Airframe 7

Airplane Components

The major components of an airplane are:

- the fuselage;
- the wings;
- the empennage (tail section);
- the flight controls;
- the landing gear (or undercarriage); and
- the engine and propeller.

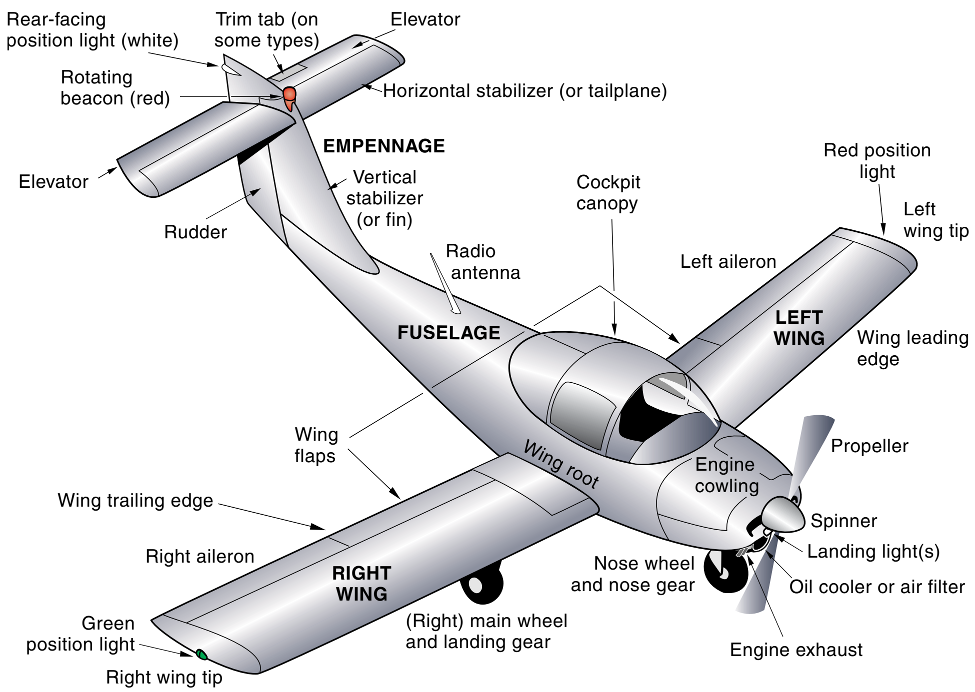

Figure 7-1 Features of a modern training airplane.

Fuselage

The fuselage is the body of the airplane to which the wings, empennage, engine and landing gear are attached. It contains a cabin with seats for the pilot and passengers plus cockpit controls and instruments. It may also contain a baggage compartment.

The fuselage of many modern training airplanes is of *semi-monocoque* construction, a light framework covered by a skin (usually aluminum) that absorbs much of the stress. It is a combination of the best features of a *strut-type* structure, in which the internal framework absorbs almost all of the stress, and a *monocoque* structure which, like an eggshell, has no internal structure and the stress is carried entirely by the skin.

Figure 7-2 Fuselage.

Figure 7-3 Composite construction.

Wings

The wings are designed to cope with the flight loads of lift and drag. They also may support other external devices such as engines (on multi-engine airplanes) and flaps.

Wings generally have one or more internal *spars* which are attached to the fuselage and extend to the wingtips. The spars carry the major loads, which are upward bending because of the lift, and downward bending because of wing-mounted engines and fuel.

Figure 7-4
Wing with fuel tank located inside.

The wings in most airplanes also contain *fuel tanks* installed between the curved upper and lower surfaces. This is an efficient use of the space available, and the weight of the fuel in the tanks also provides a downward force on the wing structure that reduces the upward bending effect of the lift forces.

In addition to the spar(s), some wings also have external *struts* connecting them to the fuselage to provide extra strength by transmitting some of the wing loads to the fuselage.

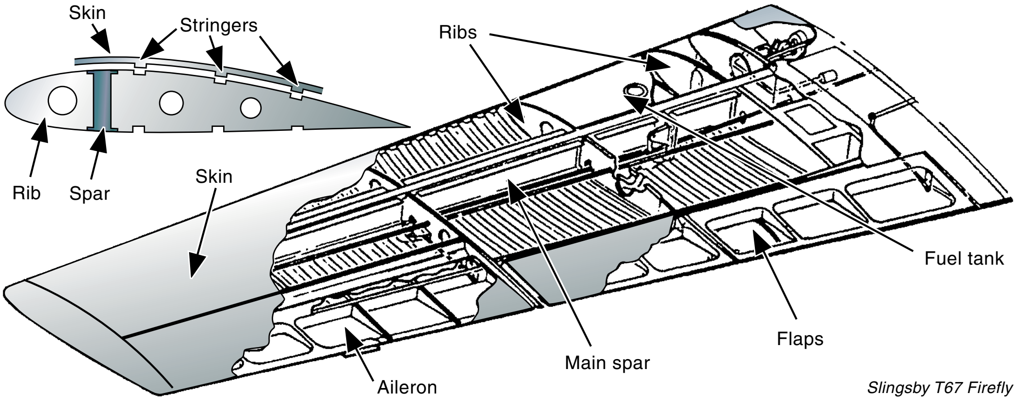

Figure 7-5 Components of a wing.

Ribs, roughly perpendicular to the wing spar(s), assisted by stringers running parallel to the spars, provide the airfoil shape and stiffen the skin which is attached to them. The ribs transmit loads between the skin and the spar(s).

Monoplanes are designed with a single set of wings placed so that the airplane is known as a high-wing, low-wing, or mid-wing monoplane. Biplanes, such as the Pitts Special, are designed with a double set of wings. The Cessna 172 is a high-wing monoplane; the Piper Warrior is a low-wing monoplane.

Figure 7-7 Biplane.

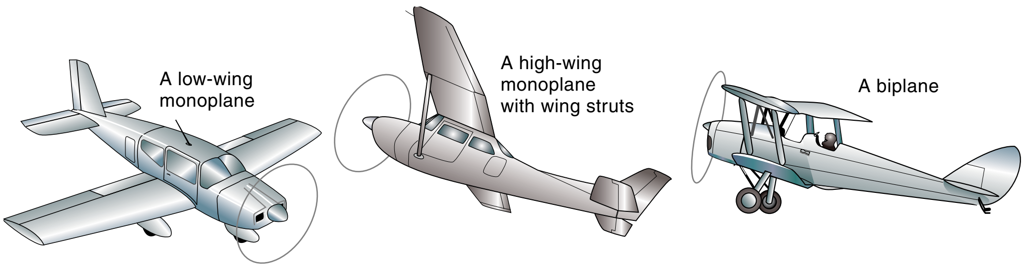

Figure 7-6 Low-wing monoplane, high-wing monoplane, and biplane.

Figure 7-8 Empennage.

Empennage

The empennage is the tail section of the airplane. It is generally constructed like the wings and consists of a fixed *vertical stabilizer* (or fin) to which is attached a movable *rudder*, and a fixed *horizontal stabilizer* with a movable *elevator* hinged to its trailing edge.

There are variations in design, some airplanes have a stabilator (all-moving tailplane), others have a *ruddervator* (combined rudder and elevator) in the form of a butterfly tail, and yet others have a high T-tail, with the horizontal stabilizer mounted on top of the vertical stabilizer.

Figure 7-9 V-tail.

Flight Controls

The main flight control surfaces are the *elevator, ailerons* and *rudder.* They are operated from the cockpit by moving the control wheel and rudder pedals. In a typical airplane, movement of the control wheel or rudder pedals operates an internal system of cables and pulleys that then moves the relevant control surface. Turnbuckles may be inserted in the cables to allow the cable tension to be adjusted by qualified personnel.

There are usually stops to protect the control surfaces from excessive movement in flight and on the ground. Stops in the flight control system may be installed to limit control wheel movement.

Figure 7-10 Aileron.

Landing Gear

The landing gear (or undercarriage) supports the weight of the airplane when it is on the ground, and may be of either the tricycle type (with a nosewheel) or the tailwheel type. Most tricycle landing gear airplanes are equipped with *nosewheel steering* through the rudder pedals, and almost all airplanes have *mainwheel brakes.*

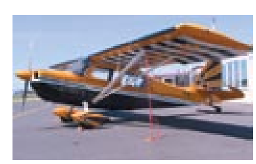

Figure 7-11 Conventional landing gear.

Figure 7-12
Spring-steel strut.

Figure 7-13
Retractable gear.

Mainwheels

The mainwheels carry most of the load when the airplane is on the ground, especially during the takeoff and landing, and so are more robust than the nosewheel (or tailwheel). They are usually attached to the main airplane structure with legs in the form of:

- a very strong spring leaf of steel or fiberglass;
- struts and braces; or
- an oleo strut.

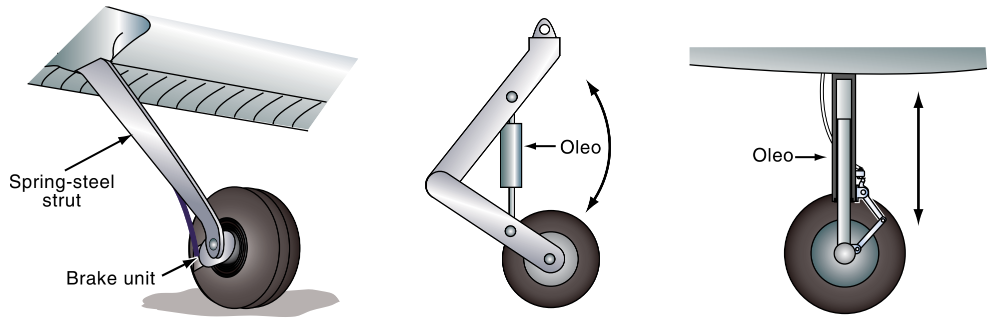

Figure 7-14 Various types of landing gear.

A squat switch is used on airplanes with retractable landing gear to prevent the wheels from being inadvertently raised when the airplane is on the ground. With the weight of the airplane pressing down on the wheel struts, the squat switch opens the gear circuit so electricity will not flow to the hydraulic gear pump, even if the gear handle is placed in the up position.

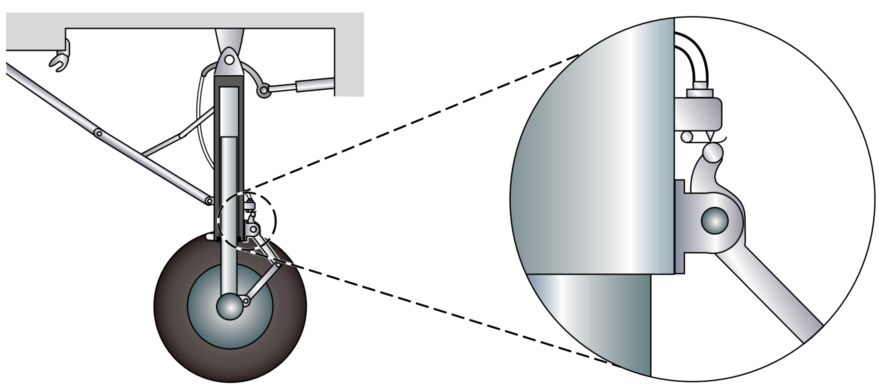

Figure 7-15 Micro-switch (squat switch).

The *oleo strut* acts as a shock absorber, and is of telescopic construction, with a piston that can move within a cylinder against an opposing pressure of compressed air. The piston is attached to the wheel by an oleo strut and the cylinder is attached to the airframe.

The greater the load on the strut, the more the air is compressed by the piston. While the airplane is moving along the ground, the load will vary, and so the strut will move up and down as the compressed air absorbs the loads and shocks, preventing jarring of the main airplane structure.

Special oil is used as a *damping agent* to prevent excessive in-and-out telescoping movements of the oleo strut and to damp its rebound action.

When the airplane is stationary, a certain length of polished oleo strut should be visible (depending to some extent on how the airplane is loaded), and this should be checked in the preflight external inspection. Items to check are:

- correct extension when supporting its share of the airplane's weight;
- the polished section of the oleo strut is clean of mud or dirt (to avoid rapid wearing of the seals during the telescoping motion of the strut); and
- there are no fluid leaks.

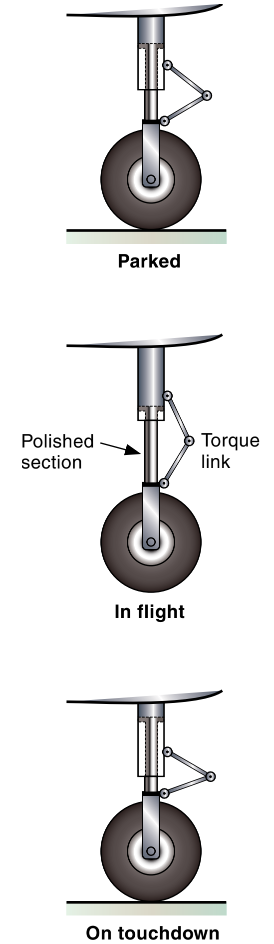

Figure 7-16 The oleo strut.

Nosewheel

The nosewheel is usually of lighter construction than the mainwheels and is usually attached to the main structure of the airplane near the engine firewall. A *torque-link* is used on nosewheel assemblies to correctly align the nosewheel with the airframe. It links the cylinder assembly attached to the airplane structure with the nosewheel assembly, and is hinged to allow for the telescopic extension and compression of the oleo.

Most airplanes have *nosewheel steering*, achieved by moving the rudder pedals which are attached by control rods or cables to the nosewheel assembly, thereby allowing the pilot greater directional control when taxiing.

Some airplanes have *castoring nosewheels* which are free to turn, but are *not* connected by controls to the cockpit. The pilot can turn the airplane by using the rudder when it has sufficient airflow over it (from either slipstream or airspeed) or with differential braking of the mainwheel brakes.

Nosewheel oleo struts are prone to *nosewheel shimmy*, an unpleasant and possibly damaging vibration set up when the nosewheel oscillates a few degrees either side of center as the airplane moves along the ground. To prevent this, most nosewheel assemblies are equipped with a *shimmy damper*, a small piston-cylinder unit that dampens out the oscillations and prevents the vibration. If nosewheel shimmy does occur, it could be because the shimmy damper is insufficiently pressurized or the torque link has failed.

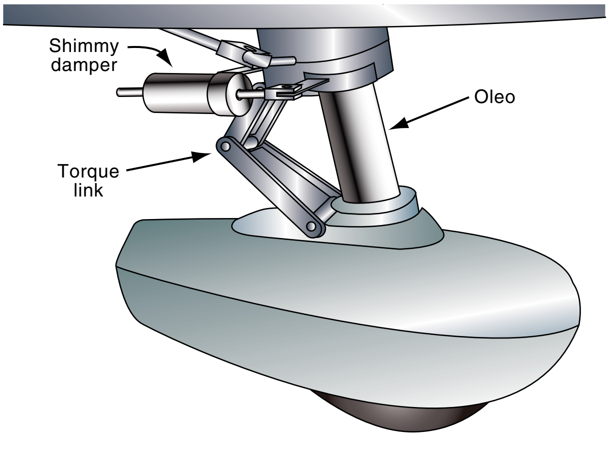

Figure 7-17 Shimmy damper.

Tires

Airplane tires must be inflated to the correct pressure for them to function as designed. Vibration during taxiing, uneven wear and burst tires may result from a pressure that is too high; damage to the tire structure and a tendency for the tire to creep with respect to the rim can occur if pressure is too low. Correct *inflation* is important in achieving a good service life from a tire. Aircraft tires are unique in that they have to withstand ballooning pressures on each landing.

Creep can occur in normal operations because of the stresses during landing, when a stationary tire is forced to rotate on touching the ground and has to "drag" the wheel around with it, and will also occur when the airplane is braking or turning.

To monitor creep, there are usually paint marks on the wheel flange and on the tire which should remain aligned. If any part of the two creep marks is still in contact, that amount of creep is acceptable, but if the marks are separated, then the inner tube may suffer damage and the tire should be inspected and serviced. This may require removal and reinstallation, or replacement.

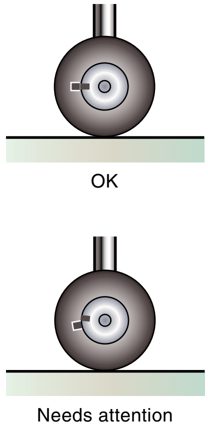

Figure 7-18
Creep marks on the tire and wheel flange enable visual checks for creep.

Tire *strength* comes from its carcass which is built up from casing cords and then covered with rubber. The ply rating is a measure of its supposed strength. Neither the rubber sidewalls nor the tread provide the main strength of the tire; the sidewalls protect the sides of the tire carcass, and the rubber tread provides a wearing surface at the contact points between the tire and the runway.

Shallow cuts or scores in the sidewalls or on the tread, or small stones embedded in the tread, will not be detrimental to tire strength. However, any large cuts (especially if they expose the casing cords) or bulges (that may be external indications of an internal casing failure) should cause you to reject the tire prior to flight. The condition of the tires should be noted during the preflight external inspection, especially with respect to:

- inflation;
- creep;
- wear, especially flat spots caused by skidding;
- cuts, bulges (especially deep cuts that expose the casing cords); and
- damage to the structure of the sidewall.

Wheel Brakes

Most training airplanes are equipped with *disc brakes* on the mainwheels. These are hydraulically operated by the *toe brakes* which are situated on top of the rudder pedals. Pressing the left toe brake will slow the left mainwheel down and pressing the right toe brake will slow the right mainwheel down. Used separately, they provide differential braking, which is useful for maneuvering on the ground. Used together, they provide normal straight-line braking.

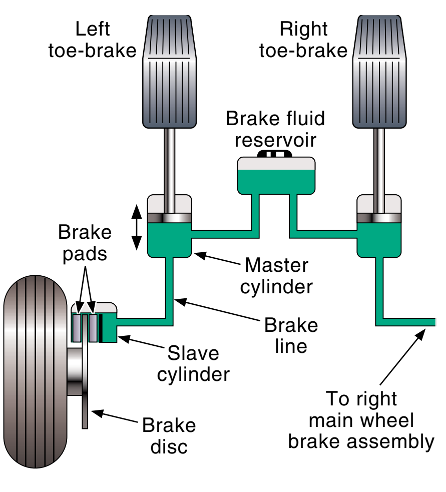

Figure 7-19
Typical simple hydraulic braking system.

A typical system consists of a separate master cylinder containing hydraulic fluid for each brake. As an individual toe brake is pressed, this toe pressure is hydraulically transmitted via the master cylinder to a *slave cylinder* which closes the brake friction pads (like calipers) onto the brake disc. The brake disc, which is part of the wheel assembly, then has its rotation slowed down.

Most airplanes have a *parking brake* (usually hand-operated, sometimes in conjunction with the toe-brakes) that will hold the pressure on the wheel brakes and can be used when the airplane is parked.

During the preflight external inspection, you should check the brakes to ensure that they will function when you need them, ensuring that:

- there are no leaks of hydraulic brake fluid from the brake lines;
- the brake discs are not corroded or pitted;
- the brake pads are not worn-out; and
- the brake assembly is firmly attached.

A severely corroded or pitted disc will cause rapid wear of the brake pads, as well as reducing their effectiveness, and, in an extreme case, the disc may even fail structurally. Fluid leaks from the brake lines or cylinders indicate a faulty system that may provide no braking at all when it is needed. Any brake problems should be rectified prior to flight.

Following a satisfactory external inspection, you should still test the brakes immediately after the airplane first moves, by closing the throttle and gently applying toe brake pressure. *Brake wear* can be minimized by judicious use of the brakes during ground operations.

Engine and Propeller

The engine is usually mounted on the front of the airplane, and separated from the cockpit by a *firewall.* In most training airplanes, the engine drives a *fixed-pitch propeller*, although more advanced airplanes will have a *constant-speed propeller* with blades whose pitch can vary. The engine and its attachments are considered in detail in the next few chapters.

Figure 7-20 Variable pitch propeller.

Review 7
Airframe

1. What is the main structural component of the wing?
2. Name the four major components of the empennage.
3. What is the airfoil shape of the wing surface formed by?
4. What sort of airplanes are designed with only one pair of wings?
5. What is the most usual form of fuselage construction in training airplanes, in which the skin covers a light structure and carries much of the stress?
6. Does a cracked or severely corroded landing gear strut found during your preflight inspection need to be inspected by a qualified maintenance technician before the airplane flies?
7. What is the agent used to dampen the rebound action in the oleo strut following a shock?
8. True or false? The oleo strut will only extend the same in flight as on the ground.
9. Why should mud or dirt noticed in a preflight inspection be cleaned off the polished section of an oleo strut prior to taxiing?
10. What is the nosewheel held in alignment by?
11. What are nosewheel oscillations either side of center damped by?
12. What is the relative movement between a tire and a wheel flange called?
13. What type of nosewheel is free to turn but is not connected to the cockpit by any control rods or cables for turning?
14. Nosewheel steering in light airplanes is usually operated by:
    a. control rods or cables operated by the rudder pedals.
    b. a steering wheel.
    c. the brakes.
15. A castoring nosewheel can be made to turn:
    a. by a steering wheel.
    b. with differential braking.
16. If a tire has moved so that the creep marks are out of alignment, then:
    a. the tire is serviceable.
    b. the tire should be inspected and possibly reinstalled or replaced.
    c. tire pressure should be checked.
17. Does a tire that has some shallow cuts in the sidewalls and a number of small stones embedded in its tread need to be rejected for further flight?
18. Does a tire that has a deep cut that exposes the casing cords or a large bulge in the sidewall need to be rejected for further flight?
19. Most light airplane braking systems are:
    a. operated by cables.
    b. operated pneumatically.
    c. operated hydraulically.

Answers are given on page 769.