders of the tire to be crushed by the wheel's rim flanges on landing or upon striking the edge of a runway while maneuvering the aircraft. Tires may flex over the wheel flange, with greater possibility of damage to the bead and lower sidewall areas. A bruise break or rupture of the tire's cord body can result.

Severe under inflation may result in cords being loosened and the tire destroyed because of extreme heat and strain produced by the excessive flexing action. This same condition could cause inner tube chafing and a resultant blowout.

Observe Load Recommendations

Since the beginning of air transportation, aircraft tires have been doing their required job with increasing efficiency and safety. But there is a limit to the load that any aircraft tire can safely and efficiently carry.

Loading aircraft tires above the limit can result in these undesirable effects:

1. Undue strain is put on the cord body and beads of the tire, reducing the factor of safety and reducing service life.
2. There is greater chance of bruising upon striking an obstruction or upon landing (bruise breaks, impact breaks and flex breaks in the sidewall or shoulder).
3. Possibility of damaging wheels. Under the severe strain of an extra load, a wheel may fail before the tire does.

Note: While additional air pressure (inflation) to offset increased loads can reduce excessive tire deflection, it puts an added strain on the cord body, and increases its susceptibility to cutting, bruises and impact breaks.

Nylon Flat-Spotting

Nylon aircraft tires will develop temporary flat spots under static load. The degree of this flat-spotting will vary according to the drop in the internal pressure in the tire and the amount of weight being sustained by the tire. Naturally, flat-spotting can be more severe during cold weather and is more difficult to work out of a tire at lower temperatures.

Under normal conditions, a flat spot will disappear by the end of the taxi run. If it doesn't, the tire can generally be reshaped by overinflating it 25 percent or 50 percent and moving the aircraft until the low spot is on the upper side. This pres-

PREVENTIVE MAINTENANCE SUMMARY

- Check tire pressures with an accurate gage at least once a week, and before each flight. Tires should be at ambient temperature.
- Check newly mounted tires or tubes daily for several days.
- Newly mounted tires should not be placed in service until cord body stretch has been compensated with re-inflation.
- Check for abnormal diffusion loss.
- Follow inflation recommendations carefully – guard against underinflation.
- Observe load recommendations.
- Move aircraft regularly or block up when out of service for long periods.

FIGURE 9-51. Preventive maintenance summary.

sure should be left in the tire for one hour. It may even be necessary to taxi or tow the aircraft until the reshaping is accomplished. Needless to say, any flat spot can cause severe vibration and other unpleasant sensations to both pilot and passengers.

Aircraft that is to remain idle for a period longer than three days should either be moved every 48 hours or blocked up so that no weight is on the tires. Aircraft in storage (out of service for more than 14 days) should be blocked up so that there is no weight on the tires.

Figure 9–51 gives a brief, summary checklist of tire preventive maintenance.

TIRE INSPECTION—MOUNTED ON WHEEL

Leaks Or Damage At Valve

To check valves for leaks, put a small amount of water on the end of the valve stem and watch for air bubbles. If bubbles appear, replace the valve core and repeat this check.

Always inspect the valve to be sure the threads are not damaged; otherwise, the valve core and valve cap will not fit properly. If threads are damaged, the valve can usually be rethreaded, inside or outside, by use of a valve repair tool, without demounting the tire from the wheel.

Make certain that every valve has a valve cap on it—screwed on firmly with the fingers. The cap prevents dirt, oil and moisture from getting inside the valve and damaging the core. It also seals in air and serves as protection in case a leak develops in the valve core.

Check the valve to be sure it is not rubbing against the wheel. If it is bent, cracked, or severely worn, demount the tire and replace the tube or valve at once.

Tread Injuries

Carefully inspect the tread area for cuts or other injuries. Be sure to remove any glass, stones, metal or other foreign objects that might be embedded in the tread or that have penetrated the cord body.

Use a blunt awl for this purpose, although a medium size screwdriver can be used if a blunt awl is not available. When probing an injury for foreign material, be careful not to enlarge the injury or drive the point of the awl or screwdriver into the cord body beyond the depth of the injury. When prying out foreign material that might be embedded, the other hand should be held over the injury in such a way that the object will not fly out and strike the person conducting the inspection in the face.

Tires with cuts or other injuries which expose or penetrate the cord body, should be removed and repaired, recapped or scrapped. Where a cut does not expose the carcass cord body, taking the tire out of service is not required.

Remove any tires that show signs of a bulge in the tread or sidewall. This may be the result of an injury to the cord body, or may indicate tread or ply separation. Always mark such a bulged area with tire crayon before deflating the tire; otherwise, it may be very difficult, if not impossible, to locate the area after the tire is deflated.

Sidewall Injuries

Inspect both sidewalls for evidence of weather or ozone checking and cracking, radial cracks, cuts, snags, gouges, etc. If cords are exposed or damaged, the tires should be removed from service.

When To Remove For Recapping

Check tires for possible need of recapping. They should be taken out of service when:

(a) They have one or more flat spots. Generally, a single flat spot or skid burn does not expose the carcass cord body and the tire may remain in service, unless severe unbalance is reported by the aircraft crew.

(b) They show 80 percent or more tread wear.

(c) There are numerous cuts that would require repair. In other words, if the cost of repairing the cuts would amount to 50 percent or more of the recapping cost, it would be considered more economical to have the tire recapped.

Uneven Wear

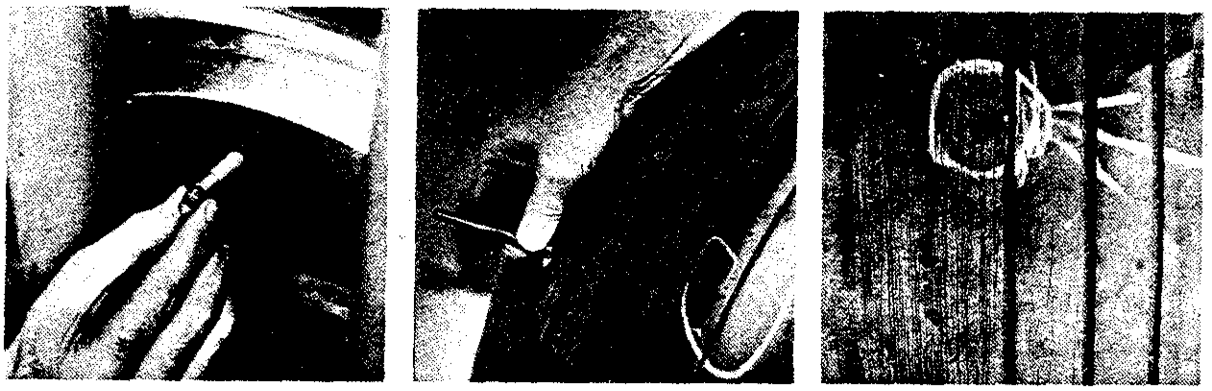
Check tires for evidence of wheel misalignment. Tires showing such wear should be demounted, turned around and remounted, in order to even up the wear. Also, check for spotty, uneven wear due to faulty brakes so mechanical corrections can be made as soon as possible.

Wheel Damage

Inspect the entire wheel for damage. Wheels which are cracked or injured should be taken out of service and laid aside for further checking, repair or replacement.

When inspecting a mounted tire on the wheel of a plane, always be sure that nothing is caught between the landing gear and the tire, and that no parts of the landing gear are rubbing against the tire.

At this time, also check the nacelle into which the tire fits, when the landing gear is retracted. Clearances are sometimes close and any foreign



A. A valve cap for every valve. B. Depth gage shows wear. C. Mark and remove foreign objects.

FIGURE 9–52. Basic tire maintenance

material or loose or broken parts in the nacelle can cause severe damage to the tire and even cause it to fail upon landing.

Figure 9–52 shows checks to be accomplished while tire is mounted.

TIRE INSPECTION—TIRE DEMOUNTED

Periodic Demounting

A definite schedule can be set up to provide for regular inspections of tires and tubes, after a certain number of hours or landings, and that each individual tire and tube be removed from the wheel for that inspection. However, if an airplane has made an emergency or particularly rough landing, the tire and tube should be demounted and inspected as soon as possible to determine whether any hidden damage exists. The wheel should also be examined at the same time.

Probe Injuries

Probe all cuts, punctures and other tread injuries with a blunt awl and remove any foreign material. When prying out the foreign material imbedded in the tread, the hand should be held over the injury in such a position that the object will not fly out and strike the person conducting the inspection in the face.

Squeezing the sidewalls together will also assist, as this will open up the cuts and injuries. Size and depth of cuts and injuries can then be determined by probing with the awl. Do not push the awl point into the cord body beyond the depth of the injury.

Repairable Injuries

Injuries into, or through, the carcass cord body, measuring no more than 1/4" on the outside and 1/8" on the inside, would be considered punctures and are easily repaired without the need for fabric reinforcement inside the tire. Tires qualified to speeds over 160 mph can be repaired if they meet the following qualifications: injuries through the tread must not penetrate more than 40 percent of the actual body plies; they should measure no more than 1 1/2" long and 1/4" wide before tread is removed; and after the tread has been removed, injuries should not be over 1" long and 1/8" wide on the surface.

Tires qualified to speeds of less than 160 mph can be repaired if the injury penetrates through more than 40 percent of the actual plies, and is no larger than 1" in length. Naturally, there must be a limit as to the number of such injuries that there can be in the tire. The decision to recondition or not recondition such a tire should be left up to the tire manufacturer.

Sidewall Conditions

Inspect both sidewalls for evidence of weather or ozone checking and cracking, radial cracks, cuts or snags.

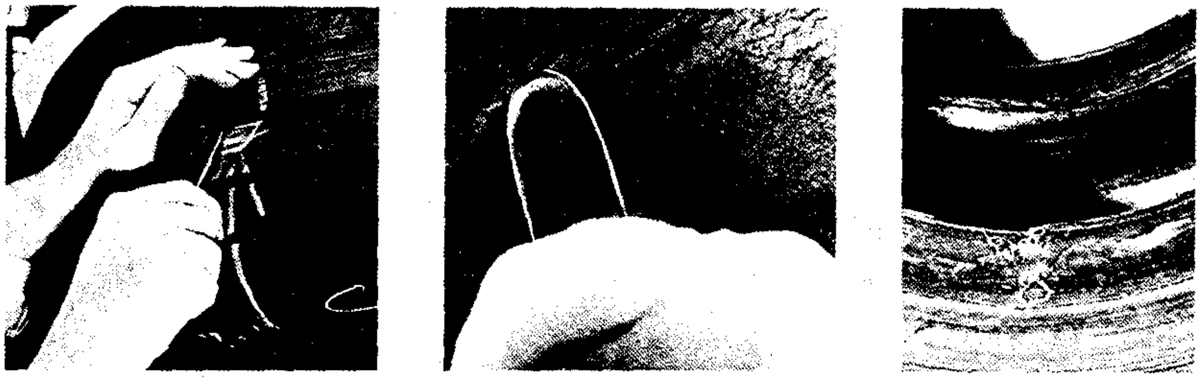
(a) Scrap any tires with radial cracks extending to the cords.

(b) Scrap any tires with weather-checking, ozone-checking, or cracking, which extends to the cords. Weather-checking is a normal condition affecting all tires and, until cords are exposed, will in no way affect the serviceability or safety of the tire.

(c) Tires with cuts or snags in the sidewall area which have damaged the outer ply should be scrapped.

Bead Damage

Check the entire bead and the area just above the heel of the bead on the outside of the tire for



A. Probe with blunt awl, shield work.

B. Are sidewall cords exposed?

C. Finishing & trip damage, repairable.

FIGURE 9–53. Basic tire maintenance

chafing from the wheel flange or damage from tire tools. Any blistering or separation of the chafer strips from the first ply beneath requires repairing or replacement of the chafer strip. If cords in the first ply under the chafer strip are damaged, the tire should be scrapped.

If protruding bead wire, bead wire separation, or a badly kinked bead is found, the tire should be scrapped.

Loose or blistered finishing strips can generally be replaced during the retreading process, but tires should not be continued in service in that condition.

Figure 9–53 shows checks to be made with tire demounted.

Bulges—Broken Cords

Check any tires which were marked for bulges when the tire was mounted and inflated. If no break is found on the inside of the tire, probe with an awl to determine whether separation exists. If separation is found, the tire should be discarded, unless there is only a small localized separation between the tread or sidewall rubber and the cord body. In this case, spot repair or retreading may be satisfactory.

Any tire found with loose, frayed or broken cords inside should be scrapped.

IMPORTANT: Do not use an awl or any pointed tool on the inside of a tubeless tire for probing or inspection purposes.

Tubeless Tires—Bead Area

A tubeless tire fits tighter on the wheel than a tube type tire, in order to properly retain air pressure. Therefore, the face of the bead (the flat surface between the toe and heel of the bead) must not be demaged as this may cause the tire to leak. The primary sealing surface of the tubeless tire is this area, so examine it carefully for evidence of damage by tire tools, slippage while in service, or damage that would permit air to escape from inside the tire. Bare cords on the face of the bead normally will cause no trouble, and such a tire should be fit for continued service either as is, or after retreading.

Liner Blisters

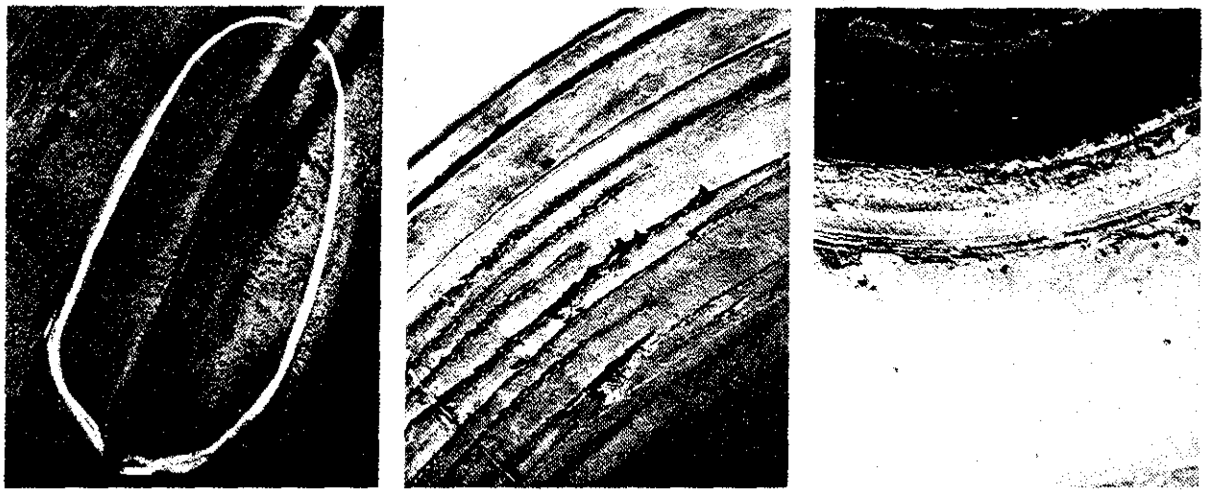
Tubeless tires with liner blisters or liner separation areas, larger than 4″ x 8″, should be scrapped. Generally, small blisters (not over two inches in diameter) will cause no trouble and do not need to be repaired. However, **do not pierce the blisters or cut them,** as this will destroy the air-retaining ability of the tire.

Thermal Fuze

Some aircraft wheels have fusible plugs that are designed to melt at specific elevated temperatures and relieve air pressure to prevent the tire's blowing out or breaking of the wheel. Should air be lost due to the melting of one of these plugs, it is recommended that the tire involved be scrapped. However, an effort should be made to determine whether the plug melted at a much lower temperature than it should have, or whether air could have been lost around the plug because of improper installation.

If a tire has been subjected to a temperature high enough to melt one of these fuze plugs, it should be carefully inspected for evidence of reversion of the rubber coating in the rim contact area.

Figure 9–54 shows typical marking for bulged area, rubber reversion around rim, and outer sidewall damage.



A. Mark bulged areas. B. Outer sidewall ply damaged, scrap tire. C. Reversion of rubber from high wheel heat.

FIGURE 9–54. Basic tire maintenance

TUBE INSPECTION

Proper Size

In tube type tires, failure of an inner tube can easily cause irreparable damage to the tire in which it is mounted, as well as to the wheel and the aircraft itself. It is very important that tubes be of the proper size and equipped with the correct valves.

When inspecting tubes **do not** inflate with more air than that which is required to simply round out the inner circumference of the tube. Too much air places a strain on splices and areas around valve stems. In addition, excessive air will damage fabric base tubes by causing the fabric base to pull away from the outside of the tube.

Inspect the tube carefully for leaks while under pressure, preferably by inflating and submerging in water. If the tube is too large to be submerged in an available water tank, spread water over the surface as you inspect the tube, and look for bubbles.

Valve Stems

Examine the tube carefully around the valve stem for leaks, signs of valve pad separation, and bent or damaged valve stems.

Wrinkles

Tubes with severe wrinkles should be removed from service and scrapped. These wrinkles are evidence of improper fitting of the tube within the tire, and wherever a wrinkle occurs, chafing takes place. A blowout could result.

Chafing

Inspect tubes for evidence of chafing by the toes of the tire beads. If considerable evidence of this chafing is present, remove the tube from service and scrap.

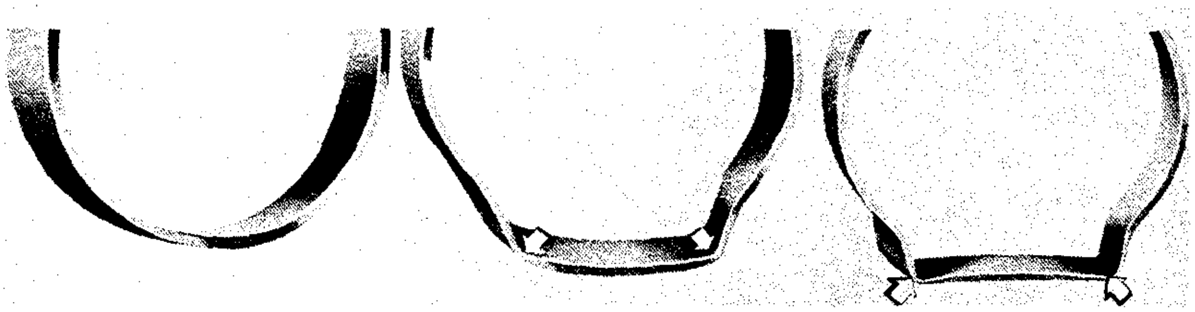
Thinning

Where the heat is greatest, the tube has a tendency to be stretched over the rounded edge of the bead seat of the wheel. This is one of the reasons why, when mounting, tubes should always be inflated until the tire beads are in position, and then completely deflated and reinflated to the final pressure. The stretch on the tube is then equalized throughout its inner and outer periphery.

Also check tubes for possible thinning out due to brake drum heat in the area where they contact the wheel and bead toes.

In figure 9–55 it can be seen that the "set" or shape of the tube can assist in determining when it should be removed from service because of thinning in the bead area. In addition, feeling the tube with the fingers in that area will tell, after a little practice, when the life has gone out of the tube and it should be scrapped.

On wheels with only one brake drum this heat-set condition will normally show up on only one side of the tube. In those cases where the brake drum is a considerable distance from the rim, it is unlikely that this condition will ever be experienced.



A. Natural contour. B. Taking a "set". C. Thinned out at edges.

FIGURE 9–55. Inner tube inspection.

Fabric Base Tubes

In cases where brake drum heat is a recognizable factor, careful checking of the tube, as well as the tire beads, should be made to prevent a failure which might be disastrous. In such instances, fabric base tubes should always be used. These have a layer of nylon cord directly imbedded in the inner circumference of the tubes to protect them from thinning out under brake drum heat. Additional protection is also provided against chafing action of the tire bead toes and from damage during mounting and demounting.

MOUNTING AND DEMOUNTING

The object of these instructions is to show how to do the job as easily, and safely as possible, using proper tools, without damaging tires, tubes or wheels.

Almost every experienced aircraft tire service man has developed methods which are more or less his own, and undoubtedly some of these methods are as practical as the suggestions given here.

These instructions are intended to be simple, so that they can be carried out with tools which are commonly available, in contrast to the specialized equipment that is usually available only at larger airports or military installations.

Inspection, Tube Installation

Before mounting any tire, examine the wheel carefully to make sure there are no cracked or injured parts. Naturally, the tire and tube should be carefully inspected, as described in the pages dealing with tire and tube inspection. A quick check should always be made to be certain that no foreign material is inside the tire or clinging to the inner tube.

Dust the inside of the tire and the inner tube outer surface with tire talc or soapstone before the tube is installed in the tire. This will prevent its sticking to the inside of the tire or to the tire beads.

Dusting also helps the tube assume its normal shape inside the tire during inflation, and lessens the chances of wrinkling or thinning out.

It is good practice to always mount the tube in the tire with the valve projecting on the serial side of the tire.

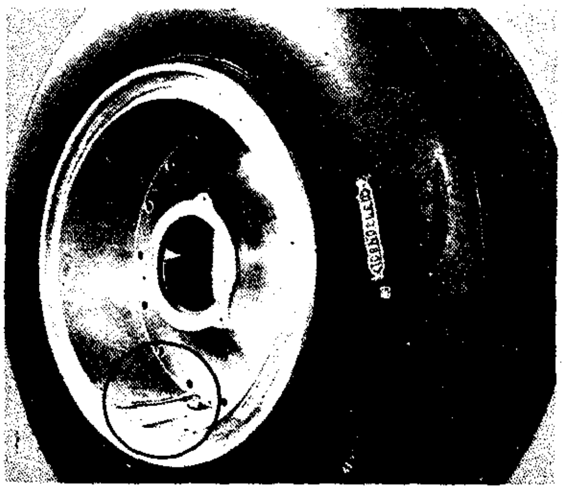
Lubrication

Tubeless tires fit tighter on the wheel than the tube type. It is therefore desirable to lubricate the toes of the beads with an approved 10 percent vegetable oil soap solution, or plain water. This will facilitate mounting and accomplish proper seating of the tire beads against the wheel flanges so there will be no air loss. Care must be used, however, to make certain that none of the solution gets on the area of the bead making contact with the wheel flange.

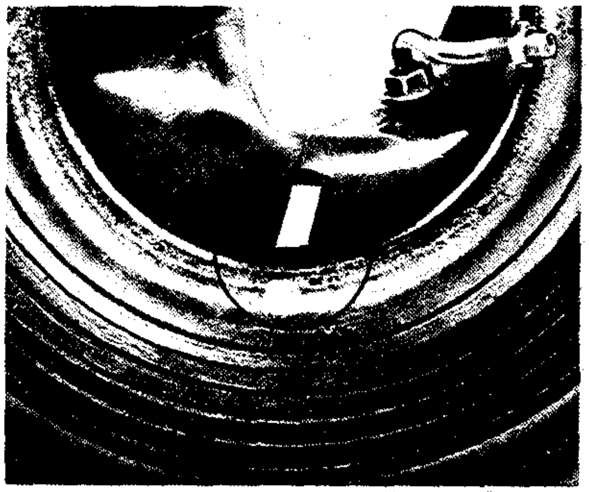
On tube type tires, lubrication of tire beads may or may not be necessary, depending upon the type of wheel being used. An approved mounting solution, such as the 10 percent vegetable oil soap solution, or water mentioned above, can be used on the bead toes, and even on the rim side of the inner tube, to facilitate mounting.

Balance

Balance in an aircraft wheel assembly is very important. From a wear standpoint, when the wheels are in landing position a heavy spot in a wheel assembly will have a tendency to remain at the bottom and thus will always strike the ground or runway first. This results in severe wear at one area of the tire tread and can necessitate early replacement. In addition, unbalanced tires can cause severe vibration which may affect the operation of the aircraft. In fact, pilots have reported that sometimes instruments could not be read because of such vibration.



A. Valve projecting on serial side of tire.



B. Tube balance mark aligned with tire balance mark.

FIGURE 9-56. Basic tire and tube assembly.

Balance marks appear on certain aircraft tubes to indicate the heavy portion of the tube. These marks are approximately ½″ wide by 2″ long. When the tube is inserted in the tire, the balance mark on the tube should be located at the balance mark on the tire (figure 9-56). If the tube has no balance mark, place the valve at the balance mark on the tire.

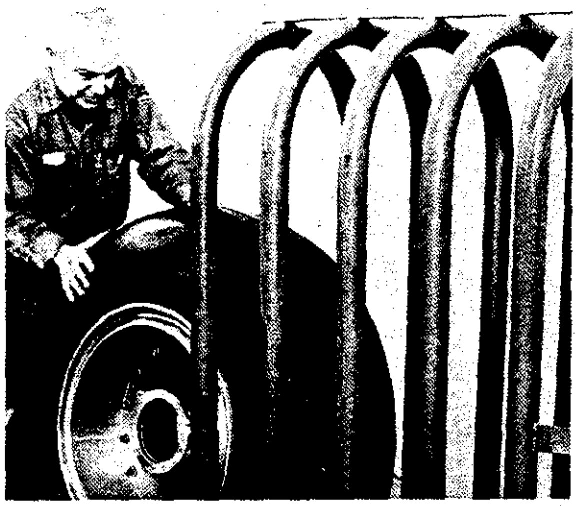
When mounting tubeless aircraft tires, the "red dot" balance mark on the tire must always be placed at the valve that is mounted in the wheel.

Inflation Safety

After the tire and tube are mounted on the wheel the assembly should be placed in a safety cage for inflation. The cage should be placed against an outside wall, constructed so as to withstand, if necessary, the effects of an explosion of either the tire, tube or wheel (figure 9-57).

The air line from the compressor or other air source should be run to a point at least 20 to 30 ft. away from the safety cage and a valve and pressure gage installed at that point. The line should

A. Clip-on chuck permits inflation at safe distance from tire safety cage.



B. Recommended for all aircraft tire shops.

FIGURE 9-57. Inflation precautions.

then be continued and fastened to the safety cage with a rubber hose extending from that connection. A clip-on chuck is then fitted on the end of the hose for actual inflation purposes. This arrangement makes it unnecessary to reach into the cage to check air pressures or to be anywhere near the safety cage while the tire is being inflated.

Seating Tube Type Tires

To seat the tire beads properly on the wheel, first inflate the tire to the pressure recommended for that particular size and for the aircraft on which it is to be mounted. Then the tire should be completely deflated and finally reinflated to the correct pressure (do not fasten valve to rim until this has been done). Use the valve extension for inflation purposes, if necessary.

This procedure accomplishes the following: it helps to remove any wrinkles in the tube and to prevent pinching the tube under the toe of the bead; it eliminates the possibility of one section of the tube stretching more than the rest and thinning out in that area; and it assists in the removal of air that might be trapped between the inner tube and the tire.

NOTE: With tubeless tires, it is not necessary to go through this inflation-deflation-reinflation procedure.

Let Stand—Then Recheck

It is recommended that a newly-mounted assembly be stored away from work areas for at least 12 hours and preferably for 24 hours. This is for the purpose of determining if there is any structural weakness in either the tire, tube or wheel. This also permits rechecking of the tire, after the 12- or 24-hour period, to determine any drop in pressure and to judge whether this drop in pressure is in accordance with normal tire growth.

By such a test, when the assembly is mounted on the aircraft, it can be done with the assurance that each part of the assembly is satisfactory for service.

Demounting Safety

Always be sure to deflate tires completely before demounting. There have been many serious accidents caused by failure to follow this important step. For even a better practice, it is recommended that tires be deflated before wheels are removed from the aircraft.

NOTE: Use caution when unscrewing valve cores, as the air pressure within the tube or tire can cause a valve core to be ejected like a bullet.

Handle Beads and Wheels With Care

With any type of wheel, the tire beads must be loosened from the wheel flange and bead seat before any further steps are taken in demounting. Be very careful not to injure the beads of the tire or the relatively soft metal of the wheel. Even with approved tools, extreme care must be taken.

A. Tubeless—Split Wheels

In the tubeless design, the tire and wheel are used to retain air pressure. Inflation is accomplished through a tubeless tire inflation valve installed in the wheel. The wheel valve hole, in which the tubeless tire inflation valve is mounted, is sealed against loss of air by a packing ring or by an "O" ring. (See figure 9-58.)

Split wheels are sealed against loss of air by an "O" ring mounted in a groove in the mating surface of one of the wheel halves.

Demountable flange wheels are similarly sealed against loss of air by an "O" ring installed in a groove on the wheel base under the area covered by the demountable flange.

The air pressure contained in the tubeless tire seals the tire bead against the wheel bead seat to prevent loss of air.

Wheels used with disc brakes have thermal fuze (relief) plugs installed in the rotor drive area of the wheel as a protective measure against the tire blowouts due to excessive heat. The plugs have a fusible metal core that melts at a predetermined temperature to relieve the high pressure build-up.

Mounting

Check tubeless tire inflation valve and thermal relief plugs for proper installation, and absence of damage. Refer to wheel manufacturer's manual for installation procedure.

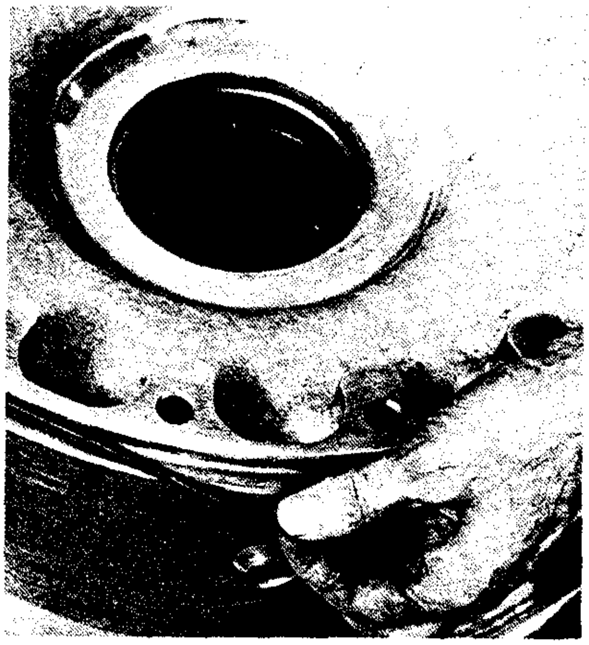
Inspect "O" ring used to seal wheel for damage and replace if necessary.

Lubricate "O" ring (as specified by the wheel manufacturer) and install in wheel groove. Make sure the "O" ring is free of kinks or twists and is seated properly.

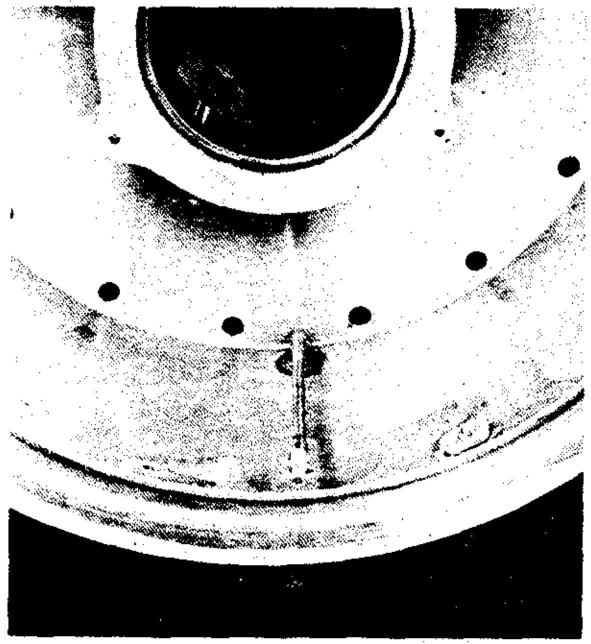
Mounting a demountable flange on a wheel base, be careful not to dislocate or damage the "O" ring previously installed in the wheel base.

Mount tubeless tires in the same manner as tube type tires. Make sure that the wheel bead seats are clean and dry to insure proper sealing of the tubeless tire bead.

Assemble wheel halves of split type wheels with the light sides (impression stamped "L" on the



A. "O"-ring seal is vital – handle and install carefully.



B. Inspect valve seals for signs of damage or deterioration.

FIGURE 9–58. Split wheel seal inspection.

flanges) 180° apart from each other to insure minimum out-of-balance condition.

Be sure that nuts, washers, and bolts used to assemble split type wheels are in proper order and that the bearing surfaces of these parts are properly lubricated. Tighten to recommended torque values. See wheel manufacturer's manual for recommended procedures.

Demounting

The procedure for demounting tubeless tires is generally the same as for tires with tubes. However, care must be taken to avoid damaging: (1) the wheel's "O" ring groove and mating register surfaces; (2) the flange area that seats the tire bead; and (3) the tubeless tire inflation valve hole sealing area. These areas of the wheel are critical and if damaged will result in failure of the wheel and tire unit to maintain required air pressure.

B. Tube Type Tires

Mounting

With the tube entirely deflated, insert it in the tire (folding makes this easier, particularly in small diameter tires), and inflate until the tube is just rounded out. The valve core should be in the valve during this operation.

Apply with brush or swab a 10 percent solution of vegetable oil soap to the rim of the tube extending well up into the tire. Use care not to lubricate any part of the bead which comes in contact with the rim flange.

Insert the valve hole section of the wheel into the tire and push the valve through the valve hole in the wheel.

Insert the other side of the wheel while holding the valve in position. Be careful during this operation not to pinch the tube between the wheel sections.

Inflate, deflate and reinflate to the recommended pressure.

Install the locking nut or nuts and tighten securely. Put on valve cap and tighten with fingers.

Demounting

Remove valve core and fully deflate.

Do not use a pry bar, tire irons or any other sharp tool to loosen tire bead as the wheel may be damaged. Break bead before loosening tie bolts to prevent damage to register surfaces.

Use a bead breaker only to loosen tire bead from both wheel half flanges by applying pressure around the entire circumference of each sidewall.

Remove the tie bolts and the bolt nuts from the wheel and pull out both parts of the wheel from the tire.

C. Removable Side Flange Drop Center Wheels

Mounting

Fully deflate tube and line up tube balance mark with tire balance mark. Start tire over flange on an angle, being careful not to damage valve.

Be sure to remove valve extensions or valve fishing tools before wheel is installed.

Demounting

Be sure to deflate fully.

Make full use of the wheel in pulling bead over flange on removable side.

Work wheel up and down to ease it out of tire.

For one-man demounting, tire can be leaned against a wall or bench, valve side out.

D. Smooth Contour Tail Wheel Tires

Note: Smooth contour tires are usually harder to handle because of stiffer beads, small clearances and small diameters.

Mounting

Inflate tube sufficiently to round out and be sure tube is worked in all around to avoid pinching.

Work bead opposite valve over edge of wheel first. Deflate tube.

Keep second bead on edge of wheel to allow for inserting valve in valve hole.

Inflate, deflate, reinflate.

Demounting

Be sure to use tools with good leverage.

Be careful not to damage soft metal of rim flange.

Keep tube inflated after lock ring is removed.

Work tube out carefully, using water as a lubricant before completing demounting.

E. One Piece Drop Center Wheels

Mounting

Insert wheel in tire, reversing the customary procedure. (Valve hole side goes in first.)

Pry bead over flange with small bites—use a fairly thin tool.

When first bead is on wheel, insert tube. Be sure no part of tube is caught under bead.

Inflate, deflate, reinflate.

Demounting

After loosening bead, lay tire flat with wooden block, 3 to 4 inches high under sidewall. Work bead off in small bites.

F. Flat Base Wheels Removable Flange Locking Ring

Mounting

Examine wheel and flanges carefully for burrs or gouges.

Line up tube and tire balance marks.

Dust tube with talc.

Lean tire against bench or wall—flange outward. Pry flange loose evenly to prevent binding.

Demounting

Loosen bead carefully.

Use lead hammer or rubber mallet to loosen side ring.

Pry up side ring carefully and evenly.

Place wheel and tire on a wooden block about 14" high and large enough to fit over the wheel hub, so that wheel can be removed easily.

CAUSES OF AIR PRESSURE LOSS IN TUBELESS AIRCRAFT TIRES

There can be numerous causes for loss of air pressure within an aircraft wheel and tire assembly, therefore, it is economical and wise to follow a systematic check list. Without such a procedure, trial and error substitution of parts can needlessly increase tire maintenance costs.

For example, complaints of air loss in tubeless aircraft tire assemblies, while more common during cold weather, have no seasonal limitations. Factors which may seem distantly related to the problem—changes in tire maintenance personnel, inaccurate gages, air temperature fluctuations—are often the underlying causes of unsatisfactory tire service, further emphasizing the need for simple check procedures.

For guidance in setting up uniform inspection methods, there are general areas of the tire and wheel assembly which can be involved in air pressure loss. (See figure 9–59.)

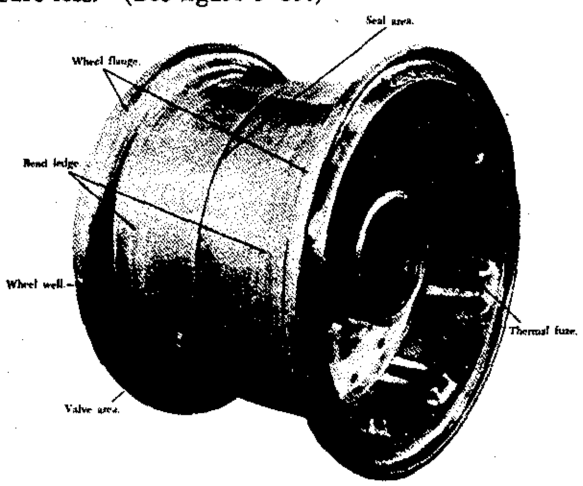


FIGURE 9–59. Air loss in split wheels.

Damaged Beads—Check for exposure of the carcass cord body in bead toe area or under face of the bead.

Improperly Seated Beads—Condition can be caused by: (a) insufficient air pressure; (b) beads not lubricated; (c) kinked or distorted beads.

Cut or Puncture—Check for cut or puncture entirely through the carcass cord body and liner.

Air Temperature

Was tire inflated in heated room and then stored outside? Air pressure will drop approximately 1 psi for every 4° drop in temperature. Tires should be checked and pressure adjusted for specific requirements when tires have reached the outside ambient temperature.

Venting of Tubeless Tires

Tubeless aircraft tires are vented in the sidewall area to permit any air that has diffused through the liner and cord body to escape, thus preventing pressure build up within the carcass cord body and possible tread or ply separation. Rate of diffusion will vary by manufacturer and the maximum permissible is no more than 5 percent in any 24-hour period.

Vent holes penetrate the sidewall rubber to, or into, the carcass cord body and may vary in size, depth and angle. Therefore, the amount of air diffused through these holes will vary. Thus, when water or a soapy solution is brushed over the outside of an inflated tubeless tire, air bubbles form. Some vent holes may emit a continuous stream of bubbles, where others may produce intermittent bubbles. This is normal and does not mean that there is anything wrong with the tire. In fact, as long as a tubeless tire is in an inflated condition, air will be coming out of these vent holes. Where the rate of loss exceeds 5 percent 24 hours, recheck for possible injuries. Vent holes may be covered or closed by spilled solvent or by the tire paint. They may also be covered during the retreading process. Check for evidence that tubeless tires have been revented after being retreaded.

Initial Stretch Period

All aircraft tires are of nylon construction and a certain amount of stretch occurs after the tire has been inflated. This, in itself, will reduce air pressure within the tire. It is absolutely necessary that the tire be inflated to its regular air pressure and let stand at least 12 hours in order to permit this expansion of the cord body. This may result in as much as 10 percent drop in air pressure. Compensate by reinflating the tire to original pressure. Only after this initial stretch period can it be determined if there is any true air loss within the tire.

THE WHEEL

Any of the following wheel conditions can contribute to air loss in the bead area of the tire:

Cracks Or Scratches In The Bead Ledge Or Flange Area

Cracks can usually be traced to fatigue failure while scratches and gouges are the result of handling damage or the improper use of tire irons.

Exceptionally Smooth Enamel Surface On Bead Seat Ledges

Corrosion Or Wear In Bead Ledge Area

Usually occurs at the toe area of the tire bead.

Poor Seating In Bead Area

May be caused by accumulation of rubber from the tire or dirt.

Knurls

Wheels converted from tube-type use should have knurls removed.

Porous Wheel Assemblies

Can be protected either by proper paint procedure and/or an impregnation process.

Holes for attachment of components of wheel assembly. In case of through bolts used to attach such items as drive lugs for brake assembly, etc., the mounting screws or bolts must be properly sealed. The recommendations of the wheel manufacturer should be followed.

Cracks in the wheel well area, in most cases, cannot be repaired.

Sealing Surfaces

Look for damage or improper machining of sealing surfaces. Care should be taken to see that there is no handling damage. Any irregularities should be corrected before remounting wheel and tire. (See figure 9–60.)

Foreign material or paint can impair the sealing surface. Thus, all foreign material should be cleaned from the sealing surface before assembly of the wheel. A light, even coat of primer is permissible. However, surface must be free of runs or dirt inclusions.

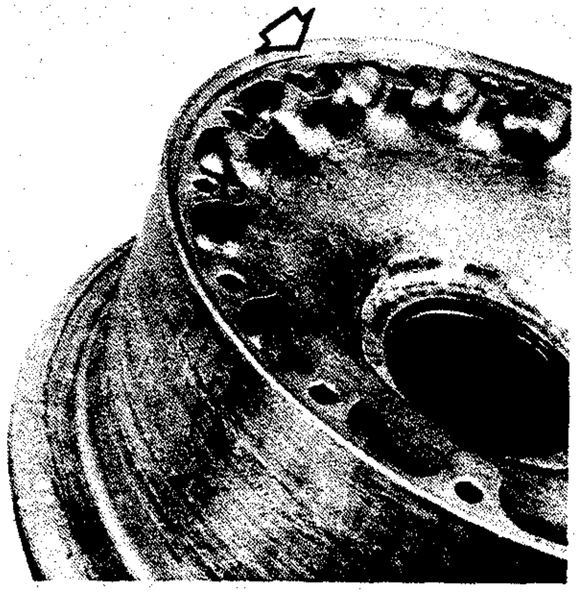


FIGURE 9-60. Wheel inspection.

Improper Installation of "O" Rings

Twisting or failure to provide lubricant when specified, may cause loss of air. The wrong size or type of "O" ring, or an "O" ring of the wrong compound for special low temperature service, may also cause leakage.

Inspect used "O" rings carefully. Be sure they are not thinned out, deformed, chipped, damaged or otherwise deteriorated.

Wheel Tie Bolts

Proper torque and torquing procedure, as specified by the wheel manufacturer, should be followed to assure adequate compression of sealing "O" ring under all temperature conditions. Low torques, low temperatures, and shrinkage of the wheel halves may cause a significant lessening of compression on the "O" ring seal.

Tubeless Wheel Valve Holes

Tubeless wheel valve holes and surrounding area must be free of scratches, gouges and foreign material.

The proper rubber grommet or "O" ring must be used as specified by the wheel manufacturer. Seals other than those specified may not function properly under the compression loads and low temperatures required for good sealing. Tightening of tubeless valve should follow specific instructions of wheel manufacturer.

Valve core should be checked and replaced when found leaking.

Valve caps should be used and tightened finger tight.

Thermal Fuze Installation

A faulty thermal fuze may cause leakage and require replacement. Usually this is the result of a poor bond between thermal melting material and bolt body.

Sealing surface for thermal fuze gasket must be clean and free from scratches and dirt. In some cases, surface can be repaired in accordance with manufacturer's instruction.

Be sure that sealing gasket is the one specified by the wheel manufacturer, sized and compounded for its specific job. Gasket should be free of distortion, cuts, etc.

To guard against air pressure losses before assembly the best insurance is a careful and complete inspection. After assembly, if air loss occurs, the use of a soap solution (or, if possible, complete immersion of wheel-tire assembly) may pinpoint the exact source of leakage.

GOOD PRESSURE GAGE PRACTICE

Quite often it is found that the differences in reported air pressures are entirely due to the difference in accuracy in different gages, rather than in any change in air pressure.

It is not unusual to find an inaccurate tire gage in constant use with a tag that states that the gage reads a certain number of pounds too high, or too low. Unfortunately, this error will change as different pressures are checked. A tire gage reading 10 lbs. high at 80 lbs. pressure may very well read 25 lbs. too high at 150 lbs. pressure. Therefore, incorrect tire gages should either be repaired or replaced. They should not be continued in service.

Cold temperatures may also affect tire gages and cause pressure readings lower than they actually are. Occasionally, too, a gage has been mistakenly treated with oil or some other lubricant in expectation of making it work better. This, of course, will actually cause incorrect readings and probably render the gage unfit for further service.

It is good practice to have gages recalibrated periodically and to use the same gage for performing an inflation cycle—for the original 12- or 24-hour stretch period. Dial type gages, of good quality, are highly recommended for all tire maintenance installations—regardless of size!

Storing Aircraft Tires and Tubes

The ideal location for tire and tube storage is a cool, dry and reasonably dark location, free from air currents and dirt. While low temperatures (not below 32° F.) are not objectionable, high room temperatures (80° F.) are detrimental and should be avoided.

Avoid Moisture, Ozone

Wet or moist conditions have a rotting effect and may be even more damaging when the moisture contains foreign elements that are further detrimental to rubber and cord fabric. Strong air currents should be avoided, since they increase the supply of oxygen and quite often carry ozone, both of which cause rapid aging of rubber. Also, particular care should be taken to store tires away from electric motors, battery chargers, electric welding equipment, electric generators and similar equipment as they all create ozone.

Fuel and Solvent Hazards

Care should be taken that tires do not come in contact with oil, gasoline, jet fuel, hydraulic fluids, or any type of rubber solvent, since all of these are natural enemies of rubber and cause it to disintegrate rapidly. Be especially careful not to stand or lay tires on floors that are covered with oil or grease. When working on engines or landing gear, tires should be covered so that oil does not drip on them.

Store In Dark

The storage room should be dark, or at least free from direct sunlight. Windows should either be given a coat of blue paint or covered with black plastic. Either of these will provide some diffused lighting during the daytime. Black plastic is preferred as it will lower the temperature in the room during the warm months and permit tires to be stored closer to the windows.

Tire Racks Preferred

Whenever possible, tires should be stored in regular tire racks which hold them up vertically. The surface of the tire rack against which the weight of the tire rests should be flat and, if possible, 3 to 4 inches wide in order that no permanent distortion to the tire is caused. If tires are piled on top of one another, they should not be stacked too high, as this will cause distortion of the tire and might result in trouble when the tires are put into service. This is particularly true of tubeless tires, as those on the bottom of the stack may have the beads pressed so closely together that a bead seating tool will have to be used to force the tire beads onto the wheel far enough to retain air pressure for inflation (figure 9–61).

Safe Tube Storage

Tubes should always be stored in their original cartons, so that they are protected from light and air currents. They should never be stored in bins or on shelves without being wrapped, preferably in several layers of heavy paper.

Tubes can also be stored by inflating slightly and inserting them in the same size of tire. This of course, should only be done as a more or less temporary measure. However, before using such an assembly, the tube should be removed from the tire and the inside of the tire carefully examined, since quite often foreign material will get between the two and if not removed, could cause irreparable damage to both tire and tube.

Under no circumstances should tubes be hung over nails or pegs, or over any other object that might form a crease in the tube. Such a crease will eventually produce a crack in the rubber.

REPAIRING

Many aircraft tires and tubes which become injured in service can be successfully repaired. Likewise, aircraft tires which have become worn out in service, or flat spotted and removed prematurely,

Size	Without Tube	With Tube Inserted	Size	Without Tube	With Tube Inserted
			56" SC and larger	3	4
26x6	5	6	12.50-16	4	5
33"	4	5	15.00-16	3	4
36"	4	5	17.00-16	3	4
44"	4	5	15.50-20	3	4
47"	3	4	17.00-20	3	4

Smaller sizes of tubess tires may be stacked five high. This would include sizes through 39 x 13. Larger sizes of tubless tires should not be stacked more than four high.

FIGURE 9–61. Permissible tire stacking.

can be recapped so that the new tread will give service comparable to the original tread. The recapping and repairing of aircraft tires has been practiced for many years and has saved aircraft operators considerable sums of money. Tires which might otherwise have been discarded have been safely reconditioned (many repeatedly) for continued service.

Recapping Aircraft Tires

Recapping is a general term meaning reconditioning of a tire by renewing the tread, or renewing the tread plus one or both sidewalls. (See figure 9-62.) There are actually four different types of recapping for aircraft tires.

Top Capping—For tires worn to the bottom of the tread design, with no more than slight flat spotting and/or shoulder wear, the old tread is roughened and a new tread is applied.

Full Capping—For tires worn all around, those flat spotted to the cords, or those with numerous cuts in the tread area, the new tread material is wider than that used on a top cap, and comes down over the shoulder of the tire for several inches.

Three-Quarter Retread—For tires needing a new tread, plus renewing of the sidewall rubber on one side, due to damage or weather checking, a full cap is applied, and in addition, approximately $\frac{1}{16}''$ of the thickness of the old sidewall rubber is buffed off one side. New sidewall rubber is then applied from the bead to the edge of the new tread, on the buffed side only.

Bead-to-Bead Retread—A new tread and both new sidewalls are applied by this method.

Tires That May Be Recapped

Tires with sound cord bodies and beads, or which meet injury limitations described under "Repairable Aircraft Tires."

Tires which are worn to 80 percent or more of their total tread depth.

Tires with one or more flat spots severe enough to cause an out-of-balance condition, regardless of the percentage of wear. Tires having so many tread cuts that repairing the tread rubber would be uneconomical.

Nonrecappable Tires

Tires having injuries which would make them nonrepairable.

Tires with six full plies or more having any spot worn through more than one body ply. (It is generally not considered economical to retread 4 and 6 ply aircraft tires.)

Tires with weather checking or ozone cracking of tread or sidewall that exposes the cords.

Repairable Aircraft Tires

When considering a tire for repairing only, the amount of service remaining in the tire is important. Any tire with at least 30 percent of tread life remaining, normally would be considered as having enough service left in it to warrant repair only.

Nonrepairable Aircraft Tires

The following conditions disqualify a tire for repair:

Any injury to the beads, or in the bead area (except injuries limited to the bead cover or finishing strip as previously mentioned under repairable aircraft tires).

A. Sidewall cords damaged beyond repair.

B. Sidewall cords OK for retread.

C. Worn through breaker only. OK for retread.

FIGURE 9-62. Operational damage

Any tire with protruding bead wire or badly kinked bead.

Any tire which shows evidence of ply or tread separation.

Any tire with loose, damaged, or broken cords on the inside.

Tires with broken or cut cords in the outside of the sidewall or shoulder area.

Tires that have gone flat, or partially flat, due to the melting or failure of fuze plugs in the wheels should normally be scrapped, even though there may be no visible evidence of damage to the inside or outside of the tire. The only exceptions would be where it was known that the fuze plug leaked air because of its being defective.

Spot Repairs

When considered economical, spot repairs can be made to take care of tread injuries such as cuts, snags, etc., which are through no more than 25 percent of the actual body plies of the tire, and not over 2″ in length at the surface. Vulcanized spot repairs are also made at times to fill in tread gouges that do not go deeper than the tread rubber and do not penetrate the cord body.

Low speed tires (under 160 mph) with tread injuries that penetrate no more than 25 percent of the actual body (breaker strips not included), and have a maximum surface length of 2″, may be repaired. If the injury penetrates beyond 25 percent of the actual body plies, it may still be repairable but the surface length of the injury should be no more than 1″.

High speed tires (over 160 mph) with tread injuries that penetrate no more than 40 percent of the actual body plies (breaker strips and fabric reinforcement strips in the tread not included) and have a maximum surface length of 1½″ with maximum width no more than ¼″, may be repaired.

Injuries through the cord body in the tread area, measuring ⅛″ or less at the largest point, are considered punctures and are easily repaired.

Shallow cuts in the sidewall or shoulder rubber only are repairable if cords are exposed but not damaged.

Tires having minor injuries through the finishing strip, or slight injuries caused by tire tools in the general bead area, are repairable if the injury does not extend into the plies of the tire, and provided there is no sign of separation in the bead area. If the finishing strips are loose or blistered, they can only be replaced by bead-to-bead retreading.

Liner blisters smaller than 4″ x 8″ may be repaired if there are no more than two in any one quarter section of the tire, and no more than five in the complete tire. Normally, however, it would be more economical to do this repair at the time the tire is recapped.

It is generally considered uneconomical to repair 4- and 6-ply aircraft tires.

OPERATING AND HANDLING TIPS

Taxiing

Needless tire damage or excessive wear can be prevented by proper handling of the aircraft during taxiing.

Most of the gross weight of any aircraft is on the main landing gear wheels—on two, four, eight or more tires. The tires are designed and inflated to absorb shock of landing and will deflect (bulge at the sidewall) about two and one-half times more than a passenger car or truck tire. The greater deflection causes more working of the tread, produces a scuffing action along the outer edges of the tread and results in more rapid wear.

Also, if an aircraft tire strikes a chuck hole, a stone, or some foreign objects lying on the runway, taxi strip, or ramp, there is more possibility of its being cut, snagged or bruised because of the percentage of deflection. Or, one of the main landing gear wheels, when making a turn, may drop off the edge of the paved surface causing severe sidewall or shoulder damage. The same type of damage may also occur when the wheel rolls back over the edge of the paved surface.

With dual main landing gear wheels, one tire might be forced to take a damaging impact (which two could withstand without damage) simply because all the weight on one side of the plane is concentrated on one tire instead of being divided between two.

As airports grow in size and taxi runs become longer, chances for tire damage and wear increase. Taxi runs should be no longer than absolutely necessary and should be made at speeds no greater than 25 mph, particularly for aircraft not equipped with nose wheel steering.

For less damage in taxiing, all personnel should see that ramps, parking areas, taxi strips, runways and other paved areas are regularly cleaned and cleared of all objects that might cause tire damage.

Braking and Pivoting

Increasing airport traffic, longer taxi runs and longer runs on takeoff and landing are subjecting tires to more abrasion resulting from braking, turning and pivoting.

Severe use of brakes can wear flat spots on tires and cause them to be out of balance, making premature recapping or replacement necessary.

Severe or prolonged application of the brakes can be avoided when ground speed is reduced.

Careful pivoting of aircraft also helps to prolong tire tread life. If an aircraft turned as an automobile or truck does—in a rather wide radius—the wear on the tire tread would be materially reduced. However, when an aircraft is turned by locking one wheel (or wheels), the tire on the locked wheel is twisted with great force against the pavement. A small piece of rock or stone that would ordinarily cause no damage, can, in such a case, be literally screwed into the tire. This scuffing or grinding action takes off tread rubber and places a very severe strain on the sidewalls and beads of the tire at the same time.

To keep this action at a minimum, it is recommended that whenever a turn is made, the inside wheel (wheels) be allowed to roll on a radius of 20 to 25 feet and up to 40 feet for aircraft with bogies.

Takeoffs and Landings

Aircraft tire assemblies are always under severe strain on takeoff or landing. But under normal conditions, with proper control and maintenance of tires, they are able to withstand many such stresses without damage.

Tire damage on takeoff, up to the point of being airborne, is generally the result of running over some foreign object. Flat spots or cuts incurred in pivoting can also be a cause of damage during takeoff or landing.

Tire damage at the time of landing can be traced to errors in judgment or unforeseen circumstances. Smooth landings result in longer tread wear and eliminate much of the excessive strain on tires at the moment of impact.

Landings with brakes locked, while almost a thing of the past, can result in flat spotting. Removal of the tire for recapping or replacement is almost invariably indicated. Brakes-on landings also cause very severe heat at the point of contact on the tire tread and may even melt the tread rubber (skid burn). Heat has a tendency to weaken the cord body and places severe strain on the beads. In addition, heat buildup in the brakes may literally devulcanize the tire in the bead area. Under these circumstances, blowouts are not uncommon because air under compression must expand when heated.

On aircraft equipped with tail wheels, a two point landing is usually somewhat smoother than a three point landing, but is ordinarily made at considerably higher speed. As a result, more braking may be required to bring the aircraft to a stop. If tires are skidded on the runway at high speed, the action is similar to tires being ground against a fast turning emery wheel.

Sometimes an aircraft will be brought in so fast that full advantage will not be taken of runway length and brakes are applied so severely that flat spots are produced on the tires. Or, if brakes are applied when the plane is still traveling at high speed and still has considerable lift, tires may skid on the runway and become damaged beyond further use or reconditioning.

The same thing may occur during a rough landing if brakes are applied after the first bounce. For maximum tire service, delay brake application until the plane is definitely settled into its final roll.

More tires fail on takeoff than on landing and such failures on takeoff can be extremely dangerous. For that reason, emphasis must be placed on proper preflight inspection of tires and wheels.

Condition of Landing Field

Regardless of the preventive maintenance and extreme care taken by the pilot and ground crew in handling the aircraft, tire damage is almost sure to result if runways, taxi strips, ramps and other paved field areas are in a bad condition or poorly maintained.

Chuck holes, pavement cracks or step-offs from these areas to the ground, all can cause tire damage. In cold climates, especially during the winter, all pavement breaks should be repaired immediately.

Another hazardous condition often overlooked is accumulated loose material on paved areas and hangar floors. Stones and other foreign materials should also be swept off all the paved areas. In addition, tools, bolts, rivets and other repair materials are sometimes left lying on the aircraft and when the aircraft is moved, these materials drop off. These objects picked up by the tires of another aircraft can cause punctures, cuts, or complete failure of the tire, tube and even the wheel. With jet aircraft, it is even more important that foreign material be kept off areas used by aircraft.

Hydroplaning

This is a condition whereby on wet runways, a wave of water can build up in front of spinning tires and when over-run, tires will no longer make contact with the runway. This results in the complete loss of steering capability and braking action. Hydroplaning can also be caused by a thin film of water on the runway mixing with the contaminants present. (See figure 9-63.)

Cross cutting of runways has been completed at some of the major airports and reportedly has greatly reduced the danger of hydroplaning. However, the ridges of concrete created by this cross-cutting can cause a chevron type of cutting of tread ribs, particularly with the higher pressure tires used on jet aircraft. These cuts are at right angles to the ribs and rarely penetrate to the fabric tread reinforcing strip. Such damage would not be considered cause for removal unless fabric was exposed due to a piece of tread rib being torn out.

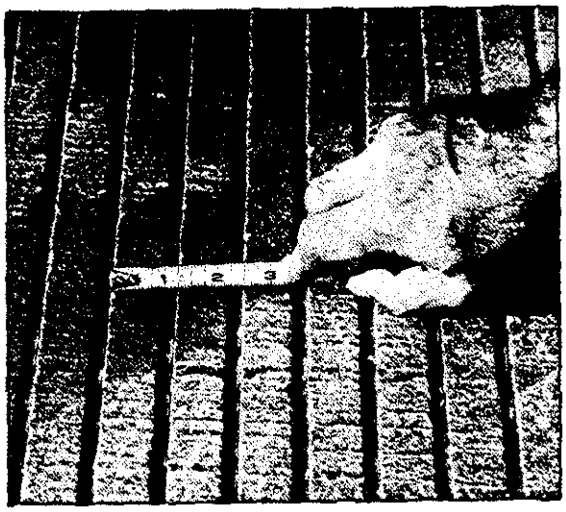


FIGURE 9-63. Cross cutting runways reduces danger of hydroplaning.

TUBE REPAIR

Most tube repairs are necessary because of valves being broken off or otherwise damaged. However, occasionally, a tube might be cut, punctured, or damaged by the tire tools during mounting or demounting. Injuries larger than one inch can be repaired by using a reinforcement patch inside the tube. This reinforcement would be the same material that is used for repairing the tube on the outside. An injury smaller than one inch should not need a reinforcement piece.

Chaffing damage caused by the toe of the tire bead, or thinning out of the tube from brake heat should be cause for immediate scrapping of the tube.

There are three general types of valves used in aircraft inner tubes:

1. The rubber valve, which has a rubber stem and a rubber base cured to the outside surface of the inner tube. This valve is similar to those used on inner tubes in passenger car service. Replacement of this valve can be made by most any gasoline service station or garage, providing they have the proper valve for replacement.
2. Metal valve with rubber base. These are easily recognized since the rubber base is similar to the one used on the all-rubber valve just described. Generally, replacement is made by the same method but it is absolutely necessary that the replacement valve have the same dimensions as the original.
3. Metal valve with a fabric-reinforced rubber base. The base may be cured on top of the tube, or it may be cured into the tube. The metal valve may have to be bent to the proper angle, or angles. Repairing of this type of tube is more difficult because it is necessary to replace the valve pad. Experienced personnel and special equipment are necessary to effect the proper cure of the replacement valve pad to the inner tube.

Repair type valves are also available for valves mentioned in 2 and 3 above. These are applied by cutting off the original valve and screwing on a replacement repair valve to the spud of the original valve. Follow instructions provided by the manufacturer of these repair type valves.

SIDEWALL-INFLATED AIRCRAFT TIRES

Some tires for small aircraft are manufactured with a valve in the sidewall, thus eliminating the need for machining the wheel to take a conventional valve (see figure 9-64).

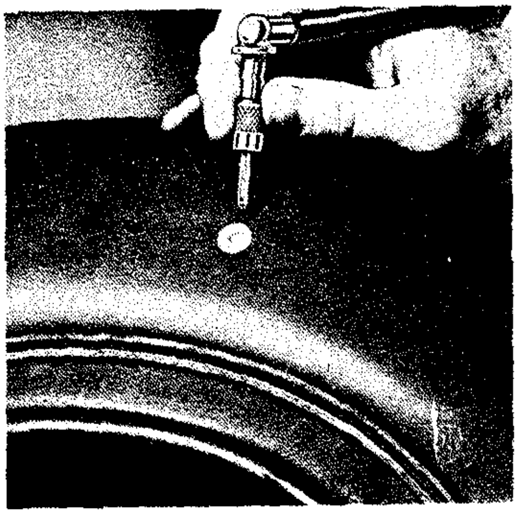


FIGURE 9-64. Sidewall-inflated tire.

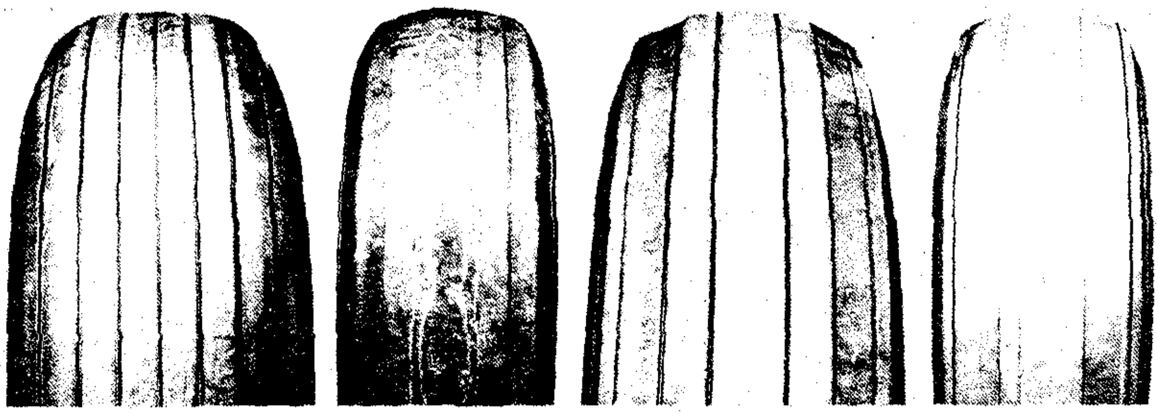
Inflation as well as checking air pressure, is accomplished by inserting a needle through the rubber sidewall valve, similar to the way footballs and other sporting goods equipment are inflated. Care should be given these needles. If damaged, they may injure the valve, resulting in air loss, particularly when the tire is under load.

Replacing these valves is easy. The only equipment needed is a knife or scissors to cut off the old valve inside the tire, and a piece of string for inserting the replacement valve. It is even possible to replace these valves without completely removing the tire from the wheel.

TIRE INSPECTION SUMMARY

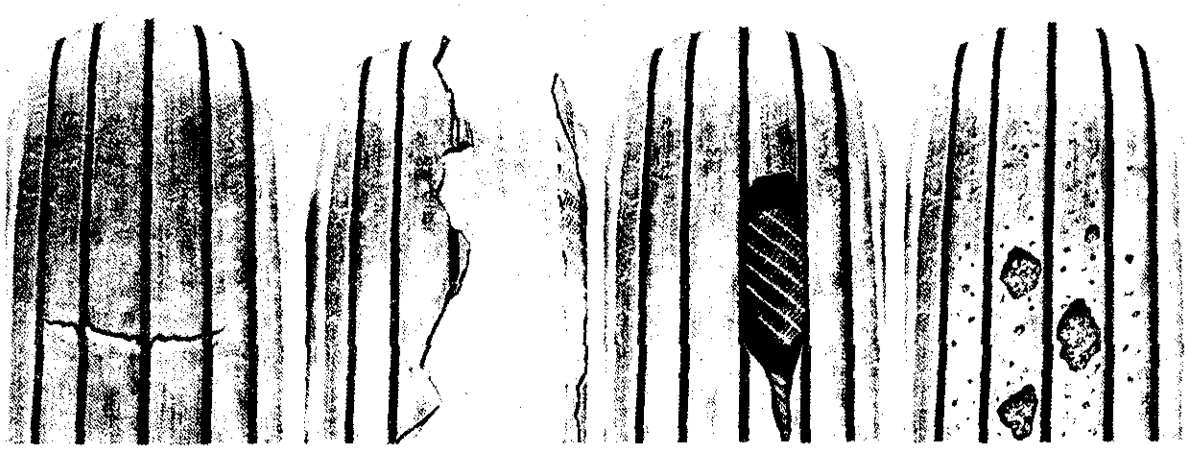
Tires in service should be inspected regularly for excessive wear or other conditions which may render the tire unsafe. This will reduce tire costs noticeably and may prevent a serious accident. Figure 9–65 shows the most common types of tire wear and damage.

A



A. Normal B. Worn out C. Under inflation D. Over inflation

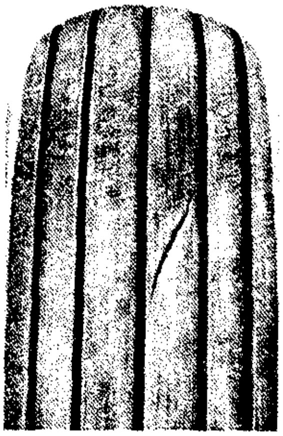
B



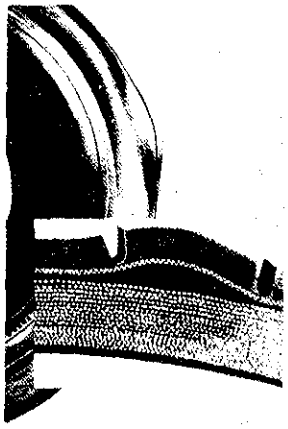
A. Open tread splice B. Thrown tread C. Peeled rib D. Tread chunking

FIGURE 9–65. Common types of tire damage: A, Tread wear; B, Tread; C, Sidewall; D, Carcass; and E, Bead.

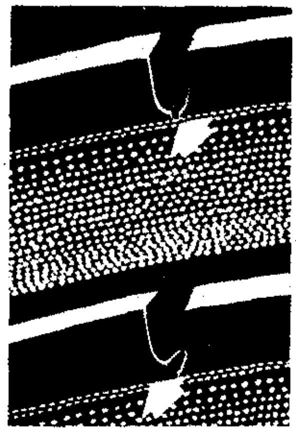
B—Cont.



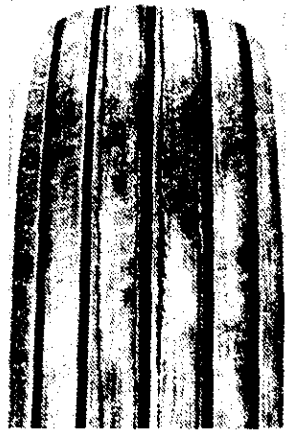
A. Cut



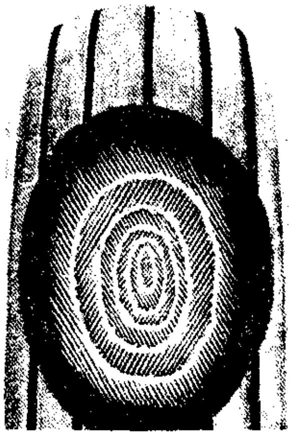
B. Blister and tread separation



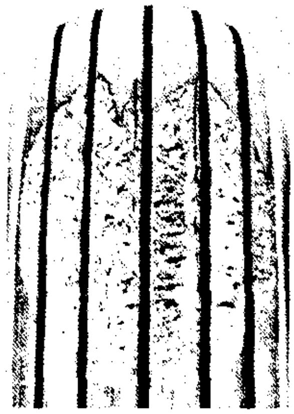
C. Groove cracking and rib undercutting



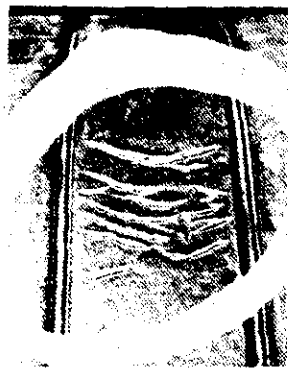
D. Flaking and chipping



A. Skid



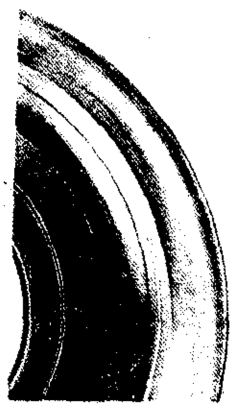
B. Tread rubber reversion



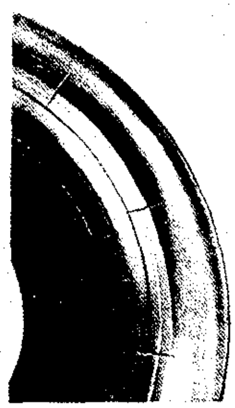
C. Chevron cutting

D. Fabric fraying

C



A. Circumferential cracks

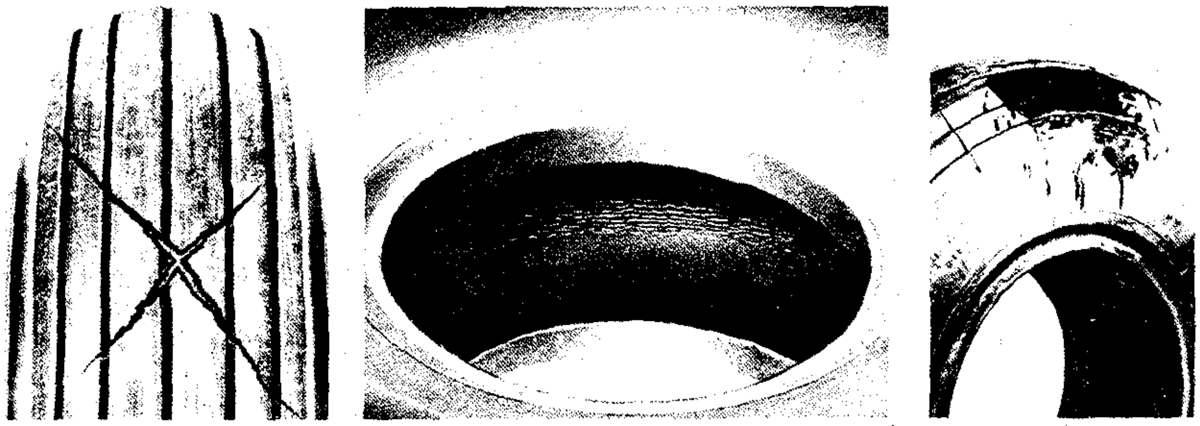


B. Radial cracks

C. Weather checking.

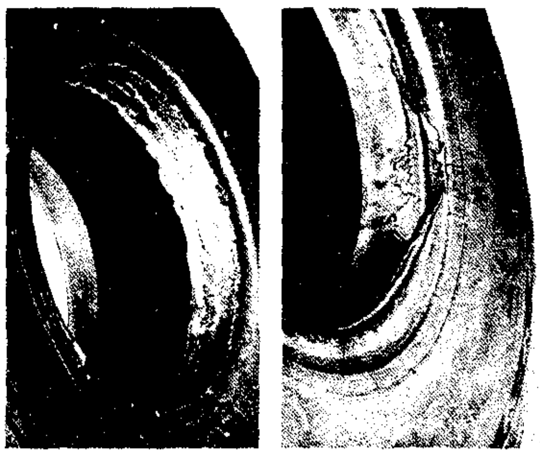
FIGURE 65—Cont.

D



A. Impact break B. Liner breakdown C. Contamination

E



A. Brake heat damage B. Chaff damage

FIGURE 65—Cont.

ANTISKID SYSTEM

The purpose of a wheel brake is to bring a rapidly moving aircraft to a stop during ground roll. It does this by changing the energy of movement into heat energy through the friction developed in the brakes. A feature found in high performance aircraft braking systems is skid control or antiskid protection. This is an important system because if a wheel goes into a skid, its braking value is greatly reduced.

The skid control system performs four functions: (1) normal skid control, (2) locked wheel skid control, (3) touchdown protection, and (4) fail-safe protection. The main components of the system consist of two skid control generators, a skid control box, two skid control valves, a skid control switch, a warning lamp, and an electrical control harness with a connection to the squat switch.

Normal Skid Control

Normal skid control comes into play when wheel rotation slows down but has not come to a stop. When this slowing down happens, the wheel sliding action has just begun but has not yet reached a full scale slide. In this situation the skid control valve removes some of the hydraulic pressure to the wheel. This permits the wheel to rotate a little faster and stop its sliding. The more intense the skid is, the more braking pressure is removed. The skid detection and control of each wheel is completely independent of the others. The wheel skid intensity is measured by the amount of wheel slow-down.

Skid Control Generator

The skid control generator is the unit that measures the wheel rotational speed. It also senses any changes in the speed. It is a small electrical generator, one for each wheel, mounted in the wheel axle. The generator armature is coupled to, and driven by, the main wheel through the drive cap in the wheel. As it rotates, the generator develops a voltage and current signal. The signal strength indicates the wheel rotational speed. This signal is fed to the skid control box through the harness.

Skid Control Box

The box reads the signal from the generator and senses change in signal strength. It can interpret these as developing skids, locked wheels, brake applications, and brake releases. It analyses all it reads, then sends appropriate signals to solenoids in the skid control valves.

Skid Control Valves

The two skid control valves mounted on the brake control valve are solenoid operated. Electric signals from the skid control box actuate the solenoids. If there is no signal (because there is no wheel skidding), the skid control valve will have no effect on brake operation. But, if a skid develops, either slight or serious, a signal is sent to the skid control valve solenoid. This solenoids' action lowers the metered pressure in the line between the metering valve and the brake cylinders. It does so by dumping fluid into the reservoir return line whenever the solenoid is energized. Naturally, this immediately relaxes the brake application. The pressure flow into the brake lines from the metering valves continues as long as the pilot depresses the brake pedals. But the flow and pressure is rerouted to the reservoir instead of to the wheel brakes.

The utility system pressure enters the brake control valve where it is metered to the wheel brakes in proportion to the force applied on the pilot's foot pedal. However, before it can go to the brakes, it must pass through a skid control valve. There, if the solenoid is actuated, a port is opened in the line between the brake control valve and the brake. This port vents the brake application pressure to the utility system return line. This reduces the brake application, and the wheel rotates faster again. The system is designed to apply enough force to operate just below the skid point. This gives the most effective braking.

Pilot Control

The pilot can turn off the operation of the anti-skid system by a switch in the cockpit. A warning lamp lights when the system is turned off or if there is a system failure.

Locked Wheel Skid Control

The locked wheel skid control causes the brake to be fully released when its wheel locks. A locked wheel easily occurs on a patch of ice due to lack of tire friction with the surface. It will occur if the normal skid control does not prevent the wheel from reaching a full skid. To relieve a locked wheel skid, the pressure is bled off longer than in normal skid function. This is to give the wheel time to regain speed. The locked wheel skid control is out of action during aircraft speeds of less than 15–20 mph.

Touchdown Protection

The touchdown protection circuit prevents the brakes from being applied during the landing approach even if the brake pedals are depressed. This prevents the wheels from being locked when they contact the runway. The wheels have a chance to begin rotating before they carry the full weight of the aircraft. Two conditions must exist before the skid control valves permit brake application. Without them the skid control box will not send the proper signal to the valve solenoids. The first is that the squat switch must signal that the weight of the aircraft is on the wheels. The second is that the wheel generators sense a wheel speed of over 15–20 mph.

Fail-Safe Protection

The fail-safe protection circuit monitors operation of the skid control system. It automatically returns the brake system to full manual in case of system failure. It also turns on a warning light.

LANDING GEAR SYSTEM MAINTENANCE

Because of the stresses and pressures acting on the landing gear, inspection, servicing, and other maintenance becomes a continuous process. The most important job in the maintenance of the aircraft landing gear system is thorough, accurate inspections. To properly perform the inspections, all surfaces should be cleaned to ensure that no trouble spots go undetected.

Periodically, it will be necessary to inspect shock struts, shimmy dampers, wheels, wheel bearings, tires, and brakes. During this inspection, check for the presence of installed ground safety locks. Check landing gear position indicators, lights, and warn-

ing horns for operation. Check emergency control handles and systems for proper position and condition. Inspect landing gear wheels for cleanliness, corrosion, and cracks. Check wheel tie bolts for looseness. Examine anti-skid wiring for deterioration. Check tires for wear, cuts, deterioration, presence of grease or oil, alignment of slippage marks, and proper inflation. Inspect the landing gear mechanism for condition, operation, and proper adjustment. Lubricate the landing gear, including the nose wheel steering. Check steering system cables for wear, broken strands, alignment, and safetying. Inspect landing gear shock struts for such conditions as cracks, corrosion, breaks, and security. Where applicable, check the brake clearances.

Various types of lubricants are required to lubricate points of friction and wear on the landing gear. These lubricants are applied by hand, an oil can, or a pressure-type grease gun. Before using the pressure-type grease gun, wipe the lubrication fittings clean of old grease and dust accumulations, because dust and sand mixed with a lubricant produce a very destructive abrasive compound. As each fitting is lubricated, the excess lubricant on the fitting and any that is squeezed out of the assembly should be wiped off. Wipe the piston rods of all exposed actuating cylinders; clean them frequently, particularly prior to operation, to prevent damage to seals and polished surfaces.

Periodically, wheel bearings must be removed, cleaned, inspected, and lubricated. When cleaning a wheel bearing, use a suitable cleaning solvent. (*Leaded gasoline should not be used.*) Dry the bearing by directing a blast of dry air between the rollers. Do not direct the air so that it will spin the bearing, as it may fly apart and injure nearby persons. When inspecting the bearing, check for defects that would render it unservicable, such as flaked, cracked, or broken bearing surfaces; roughness due to impact pressure or surface wear; corrosion or pitting of the bearing surfaces; discoloration from excessive heat; cracked or broken cages;

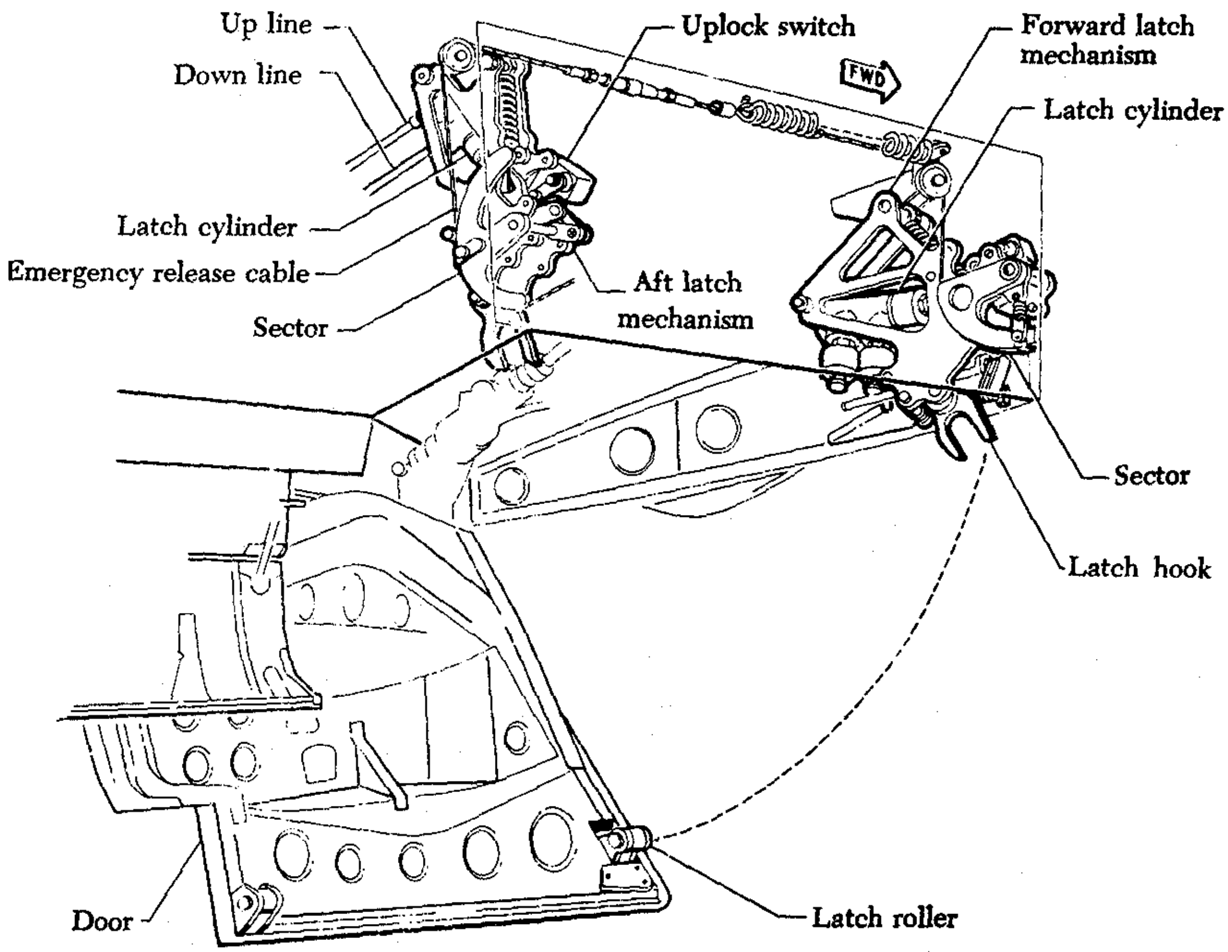


FIGURE 9–66. Main gear door latch mechanisms.

or scored or loose bearing cups or cones which would affect proper seating on the axle or wheel. If any of these defects exist replace the bearing with a servicable one. To prevent rust or corrosion, lubricate the bearing immediately after cleaning and inspecting it.

To apply lubricant to a tapered roller bearing, place a small amount of the proper lubricant on the palm of the hand. Grasp the cone of the bearing assembly with the thumb and first two fingers of the other hand, keeping the larger diameter of the bearing next to the palm. Move the bearing assembly across the hand toward the thumb, forcing the lubricant into the space between the cone and rollers. Turn the assembly after each stroke until all openings between the rollers are filled with lubricant. Remove the excess lubricant from the cone and the outside of the cage.

Landing Gear Rigging and Adjustment

Occasionally it becomes necessary to adjust the landing gear switches, doors, linkages, latches, and locks to assure proper operation of the landing gears and doors. When landing gear actuating cylinders are replaced and when length adjustments are made, overtravel must be checked. Overtravel is that action of the cylinder piston beyond the movement necessary for landing gear extension and retraction. The additional action operates the landing gear latch mechanism.

Because of the wide variety of aircraft types and designs, procedures for rigging and adjusting landing gear will vary. Uplock and downlock clearances, linkage adjustments, limit switch adjustments, and other landing gear adjustments vary widely with landing gear design. For this reason, always consult the applicable manufacturers maintenance or service manual before performing any phase of landing gear rigging or installation.

Adjusting Landing Gear Latches

The adjustment of latches are of prime concern to the airframe mechanic. A latch is used in landing gear systems to hold a unit in a certain position after the unit has traveled through a part of, or all of, its cycle. For example, on some aircraft, when the landing gear is retracted, each gear is held in the up position by a latch. The same holds true

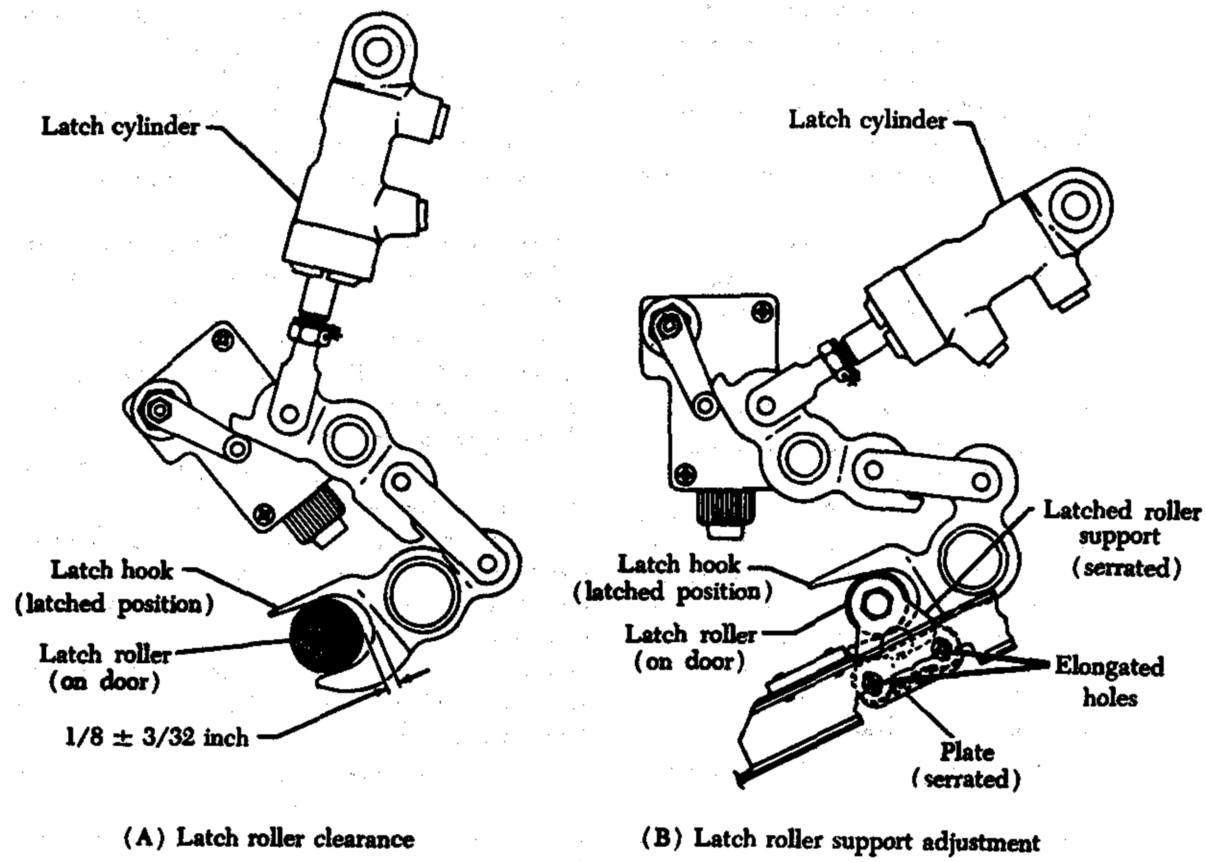


FIGURE 9–67. Landing gear door latch installations.

when the landing gear is extended. Latches are also used to hold the landing gear doors in the open and closed positions.

There are many variations in latch design. However, all latches are designed to accomplish the same thing. They must operate automatically, at the proper time, and hold the unit in the desired position. A typical landing gear door latch is described in the following paragraphs.

On this particular aircraft, the landing gear door is held closed by two door latches. As shown in figure 9–66, one is installed near the rear of the door. To have the door locked securely, both locks must grip and hold the door tightly against the aircraft structure. The principal components of each latch mechanism shown in figure 9–66 are a hydraulic latch cylinder, a latch hook, a spring loaded crank-and-lever linkage, and a sector. The latch cylinder is hydraulically connected with the landing gear control system and mechanically connected, through linkage, with the latch hook. When hydraulic pressure is applied, the cylinder operates the linkage to engage (or disengage) the hook with (or from) the latch roller on the door. In the gear-down sequence the hook is disengaged by the spring load on the linkage. In the gear-up sequence, spring action is reversed when the closing door is in contact with the latch hook and the cylinder operates the linkage to engage the hook with the latch roller.

Cables on the landing gear emergency extension system are connected to the sector to permit emergency release of the latch rollers. An uplock switch is installed on, and actuated by, each latch to provide a gear-up indication in the cockpit.

With the gear up and the door latched, inspect the latch roller for proper clearance as shown in figure 9–67, view A. On this installation the required clearance is $1/8 \pm 3/32$ in. If the roller is not within tolerance it may be adjusted by loosening its mounting bolts and raising or lowering the latch roller support. This may be done due to the elongated holes and serrated locking surfaces of the latch roller support and serrated plate (view B).

Landing Gear Door Clearances

Landing gear doors have specific allowable clearances which must be maintained between doors and the aircraft structure or other landing gear doors. These required clearances can be maintained by adjusting the door hinges and connecting links and trimming excess material from the door if necessary.

On some installations, door hinges are adjusted by placing the serrated hinge and serrated washers in the proper position and torquing the mounting bolts. Figure 9–68 illustrates this type of mounting, which allows linear adjustments. The amount of linear adjustment is controlled by the length of the elongated bolthole in the door hinge.

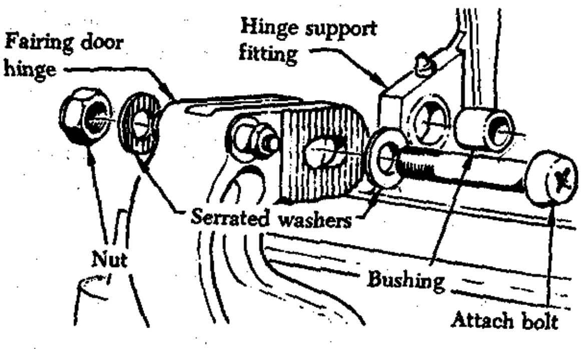


FIGURE 9–68. Adjustable door hinge installation.

The distance the landing gear doors open or close depends upon the length of door linkage and the adjustment of the door stops. The manufacturer's maintenance manuals specify the length of door linkages and adjustment of stops or other procedures whereby correct adjustments may be made.

Landing Gear Drag and Side Brace Adjustment

The landing gear side brace illustrated in figure 9–69 consists of an upper and lower link, hinged at the center to permit the brace to jackknife during retraction of the landing gear. The upper end pivots on a trunnion attached to the wheel well overhead. The lower end is connected to the shock strut.

On the side brace illustrated, a locking link is incorporated between the upper end of the shock strut and the lower drag link. Usually in this type installation, the locking mechanism is adjusted so that it is positioned slightly overcenter. This provides positive locking of the side brace and the locking mechanism, and as an added safety feature, prevents inadvertant gear collapse caused by the side brace folding.

To adjust the overcenter position of the side brace locking link illustrated in figure 9–69, place the landing gear in the down position and adjust the lock link end fitting so that the side brace lock link is held firmly overcenter. Manually break the

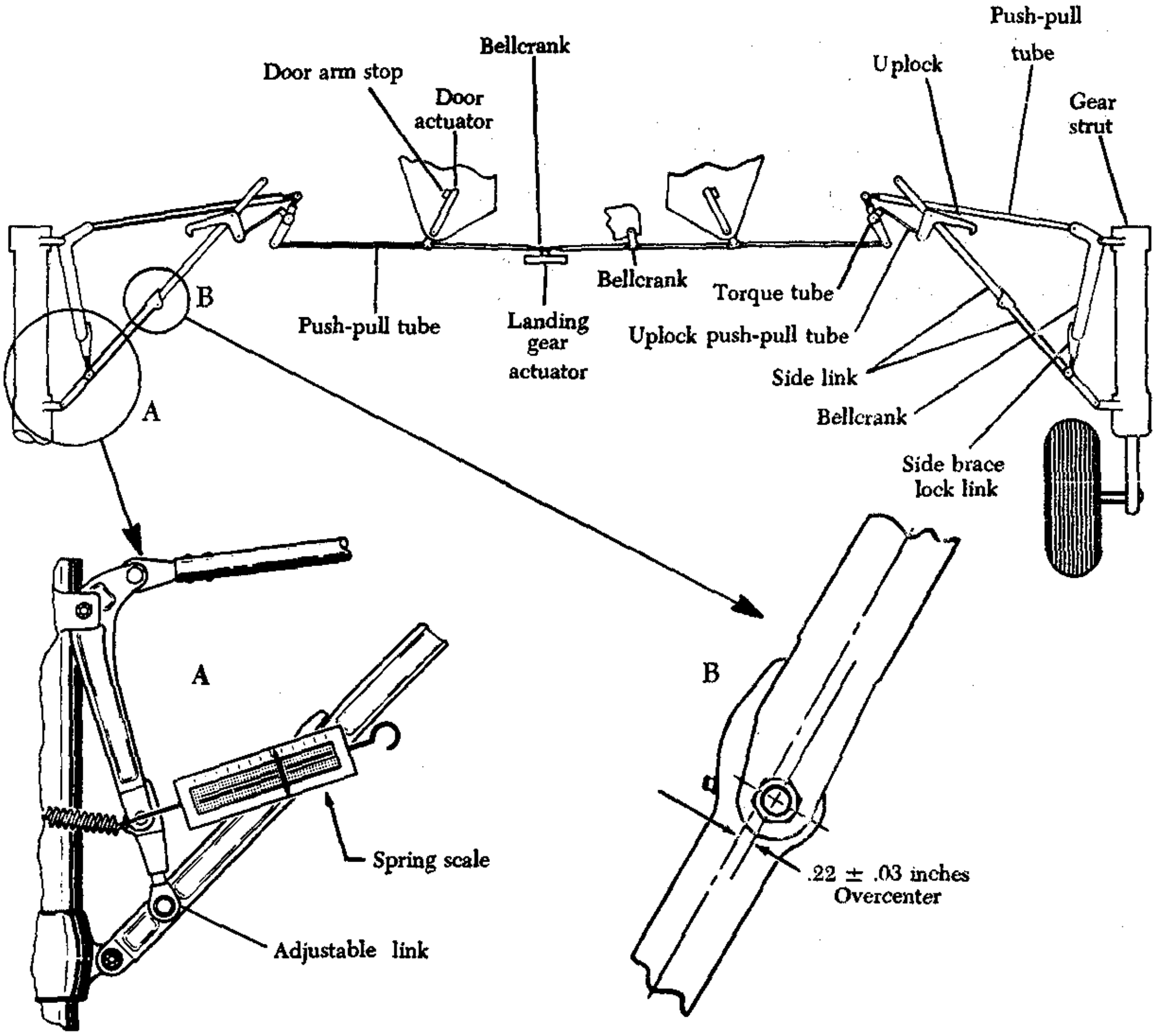


FIGURE 9–69. Landing gear schematic showing overcenter adjustments.

lock link and move the landing gear to a position 5 or 6 in. inboard from the down locked position, then release the gear. The landing gear must free-fall and lock down when released from this position.

In addition to adjusting overcenter travel, the down lock spring tension must be checked using a spring scale. The tension should be between 40 to 60 lbs. for the lock link illustrated. The specific tension and procedure for checking will vary on other aircraft.

Landing Gear Retraction Check

There are several occasions when a retraction check should be performed. First, a retraction check should be performed during an annual inspection of the landing gear system. Second, when performing maintenance that might affect the landing gear linkage or adjustment, such as changing an actuator, make a retraction check to see whether everything is connected and adjusted properly. Third, it may be necessary to make a retraction check after a hard or overweight landing has been made which may have damaged the landing gear. Closely inspect the gear for obvious damage and then make the retraction check. And finally, one method of locating malfunctions in the landing gear system is to perform a gear retraction check.

There are a number of specific inspections to perform when making a retraction check of landing gear. Included are:

(1) Landing gears for proper retraction and extension.
(2) Switches, lights, and warning horn or buzzer for proper operation.

(3) Landing gear doors for clearance and freedom from binding.

(4) Landing gear linkage for proper operation, adjustment, and general condition.

(5) Latches and locks for proper operation and adjustment.

(6) Alternate extension or retraction systems for proper operation.

(7) Any unusual sounds such as those caused by rubbing, binding, chafing, or vibration.

The procedures and information presented herein were intended to provide familiarization with some of the details involved in landing gear rigging, adjustments, and retraction checks and do not have general application. For exact information regarding a specific aircraft landing gear system, consult the applicable manufacturer's instructions.