The Pilot's Manual

Flight School

Master the flight maneuvers required for private, commercial, and instructor certification

Sixth Edition

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Foreword by Barry Schiff

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Personal Progress Table

1

The Training Airplane

OBJECTIVES

To name and describe:

- the main components of a basic training airplane; and
- the systems, controls and instruments used by the pilot.

Figure 1-1 A Cessna trainer.

CONSIDERATIONS

The Airframe

The structure of the airplane is called the *airframe*. It consists of a *fuselage* to which the *wings*, the *empennage*, the *landing gear* and the engine are attached. A propeller converts engine *torque* to generate *thrust* to propel the airplane through the air. Forward speed causes the airflow over the wings to generate an aerodynamic force, known as *lift*, that is capable of overcoming the force of gravity (*weight*) and that supports the airplane in flight. The airplane can even fly temporarily without thrust if it is placed in a *glide*—its forward momentum assisted by gravity keeps it moving through the air, and this allows the wings to produce lift. However, the path is inevitably downward. In the absence of vertical air currents, thrust is essential to allow level, turning and climbing flight.

Lift is the means by which flight is attained.
Thrust is the means by which flight is sustained.

The tail assembly of the aircraft is situated some distance to the rear of the main load-carrying sections of the fuselage and provides a balancing, or *stabilizing*, force much like the tail feathers on an arrow or a dart. The tail section consists of a *vertical stabilizer* (or *fin*) and a *horizontal stabilizer* (or *tailplane*), both of which are shaped to produce stabilizing forces. The pilot and passengers are housed in the cockpit, usually in side-by-side seating—the pilot (or *pilot in command* in a two-pilot aircraft) sits on the left side.

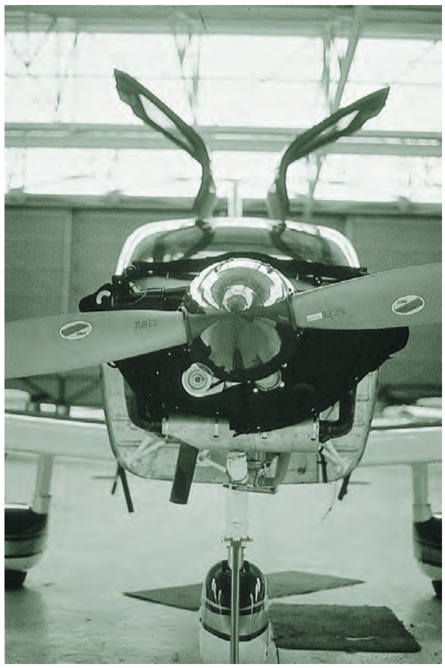


Figure 1-2 Tobago aircraft.

Controls and instruments are placed in the cockpit to enable the safe and efficient operation of the airplane and its systems, and for navigation and communication.

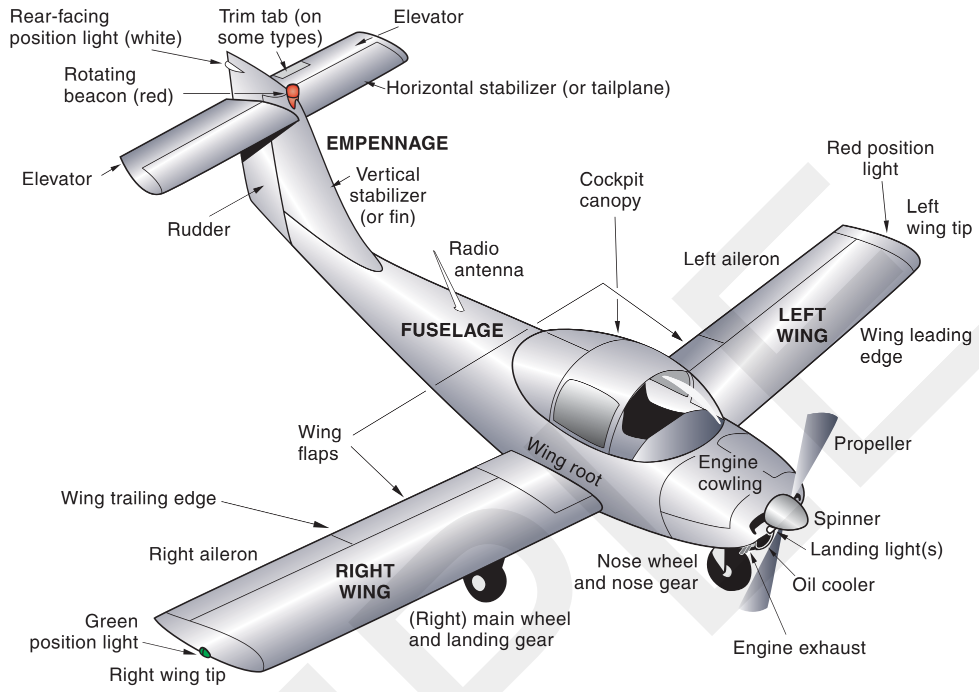


Figure 1-3 Parts of an airplane.

Aircraft Types

Light aircraft were traditionally classified under Title 14 of the Code of Federal Regulations (14 CFR) Part 23 which described structural and performance standards. These represented the fleet of General Aviation (GA) aircraft up to a certain weight limit.

More recently, the FAA has introduced a new category—the *Light Sport Aircraft* (LSA) category which offers relaxed construction, performance and licensing standards for pleasure flying and for training.

Figure 1-4 Vans Aircraft RV-6A light-sport airplane.

The LSA category allows a wide range of designs that are placed between the ultralights and the GA categories. It allows adventurous designs and fun flying at lower cost, using less energy and with less of the burden of regulations and testing.

Many pilots are now introduced to aviation via the LSA category and traditional, well respected manufacturers such as Cessna are now testing new designs that will be placed within this category.

This manual describes flight techniques which are equally applicable to all GA and LSA airplanes although there will be unique characteristics shown by some more radical designs and configurations. The techniques remain a vital foundation for a trainee pilot.

Figure 1-5 Traditional control wheel or yoke.

Primary Controls

Flight Controls

The most common primary flight control has been the wheel or *yoke*. This is still prevalent although there are more diverse options available now. The yoke came about because of high control forces and the need to be able to use both hands for control inputs. It also allowed relief so that the pilot could change hands. Also, the yoke provided a convenient place for transmit buttons, trim switches and some autopilot functions. It is retained in many larger aircraft even though the control forces have now been overcome by hydraulic actuators.

With the widespread use of ultralights and homebuilt aircraft there was a reappearance of the central control column or *joystick*. Many feature the transmit button on the top and some even have electric trim switches. The stick is better for highly maneuverable aircraft—for aerobatics, display flying and crop dusting—as it provides greater leverage and instantaneous control deflection. (It can also be held between the knees when cruising).

Figure 1-6 Traditional joystick—Lancair.

As more advanced types have been introduced into the GA fleet the *side-stick* as used in modern complex transport airplanes, has appeared. The control forces and response have been refined to the point where only a small mechanical advantage is needed. The magnificent Cirrus and Sky Arrow aircraft both used side sticks—as does the Australian Lightwing Speed.

Figure 1-7 Side stick control—Cirrus.

Aircraft Attitude

The attitude of the aircraft together with thrust from the propeller allows the aircraft to sustain a particular flight path. This is the essence of aircraft control. Thus the pilot's task is to set an attitude and power, check the response from the instruments and make a correction if necessary. This is the process of piloting the aircraft.

The *attitude* is simply the position of the nose of the aircraft in relation to the horizon: high, low, tilted left or right, and by how much. It is a matter of a visual judgment that is easy to learn.

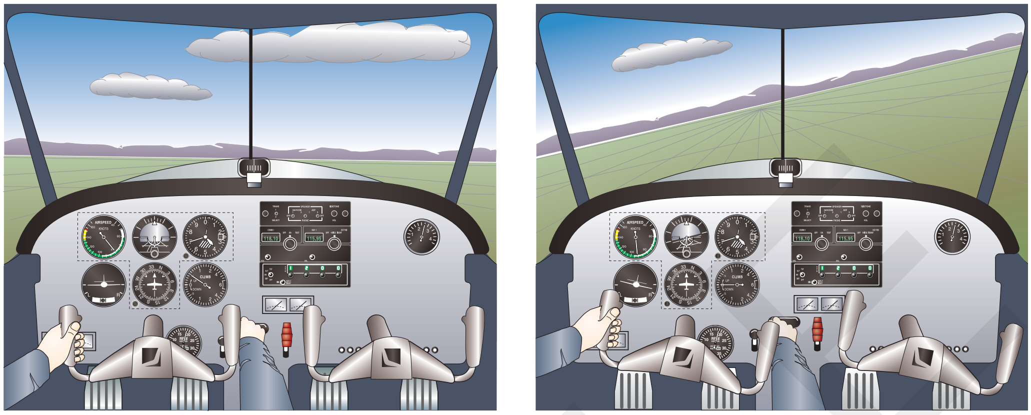


Figure 1-8 Visual attitudes—nose-up and right bank.

The attitude, or position in flight, of the airplane is controlled using the flight controls. These are surfaces that, when deflected, alter the pattern of the airflow around the wings and tail, causing changes in the aerodynamic forces they generate.

Control Surfaces

The movable parts of the aircraft's structure are called *control surfaces*:

- The *elevators* (hinged to the trailing edge of the horizontal stabilizer) control pitching of the nose up or down and are operated from the cockpit with backward and forward movements of the control column.
- The *ailerons* (hinged to the outer trailing edge of each wing) control rolling of the airplane and are operated by left and right movement of the control column.
- The *rudder* is the movable surface controlled by the rudder pedals on the floor of the cockpit (hinged to the trailing edge of the fin or vertical stabilizer). The rudder is used to steer the aircraft on the ground and to balance the aircraft in the air.
- The *flaps* are surfaces that move down only, operated by a manual lever or dedicated switch. They are attached to the inner rear section, known as the *inboard section*, of each wing and move together. They provide additional lift and better forward and downward view for flight at low speeds. They are used mainly for the approach and landing.

The primary controls include the elevators, ailerons and rudder.

Figure 1-9 Left aileron (left); vertical stabilizer and rudder (right).

- The elevator has a smaller hinged surface, to balance the elevator control force, called a *trim tab*. It is usually operated by a trim wheel or handle beside the pilot or above in the cabin ceiling. Some aircraft also have trim tabs on the rudder and ailerons.

The secondary controls include flaps and trim tabs.

Figure 1-10 Flaps (left); elevator and trim tab (right).

Even though the aerodynamic components of various airplane types serve the same basic functions, their actual location on the structure and their shape can vary. For example, the wings may be attached to the fuselage in a high-, low- or mid-wing position; the horizontal stabilizer is sometimes positioned high on the fin (known as a *T-tail*); and the combined horizontal stabilizer and elevator is sometimes replaced by a *stabilator* (or *all-flying tailplane*). The stabilator is also fitted with a tab.

Figure 1-11 Stabilator with tab.

Engine/Propeller Controls

The throttle, which is operated by the pilot's right hand, controls the power (thrust) supplied by the engine-propeller combination. *Opening* the throttle by pushing it forward increases the fuel-air supply to the engine, resulting in increased revolutions and greater power. Retarding the throttle, or *closing* it, reduces the power to idle RPM but does not stop the engine, being just the same as the accelerator in your car.

Push the throttle forward for a greater power and pull it back for reduced power.

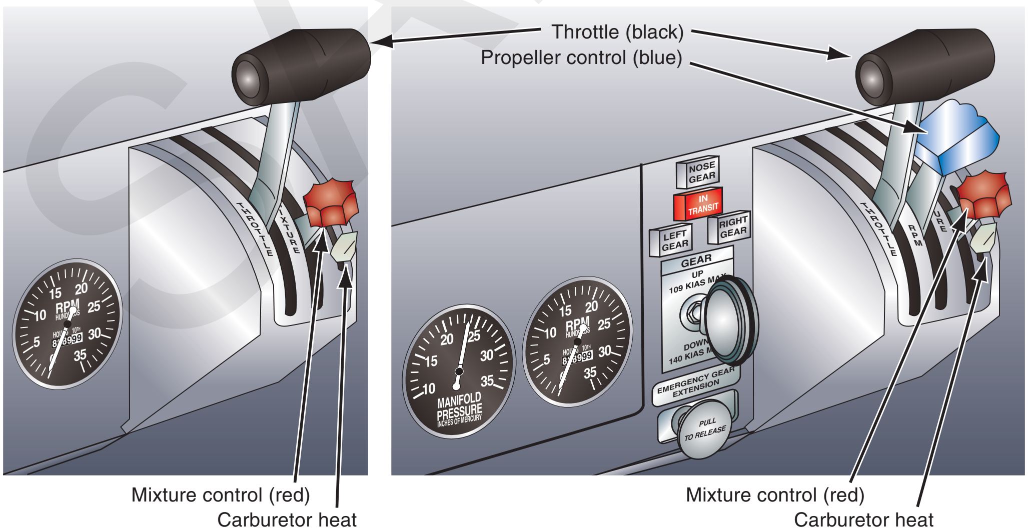


Figure 1-12 Engine controls—fixed-pitch propeller (left) and constant-speed propeller (right).

Figure 1-13 Push/pull knobs for throttle, propeller and mixture controls (Cessna aircraft).

Figure 1-14 Manifold pressure gauge and tachometer.

Figure 1-15 Tricycle landing gear.

Figure 1-16 Tail wheel landing gear.

Some airplanes have the engine controls in the form of push/pull knobs. Push/pull controls are direct mechanical plungers which are pushed forwards (in) for greater power or propeller RPM. Some have a vernier (rotational) facility for fine adjustment once the broad setting has been made.

The engine rotates the propeller and together, they produce the thrust to propel the aircraft. The power of the engine is controlled by the throttle, which determines the amount of fuel to the engine. The propeller is driven directly by the engine and may have fixed blades or variable-pitch blades. In the case of variable-pitch blades, there is an additional propeller lever next to the throttle and an additional instrument, called the *manifold pressure gauge*, next to the RPM indicator or tachometer.

Landing Gear

Most modern training airplanes have a tricycle landing gear (or undercarriage) that consists of two main wheels and a nose wheel to provide support on the ground. Other aircraft have a tail wheel instead of a nose wheel. The nose wheel on most aircraft types is connected to the rudder pedals so that movement of the pedals will turn it, assisting in directional control on the ground. Most aircraft have brakes on the main wheels. Brakes are operated individually or together by pressing the top of the rudder pedals; thus, they can be used to assist steering as well as braking. There is also a parking brake knob or lever.

Aircraft Systems

Engine and Propeller

The typical training airplane has a piston engine that uses aviation gasoline (AVGAS). The engine revolutions per minute (RPM) are controlled by the throttle. This is indicated in the cockpit on the *tachometer*, or RPM gauge. Oil for lubricating and cooling the engine is stored in a sump at the base of the engine. Its quantity should be checked with a *dipstick* prior to flight. There are two cockpit gauges to register oil pressure and oil temperature when the engine is running. These gauges are normally color-coded, with the normal operating range shown as a green arc or by upper and lower green marks.

Fuel is mixed with air in a *carburetor*, and the mixture passes through the induction system (*manifold*) into the cylinders where combustion occurs. The carburetor heat control, located near the throttle, is used to supply hot air to protect the carburetor from icing.

Fuel System

The fuel is usually stored in wing tanks. High-wing airplanes usually rely on gravity to supply fuel to the engine-driven pump, whereas low-wing airplanes have an additional electric fuel pump (*boost pump*). There are fuel gauges in the cockpit to indicate the quantity, but

Figure 1-17 The oil quantity should be checked during the preflight inspection prior to every flight.

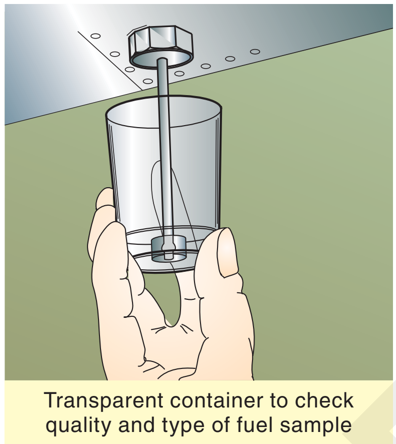


Figure 1-18 A typical method of checking the fuel.

Fuel management is a high priority—the fuel tanks should be checked visually prior to each flight.

they are not always totally reliable. Therefore, it is a requirement to check the contents of the tanks, either visually or by using a dipstick, prior to each flight. It is also essential to confirm both that the fuel is of the correct grade (which is identified by its color) and that it is not contaminated, the most likely contaminant being water. Water is more dense than AVGAS and gathers at the lowest points in the fuel system. The check is performed by inspecting a small sample taken from the fuel drain valve beneath each fuel tank and from the fuel strainer or filter.

A fuel tank selector in the cockpit allows fuel to be supplied from each tank as desired or, in some cases, from both tanks simultaneously. The fuel selector can also be used to prevent the supply of fuel to the engine compartment in the event of a fire.

A mixture control adjusts the richness of the fuel-air mixture provided to the engine and is suited for flight at higher altitudes, generally above 5,000 feet. When pulled fully out, the mixture control has the function of cutting the fuel supply to the engine altogether. It is used to shut down the engine to ensure the fuel lines are evacuated.

Ignition System

The engine has dual ignition systems that provide sparks to ignite the fuel-air mixture in the cylinders. The electrical current for the sparks is generated by two *magnetos* geared to the engine. The dual ignition systems provide more efficient combustion and greater safety in the event of one system failing. They function with the rotation of the engine and do not require an electrical current. Battery power is only required for starting the engine.

An ignition switch in the cockpit is normally used to select both magnetos, although it can select the left or right magneto individually to check for correct functioning of each. It also has an off position to prevent inadvertent starting of the engine if the propeller is turned.

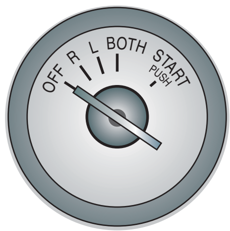


Figure 1-19 The combined ignition/start switch.

The ignition switch is not generally used to stop the engine. The fuel mixture control has a *cutoff* position. Most ignition switches have a further position, *start*, that connects the battery to an electric starter. Once the engine starts, the ignition switch returns to *both*—it springs back to this position when released—and the engine runs without electrical supply from the battery.

Electrical System

The battery is used to start the engine. The alternator (or generator) is used to power the electrical system once the engine is running.

The battery is a source of electrical power to start the engine. The battery also provides an emergency electrical backup supply for lights and radios if the engine-driven alternator (or generator) fails. There is a master switch to turn the battery circuit on and off.

The electrical system supplies various aircraft services, such as some flight instruments, the radios, cabin lights, landing lights and navigation lights. In some aircraft, it also supplies the flap motor, the pitot heater and the stall warning system. Airplanes equipped with an alternator need a serviceable battery so that the alternator has an exciter current. The electrical system incorporates an ammeter and/or warning light to verify the electrical current is flowing. There may be a separate switch for the alternator circuit. Each electrical circuit is protected from excessive current by a fuse or a circuit breaker. Note that the two magneto systems providing the ignition sparks to the engine are totally separate from the electrical system (alternator/generator, battery, circuit breakers and fuses).

Radios

The radios have an on/off switch and volume control (usually combined in the one knob), a *squelch* control to eliminate unwanted background noise, a microphone for transmitting, and speakers or headphones for receiving messages. There may be an avionics master switch for all radios and navigation aids. There will be a separate control panel for the *intercom* (internal communications system).

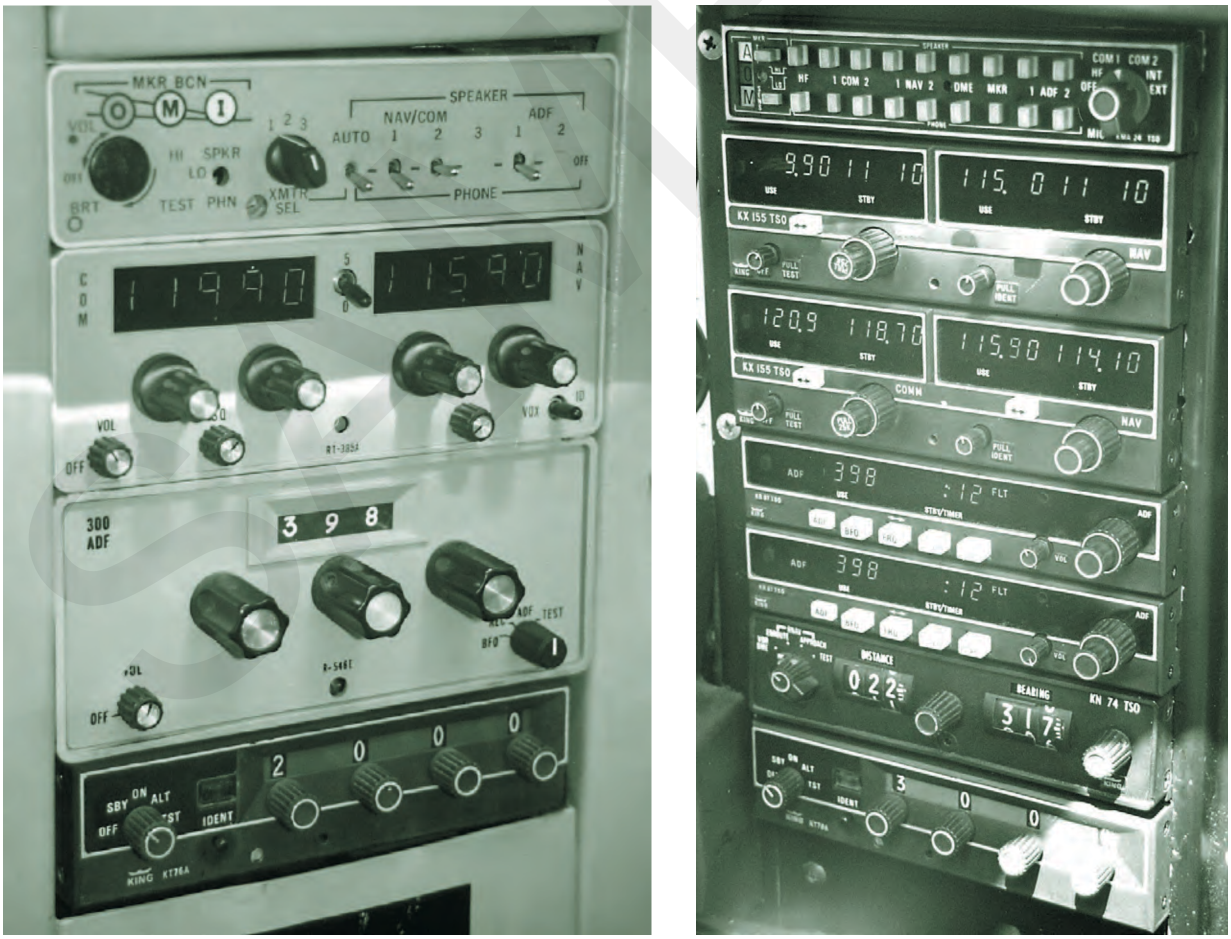


Figure 1-20 Radio control panels.

Instruments and Units of Measurements

Instruments

The panel in front of the pilot contains instruments that provide important information. The main groups of instruments are the *flight instruments* (which are directly in front of the pilot) and the *engine instruments* (which are generally situated near the throttle).

Figure 1-21 Typical instrument panel (Cessna).

Figure 1-22 Typical instrument panel (Piper).

The flight instruments include an *airspeed indicator* (ASI), an *attitude indicator* (AI) to depict the airplane's attitude relative to the horizon, an *altimeter* (ALT) to indicate height above a selected reference, a *vertical speed indicator* (VSI) to show climb or descent, a *heading indicator* (HI) (sometimes called a *directional gyro* (DG)) to show direction, and either a *turn coordinator* or *turn indicator* with an associated *balance ball*.

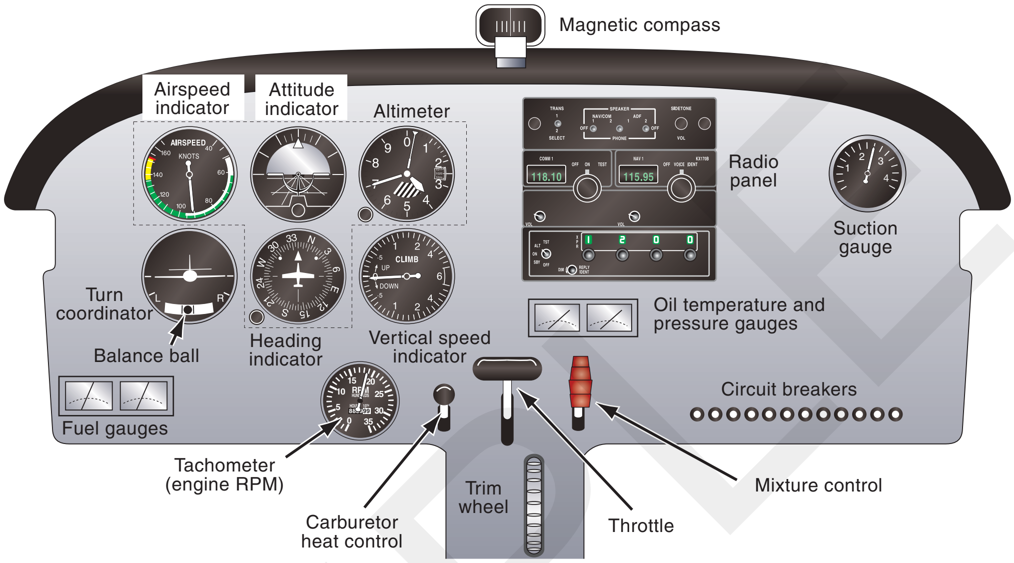


Figure 1-23 A typical instrument panel.

There are two types of flight instruments:

- *control* instruments (to set attitude and power); and
- *performance* instruments (to confirm that the flight path and airspeed are as desired).

The instruments related to airspeed and altitude are sensitive to static and dynamic (moving) air pressure obtained from the pitot-static pressure system. Those instruments related to attitude, direction and turning are operated by internal spinning gyroscopes (with the exception of the magnetic compass). The gyroscope rotors may be spun electrically or by a stream of air induced by suction from the vacuum system. The magnetic compass is usually located well away from the magnetic influences of the instrument panel and radio.

The engine instruments include the *tachometer* (engine RPM), and in the case of an aircraft with a constant-speed propeller, there is also a *manifold pressure gauge* (MP gauge). In this instance, the pilot sets both controls to a preset value to obtain a desired power output. There are oil pressure and oil temperature gauges, and there may be a fuel pressure gauge. Some aircraft also have a *cylinder head temperature* (CHT) or *exhaust gas temperature* (EGT) gauge. Other instruments may include an *ammeter*, to monitor the electrical system, a *suction gauge* for the vacuum system and a *carburetor inlet temperature gauge* to warn of possible icing.

Units of Measurement

In aviation, there is a multiplicity of units and variance in their use. Although some metric units are used, the international aviation community has retained some traditional units of measurement for very valid operational reasons. In particular, the United States is yet to transfer to international units and many aircraft are manufactured in this country. Be extra careful and check with your instructor for the units displayed in your aircraft.

Speed and Distance

The standard unit for airspeed is the *knot*, which is derived from nautical traditions. A knot is one nautical mile per hour. The knot is retained in aviation because it is a division of the system of measuring position and distance over the surface of the earth—*latitude* and *longitude*.

A distance of one nautical mile equates to one sixtieth of a degree of latitude at the equator. A *nautical mile* is 6,076 feet, 1.1508 statute miles or 1.852 kilometers. A knot is one nautical mile per hour. Thus 60 knots is close to 70 mph. Don't try to convert this: you will become familiar with knots and learn what flying at 100 knots feels like.

Some aircraft still use miles per hour, but such aircraft must also have knots shown on the airspeed indicator. Some European aircraft use kilometers per hour (kph), but this is not the standard. Wind speed is also given in knots for airports and for flight forecasts. Takeoff and landing performance charts outside the United States use units of meters for distance instead of feet. A foot is approximately 30 centimeters. A meter is 39.37 inches.

Figure 1-24 Airspeed indicator (ASI).

Figure 1-25 Pitot head.

Airspeed

Airspeed is measured in knots (nautical miles per hour). The ASI is provided with ram air pressure through the pitot head.

Altitude

The unit for altitude is *feet* in hundreds or thousands. All aeronautical charts have the height of terrain in feet above mean sea level (MSL), and weather forecasts show the height of cloud in thousands of feet. The altimeter has three pointers for hundreds, thousands, and tens of thousands of feet. It is read cumulatively, in the same way as the traditional clock face of hours *plus* minutes—here thousands plus hundreds of feet.

Figure 1-26 Altimeter.

Direction

Direction is indicated in degrees relative to magnetic north, since the compass aligns to this reference. North is both 000° and 360° (i.e. there are 360° in a full circle); however, it is always referred as 360°. East is 090°, south is 180° and west is 270°.

Runway direction is indicated to the nearest ten-degree increment, i.e. plus or minus 5°. Runway 27 points west (it is within plus or minus 5° of west or 270°) and Runway 4 points to the north east. The opposite direction on the same runway (called the *reciprocal*) is 180° about. Runway 27 and 09 are the same runway but in two opposite directions, as are 4 and 22.

A direct-reading magnetic compass (see figure 1-28 on the next page) is also part of a standard cockpit.

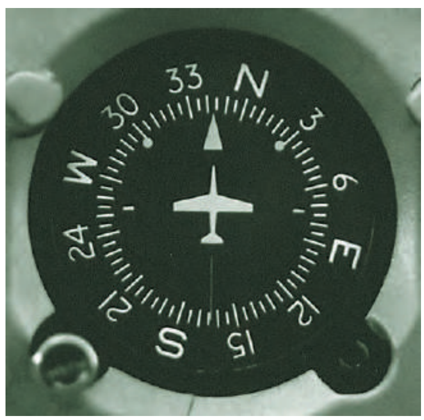


Figure 1-27 Heading indicator.

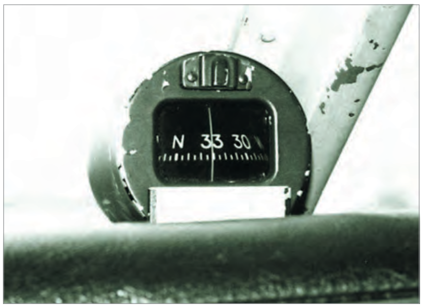


Figure 1-28 Magnetic compass.

Figure 1-29 Attitude indicator.

Figure 1-30 Tachometer.

Figure 1-31 Manifold pressure gauge.

Attitude

The vertical direction in which the nose of the aircraft is pointing relative to the horizon is described in degrees of *pitch* (how far above or below the horizon). *Bank* is the degree of tilt, left or right. Turns are described by the *angle of bank*, e.g. a 30°, or 45°, banked turn, or bank. Attitude is a combination of pitch and bank and is set by reference to the visual horizon or the attitude indicator (AI).

On all instruments, except the HI and the AI, the needles move. On the HI, the card rotates to show heading at the top. In the AI, the horizon moves to remain aligned with the earth's horizon.

Weight/Mass

United States aircraft have performance charts and load sheets with units of pounds (lb), whereas other parts of the world use the kilogram for weight. A kilo is approximately 2.2 pounds.

Fuel

United States aircraft have fuel tanks, gauges and charts calibrated in U.S. gallons (USG) and gallons per hour. Many other countries use metric units and so the volume of fuel is measured in liters, and consumption of fuel is measured in liters per hour. One USG is approximately four liters.

Pressure

Tire and fuel pressure is indicated in *pounds per square inch* (psi), and manifold pressure (in the engine intake) is indicated in *inches of mercury* (in. Hg), which is a very traditional unit of atmospheric pressure. This is also used for atmospheric pressure but metric is again common outside the United States where millibars (mb) or hectopascals (hPa) are used.

The altimeter's pressure setting is adjusted for surface pressure. The standard setting is 29.92 in. Hg. This setting varies with changing weather patterns, and the altimeter is adjusted for the day and the time of the flight.

Propeller Speed

The speed of rotation of the propeller is indicated in *revolutions per minute* (RPM) on the tachometer. The typical range is from 800 RPM as the engine idles to about 2,700 at full power.

Manifold Pressure

Your first aircraft may have a constant-speed propeller, in which case, the power is a combination of RPM and manifold pressure (MP). Units for MP are *inches of mercury* or *simply inches*. A typical cruise power setting might be 23 inches and 2,300 RPM.

Cockpit Design

The modern GA or LSA aircraft has made great advances in design. At last the private pilot can have features and comfort that was previously only available to high performance and expensive airplanes—military or civilian.

The structures are more efficient with beautiful aerodynamic shaping, well balanced and responsive control and electronic displays (glass cockpits) with powerful computing power and data processing for flight planning, weather reporting, navigation and flight management.

Electronic Instruments

While the data required by a pilot remains the same, many modern aircraft display this information in novel ways.

If we take a closer look at the primary flight display (PFD) you can see the essential data.

Other Equipment

A fire extinguisher may be provided in the cockpit. The fire extinguisher should be checked for serviceability and that it is security-fitted. Light aircraft fire extinguishers may be toxic in a confined space, and ventilation must be provided as soon as possible after use. *Control locks* may be carried. These are fitted internally to lock the control column and externally on the actual flight controls. The purpose of control locks is to prevent control-surface

Figure 1-32 Cockpit of Lightwing aircraft.

Figure 1-33 Cirrus instrument panel showing the primary flight display (PFD) and multi function display (MFD).

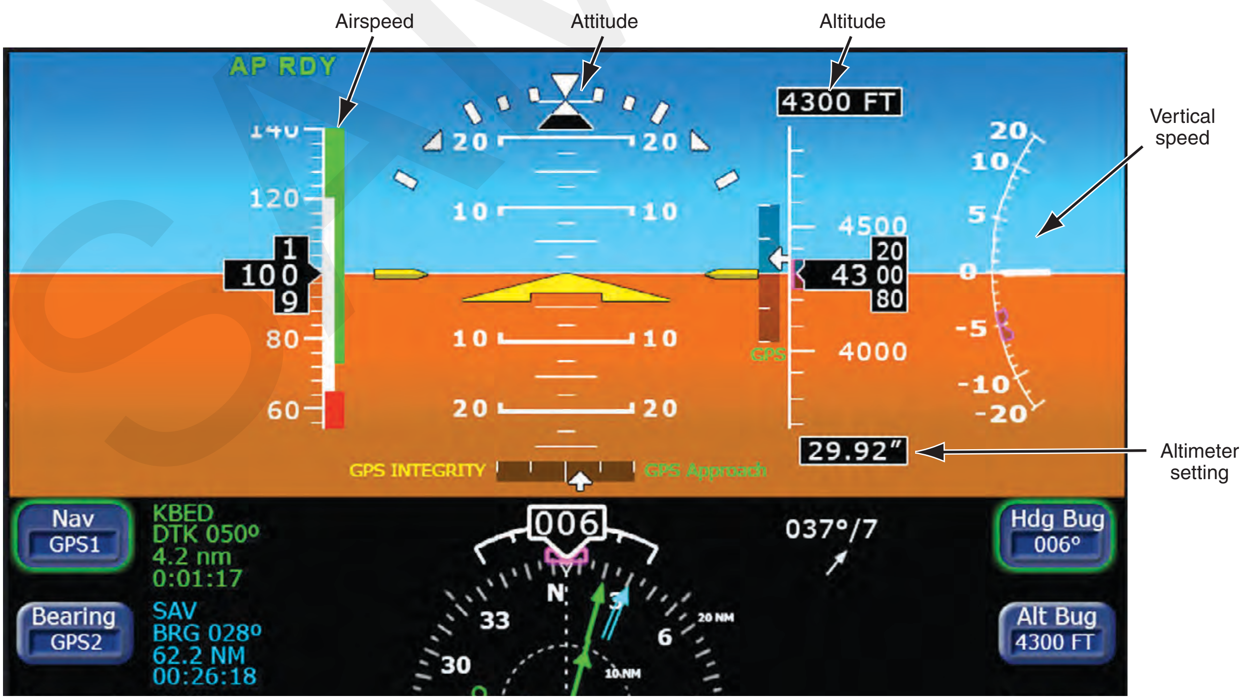


Figure 1-34 Close-up of Avidyne PFD.

movement and damage from the wind when the airplane is parked. It is vital that you remember to remove control locks prior to flight.

A *pitot cover* may be carried to protect the pitot head from blockage by insects and water while the airplane is parked. The pitot cover must be removed prior to flight if the airspeed indicator is to read correctly. Wheel chocks may be carried to place ahead of and behind the wheels as a precaution against movement when the airplane is parked. There may also be a tie-down kit of ropes, pegs and mallet to secure the airplane to the ground and prevent strong winds lifting the wings or tail. A first-aid kit may be carried.

Figure 1-35 Pitot cover and tie-down rope.

Additional Design Features

Figure 1-36
Socata TB 20 Trinidad.

While most student pilots will commence their training in a conventional Cessna, Piper or similar airplane, many will start on an airplane with additional features. This section will briefly introduce these various systems and features, but you must learn in detail the features and idiosyncrasies of your aircraft.

Constant-Speed Propeller

Many pilots learn to fly in an aircraft with a variable-pitch (constant-speed) propeller. In this system the propeller blade angle can be adjusted in flight within a governed range to provide the optimum power versus fuel economy.

This propeller acts in much the same way as the automatic transmission in your car with best acceleration when required (fine pitch) and best economy when cruising (coarse pitch). The mechanism is powered by oil pressure, and if the oil is lost, the propeller goes automatically to fine pitch for maximum thrust at low speed. The mechanism, called the *constant-speed unit* (CSU), is contained within the spinner.

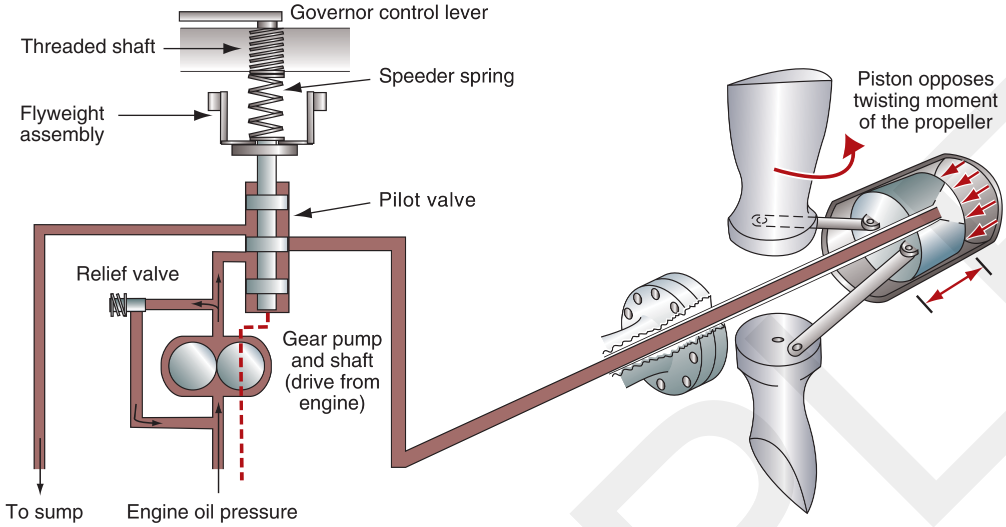


Figure 1-37 Constant-speed mechanism.

Why Complicate Things? The fixed-pitch propeller is a one-piece unit made from wood, kevlar or aluminum. The CSU adds weight and complexity. However, in return, it optimizes the angle of the propeller blades to produce maximum thrust at a particular forward speed and RPM.

How to Operate the CSU. The pilot now has two controls, one for engine power and one for propeller blade angle (together they generate thrust):

- the throttle controls manifold pressure (the pressure and amount of fuel-air mixture inducted to the engine); and
- the propeller lever (sometimes called the pitch lever) to set blade angle.

The throttle lever is topped by a smooth black knob and the propeller lever by a blue ribbed disc so they can be felt as well as seen. (The mixture lever is capped by a red indented knob.) With the propeller lever fully forward, the throttle changes the engine speed and manifold pressure just like a fixed-pitch propeller. A governor limits the maximum RPM (provided the throttle is used smoothly and slowly).

When the airplane is climbing or cruising, the pilot can set the optimum RPM by retarding the propeller lever and adjust the manifold pressure by retarding the throttle to achieve optimum engine conditions and fuel economy. Full power is used for takeoff and usually reduced to around 25 inches or 2,500 RPM for climb and maximum continuous power and around 23 inches or 2,300 RPM for cruise, but check the settings for your airplane.

Figure 1-38
Constant speed propeller (Beechcraft Bonanza A36).

Figure 1-39
Engine instruments—CSU.

For changes in airspeed and small changes in throttle setting, the governor maintains the set RPM. As the aircraft climbs, the manifold pressure will drop (no turbocharger) and so the throttle must be advanced to maintain 25 inches. For all engines, make the throttle and RPM changes smoothly and not too quickly. About two full seconds from idle to full power is normal. For the propeller RPM, a similar time is needed from cruise settings to full power.

When increasing power, advance the propeller lever first. When reducing power, reduce the throttle first.

The main principles to recall are:

- when operating at low power (start, taxi, run-up etc.) always have the propeller in fine pitch (high RPM, lever fully forward);
- for engine start and shutdown have the propeller lever fully forward;
- when increasing power always advance the propeller lever before the throttle;
- when reducing power always retard the throttle before the propeller RPM;
- when reducing power to idle always set the propeller to high RPM for a power increase when you may need it;
- for takeoff the propeller must be in high RPM and there may be a time limit (5 minutes or so) on maximum RPM;
- in the climb, adjust the throttle to maintain manifold pressure;
- on base leg or final approach, always put the propeller to high RPM in case you need to go around;
- before critical exercises, such as stalling and unusual attitude recoveries, place the propeller in high RPM for instant power for recovery (also full rich mixture is usual); and
- for a practice forced landing, have the propeller in high RPM for the go-around but, for an actual forced landing, the propeller generates less drag in the low RPM (full coarse) position.

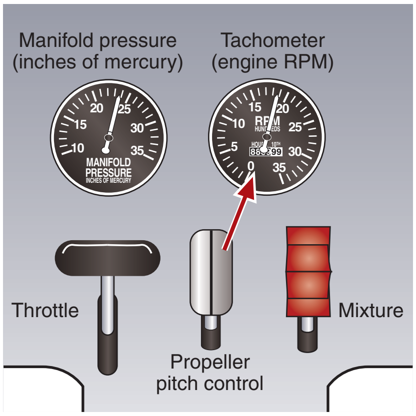


Figure 1-40
Engine controls—CSU.

Fuel Injection

A fuel-injected engine has the fuel injected directly into the engine cylinders in metered amounts. Most systems are electronically controlled and are more efficient than the traditional carburetor.

However, some are prone to fuel vaporization and overfuelling on start, and they may be difficult to start when hot. If your engine is designated, say, IO 360 or IO 540, it is the injected version of the engine. Learn and practice the hot-start procedure with your instructor.

Figure 1-41
Two-stroke engine.

Two-Stroke Engine

Many light or ultralight aircraft have two-stroke engines, which are lightweight, powerful, have a high RPM and may be air-cooled or liquid-cooled. Because the two-stroke engine works best at very high RPM, the propeller may be driven via a gearbox or belts to reduce propeller RPM and noise. (Airplanes usually have a direct drive to the propeller, even with a CSU.)

Low-Inertia Airplanes

Many pilots learn on ultralight airplanes that have relatively high drag and low momentum. They are often called *low-inertia* airplanes. These require greater and quicker pilot reaction in the event of engine failure and also when operating near the ground. They are more vulnerable to wind, vertical gusts and turbulence. Some have limited control and performance. However, they are great fun to fly if treated with respect.

Figure 1-42
Low-inertia tailwheel airplane.

Tail Wheel

A tail wheel airplane requires particular consideration. If you are learning to fly in a tail wheel airplane, which is very valuable training, consider the ASA publication in the Focus series entitled *Conventional Gear: Flying A Taildragger* (Newcastle, Washington: ASA, 2001) by David P. Robson.

High-Lift Devices

Some training airplanes have high-lift devices in addition to conventional trailing-edge flaps. These may include less common drooped ailerons (which act like additional flaps) and leading-edge slats. Slats are small airfoil sections (miniature wings) attached ahead of the leading edge of the main wing. Slats may extend along the complete span of the wings. They considerably increase the maximum lift that can be generated by a wing and so minimize speeds and distances for takeoff and landing. They also allow a much slower but steeper climb and approach path. The slats may be fixed open or may be retractable to reduce drag when cruising.

Figure 1-43
Leading-edge slats.

These devices retain attachment of the airflow over the upper surface of the wing at high angles of attack (the angle the wing presents to the air) and thus increase the lift coefficient (the lifting capacity of the wing). The higher lift allows the aircraft to fly at lower speeds—sometimes very slow speeds. Airplanes with full-span slats need very long landing gear legs because their attitude on landing is so high.

Figure 1-44
Washout.

Features for Safer Stall Characteristics

Most airplanes have devices to reduce the symptoms of the stall and in some cases prevent the full stall altogether. Features include:

- limited elevator deflection;
- slots;
- stall strips;
- vortex generators;
- tapered wing planform;
- wing twist (called *washout*); and
- different airfoil section of the outer part of the wing to encourage the inner area to stall first.

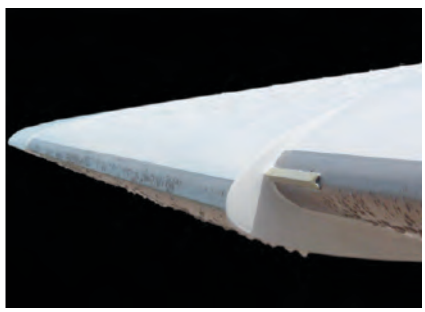


Figure 1-45
Modified leading edge.

All of these affect the symptoms and behavior of the aircraft at the stall and you should know about any that are fitted to your airplane. Don't forget the other factors such as CG position that also affect stall behavior.

Figure 1-46 Electric flaps.

Electric Flaps

Your airplane may have mechanically actuated flaps (operated by a handle as with the parking brake) or electrically operated by a switch. These may have two to three predetermined settings or may be infinitely variable over the range of travel. In the event of electrical failure, there may be a need to conduct a no-flap landing, hence it is taught in emergency procedures.

Retractable Gear

Figure 1-47 Retractable gear.

The retractable landing gear is usually electrically operated by a direct-drive motor or hydraulically by an electrical hydraulic pump. Both have specific techniques for emergency (manual) extension of the gear in the event of electrical or hydraulic system malfunctions.

The direct-drive version has to be cranked down; the hydraulic version may have a hand pump, emergency pressure accumulators or simply use gravity by unlocking the gear legs and allowing them to fall into the down and locked position. The emergency extension for your airplane must be learned but also practiced in clear conditions— for example, one aircraft requires 50 cranks of a handle that is located behind the front seats, and this requires some skill to operate and fly at the same time.

All airplanes have a maximum airspeed for gear extension and perhaps a higher speed for flight with the gear down and locked. The gear can be damaged above these speeds. Some aircraft with very high gear-down speeds can make use of this added drag for emergency descents as the drag of the gear allows a much steeper and quicker descent.

Retractable gear airplanes have a warning horn that sounds if the throttle is closed with the gear retracted. There is also a micro-switch (squat switch) that prevents retraction on the ground if there is weight on the landing gear.

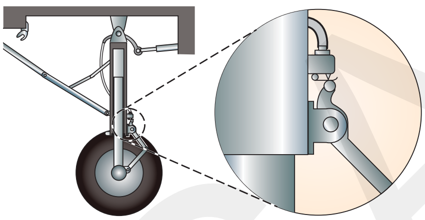


Figure 1-48 Squat switch.

Speed Brakes/Air Brakes

Some very low drag airplanes have speed brakes to increase drag for slowing to approach speeds and to contain speed during cruise descents.

Aileron/Rudder Interconnect

You will learn about a negative feature, called *adverse aileron yaw*, where the drag of the aileron causes yaw in the opposite direction to the commanded roll. Thus it is adverse because it resists the roll.

One method to counter this effect is to have the rudder automatically deflect in the same direction as the applied aileron, thus yawing the airplane in the same direction as the roll. This is a mechanical interconnect and as well as the positive counter to adverse yaw has some limitations.

Figure 1-49 Speed brake.

When taxiing, the yoke rotates as the rudder is applied as there is a tendency to try to steer the airplane with the yoke, which is less effective than the rudder. So, in a crosswind landing, where the pilot needs to apply aileron and rudder in opposite direction, there is some resistance due to the interconnect. Discuss these features with your flight instructor.

Supercharger/Turbocharger

It is unlikely you will have a boosted engine in your training airplane. If you do there are strict conditions on power increases and reductions to allow the temperatures to stabilize before descent, glides and engine shutdown. Some turbos have manual controls; other are completely automatic and produce power on demand.

The primary purpose of the turbocharger in an airplane is to compensate for the reduction in power as the airplane climbs. The turbocharger maintains sea-level full power until a certain altitude, called *full throttle height*.

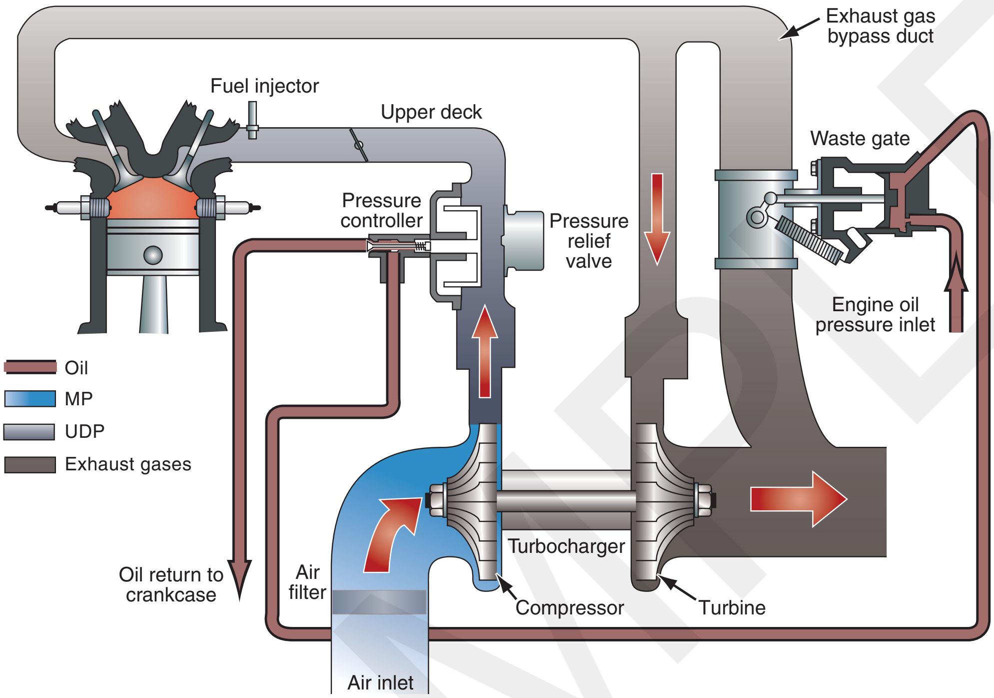


Figure 1-50 Turbocharger.

Tip Tanks

Some airplanes have additional fuel carried in tanks mounted on the wing tips. These tip tanks also provide structural and aerodynamic advantages. Check how to fill these tanks and how to access all the aircraft's fuel in the correct sequence and the tank selections needed.

Figure 1-51 Tip tank.

Oxygen

The use of supplemental oxygen is recommended above cabin altitudes of 10,000 feet MSL.

An airplane that can climb and cruise above 10,000 feet (probably turbocharged) will also require crew oxygen or cabin pressurization. In the latter case emergency oxygen and quick-donning masks are also essential elements. You should not only learn to operate the system but practice using it. Be careful to use only *aviator's grade* oxygen in certified delivery systems.

While the use of supplemental oxygen is *recommended* above cabin altitudes of 10,000 feet MSL, it is *required* by the Federal Aviation Regulations for:

- all time in excess of 30 minutes above 12,500 feet MSL cabin altitude; and
- all time above 14,000 feet MSL cabin altitude.

The term cabin altitude is used to describe the air in the cockpit that a pilot is breathing. A pressurized airplane flying at 31,000 feet may have the cabin pressurized to 8,000 feet, which means the pilots have the same amount of oxygen to breathe as in an unpressurized airplane at 8,000 feet MSL. In this case, there is no need to use the oxygen masks. If, however, there was a sudden depressurization and the cabin air escaped, the pilots would require oxygen immediately.

Pressurization and Air Conditioning

A training airplane has insufficient excess power to be able to power pressurization turbines and air-conditioner compressors. It is the higher-performance turbocharged airplane that carries these systems and their use will be part of your type rating. You need to learn about the particular system in your airplane. Also check the maximum cabin pressure differential your aircraft can accept as this will impose maximum altitude limits.

Cirrus Airframe Parachute System

Some designs even feature a unique safety measure—a parachute system that will lower the complete aircraft and its passengers safely to earth. One is called the *Cirrus Airframe Parachute System* (CAPS). This feature offers a safe escape in the event of engine failure at night or over harsh terrain, if control is lost in marginal weather, or safe recovery by a passenger in the event of pilot incapacitation.

Figure 1-52 Cirrus CAPS system.

REVIEW 1

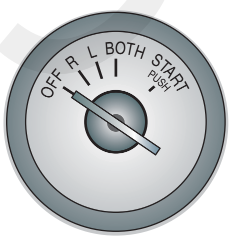
The Training Airplane

1. Locate the following on the diagram below:
   - fuselage;
   - right wing;
   - left wing;
   - empennage;
   - nose wheel;
   - oil cooler;
   - wing trailing edge;
   - vertical stabilizer;
   - elevator;
   - propeller;
   - rudder;
   - left and right wing tips;
   - wing root;
   - flaps;
   - spinner;
   - wing leading edge;
   - radio antenna;
   - (right) main landing gear;
   - cockpit canopy;
   - rotating beacon (red);
   - red position light;
   - right aileron;
   - elevator trim tab
   - green position light;
   - engine cowling;
   - rear-facing position light (white);
   - landing light(s);
   - left aileron; and
   - horizontal stabilizer.

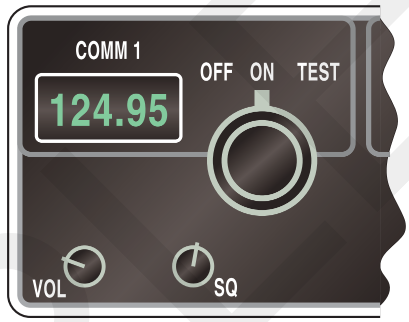
2. Will easing the control column rearward in normal flight raise or lower the nose of the airplane?
3. Rotating the control column to the right will cause the airplane to roll in which direction?
4. How is the rudder operated?
5. Will moving the throttle forward increase or decrease engine power?
6. On the ground, wheel brakes can be operated by pressing the top of which pedals?
7. Where are the fuel tanks located?

8. What fluid is used to lubricate and cool the engine?
9. Identify the following on the diagram below:
   - the flight instruments;
   - the engine gauges and controls;
   - the radio panel;
   - the magnetic compass.

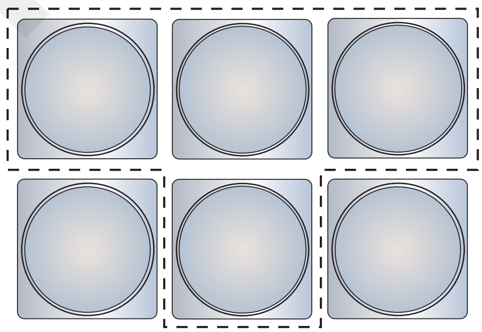
10. Which control adjusts the fuel-air mixture?
11. Which components generate the spark that ignites the fuel-air mixture? In what way do dual ignition systems affect the efficiency of the combustion in each cylinder? Do dual ignition systems provide more safety in the case of failure to one system?
12. What is the source of the electrical power needed to start the engine?
13. Radios and other electrical services can be powered by the battery when the engine is not running. When the engine is running, how are the radios and other services powered and the battery recharged?
14. Which switch is pictured below?



15. Identify the item of equipment pictured below. What does the SQ label stand for? What is removed when this control is activated?



16. Where on an instrument panel are the following instruments located: attitude indicator, heading indicator, airspeed indicator, turn coordinator, altimeter and vertical speed indicator? Where is the balance ball located?



Answers are given on page 575.

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