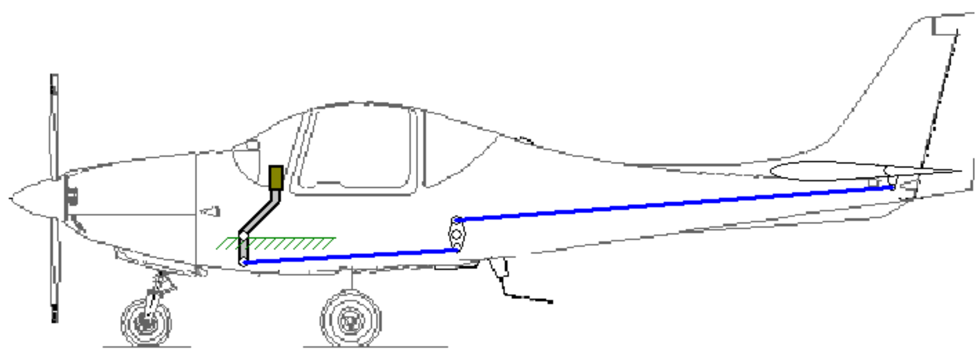
DIRECT MECHANICAL (CONVENTIONAL) CONTROL

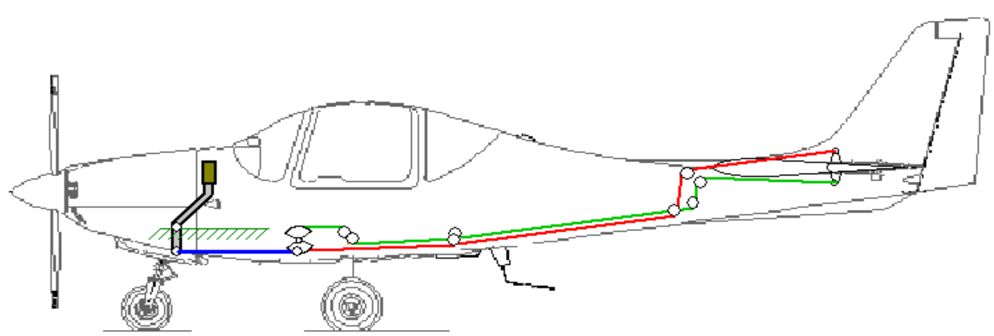
PUSH-PULL RODS SYSTEM

1. The linkage from cabin to control surface can be fully mechanical if the aircraft size and its flight envelop allow;
2. In this case the hinge moment generated by the surface deflection is low enough to be easily contrasted by the muscular effort of the pilot.
3. Two types of mechanical systems are used: push-pull rods and cable-pulley.
4. In the first case a **sequence of rods** link the control surface to the cabin input.
5. **Bell-crank levers** are used to change the direction of the rod routings.
6. Vibrations of the rods can introduce oscillating deflections of the surface.



CABLE-PULLEY SYSTEM

1. The couples of cables are used in place of the rods.
2. In this case **pulleys** are used to alter the direction of the lines,
3. **Idlers** to reduce any slack due to structure elasticity, cable strands relaxation or thermal expansion.
4. Often the cable-pulley solution is preferred, because is more flexible and allows reaching more remote areas of the airplane.

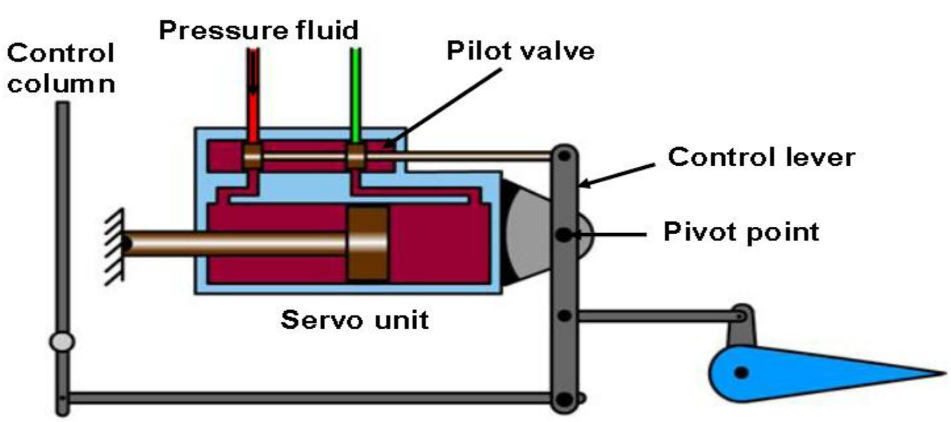


POWER OPERATED AND POWER ASSISTED

- Aircraft with cruise speeds of approximately 300 knots and faster develop significant air loads on the control surfaces that are difficult for the pilot to overcome when operating the controls without mechanical advantage.
- As a result, aircraft in this category will typically employ hydraulically operated flight controls.
- Conventional cable or pushrod systems are installed in the aircraft as usual, but tied into a power transmission quadrant.
- When the system is activated, the pilot's control inputs do not go directly to individual control surfaces.
- Instead, the inputs open and close hydraulic valves that direct hydraulic fluid to individual actuators. The actuator moves the control surface to the requested position.
- There are two primary methods of providing for hydraulic control system failure.

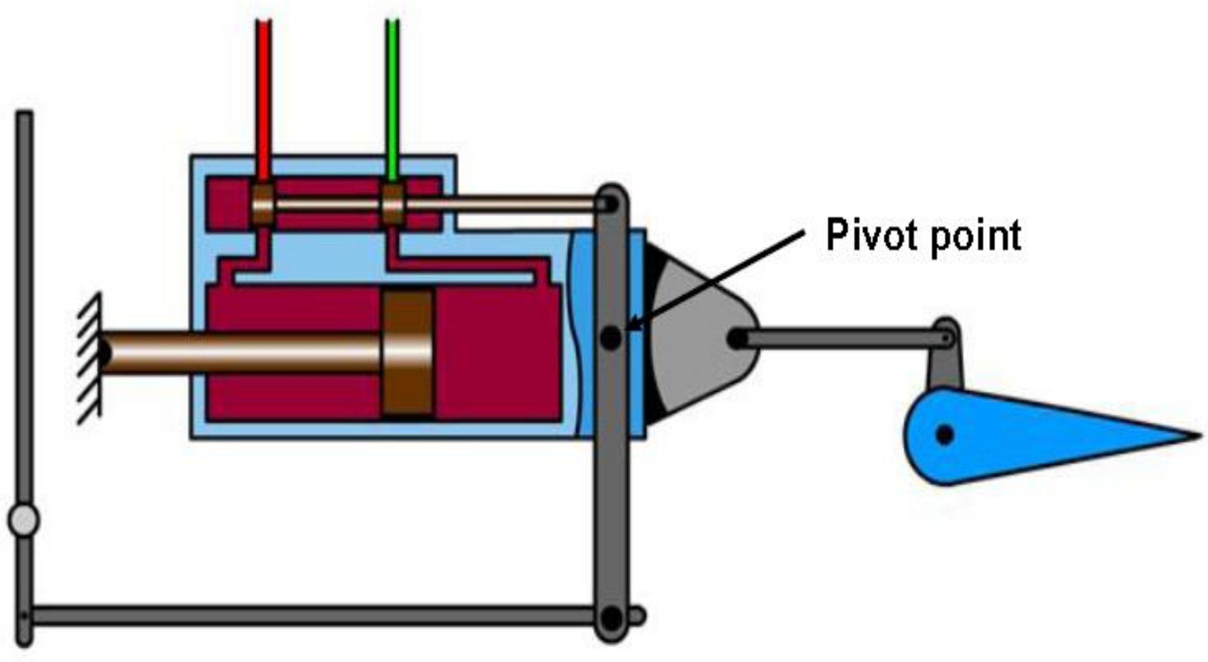
POWER ASSISTED CONTROL

- The pilot’s control is connected to the control surface through push pull rod and control lever.
- E.g., control column to initiate a climb say, the control lever pivots about point ‘X’ and Moving the elevators up**.**
- At the same time, the control valve pistons are displaced and this allows oil from the hydraulic system to flow to the left hand side of the actuating jack piston.
- The rod of which is secured to the aircraft’s structures.
- The reaction of the pressure exerted on the piston causes the whole servo unit, and control lever, to move to the left because of the greater control effort produced.
- The pilot is assisted in making further upward movement of the elevator.



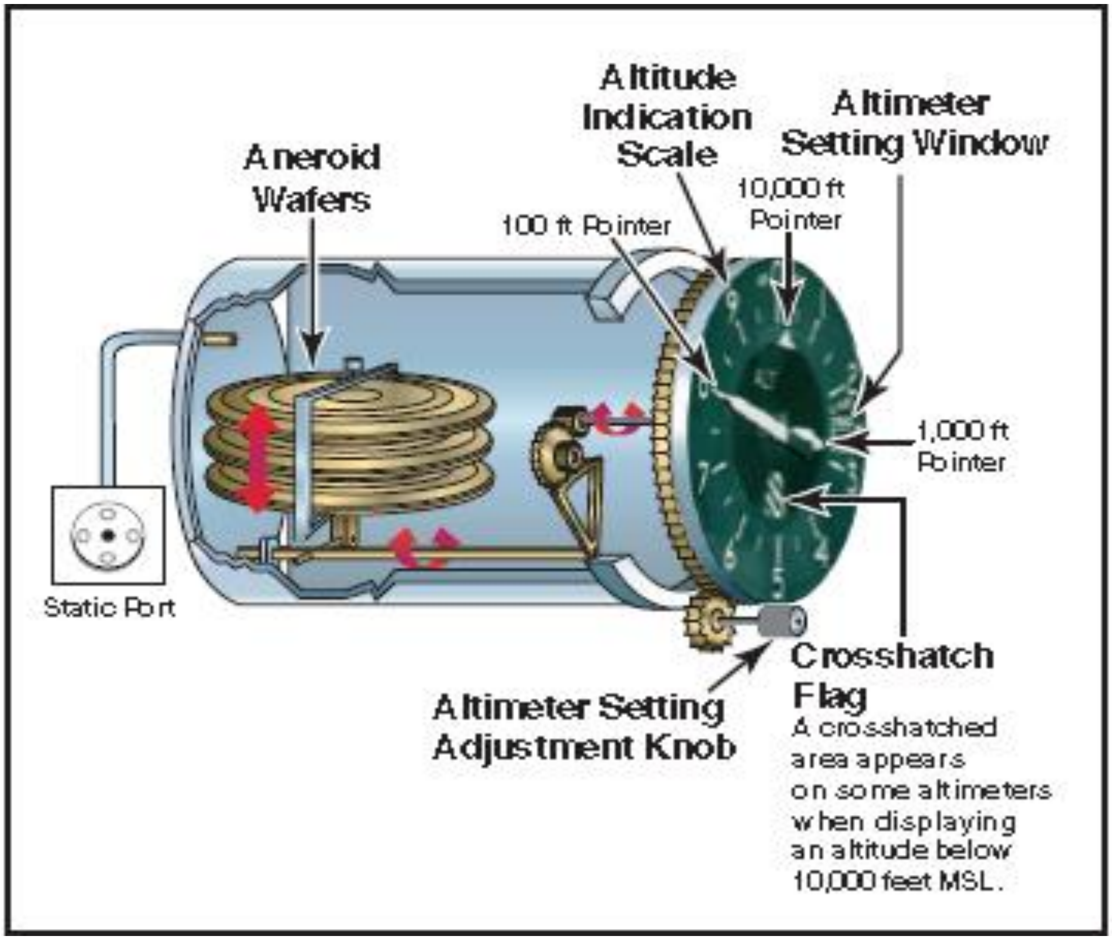
FULLY POWERED CONTROL

- In this system pilot control is connected to the control lever only while servo-unit directly connected to the control surface.
- Thus, the effort required by the pilot to move the control column is simply that needed to move the control lever and control valve piston.
- It does not vary with the effort required to move the control surface, which is supplied solely by servo-unit hydraulic power.
- Since no forces are transmitted back to the pilot. The pilot has no feel of the aerodynamic load acting on the control surfaces.
- It is necessary to incorporate an ‘artificial feel’ device connected between the pilot’s controls and servo-unit control lever.
- A commonly used system for providing artificial feel is the one known as ‘q’ feel.
- In this system, the feel force varies with dynamic pressure of the air, the pressure being sensed by pitot –tube or bellows type sensing element.
- The sensing element connected in the hydraulic powered controls.
- The hydraulic unit produces control forces dependent on the amount of control movement and forward speed of the aircraft.



ALTIMETER

1. The altimeter measures the height of the airplane above a given pressure level. Since it is the only instrument that gives altitude information.
2. A stack of sealed **aneroid** wafers comprises the main component of the altimeter. These wafers expand and contract with changes in atmospheric pressure from the static source.
3. The mechanical linkage translates these changes into pointer movements on the indicator. [Figure 6-2]



PRINCIPLE OF OPERATION

4. The pressure altimeter is an aneroid barometer that measures the pressure of the atmosphere at the level where the altimeter is located, and presents an altitude indication in feet.
5. The altimeter uses static pressure as its source of operation. Air is denser at sea level than aloft, so as altitude increases, atmospheric pressure decreases.
6. This difference in pressure at various levels causes the altimeter to indicate changes in altitude.

7. Some have one pointer while others have two or more.
8. The dial of a typical altimeter is graduated with numerals arranged clockwise from 0 to 9.
9. Movement of the aneroid element is transmitted through gears to the three hands that indicate altitude.
10. The **shortest hand** indicates altitude in tens of thousands of feet; the **intermediate hand** in thousands of feet; and the **longest hand** in hundreds of feet.
11. This indicated altitude is correct, however, only when the sea level barometric pressure is standard (29.92 inches of mercury), the sea level free air temperature is standard (+15°C or 59°F), and the pressure and temperature decrease at a standard rate with an increase in altitude.

Pilots are mainly concerned with five types of altitudes:

Indicated Altitude That altitude read directly from the altimeter (uncorrected) when it is set to the current altimeter setting.

True Altitude The vertical distance of the airplane above sea level—the actual altitude. It is often expressed as feet above mean sea level (MSL).
Airport, terrain, and obstacle elevations on aeronautical charts are true altitudes.

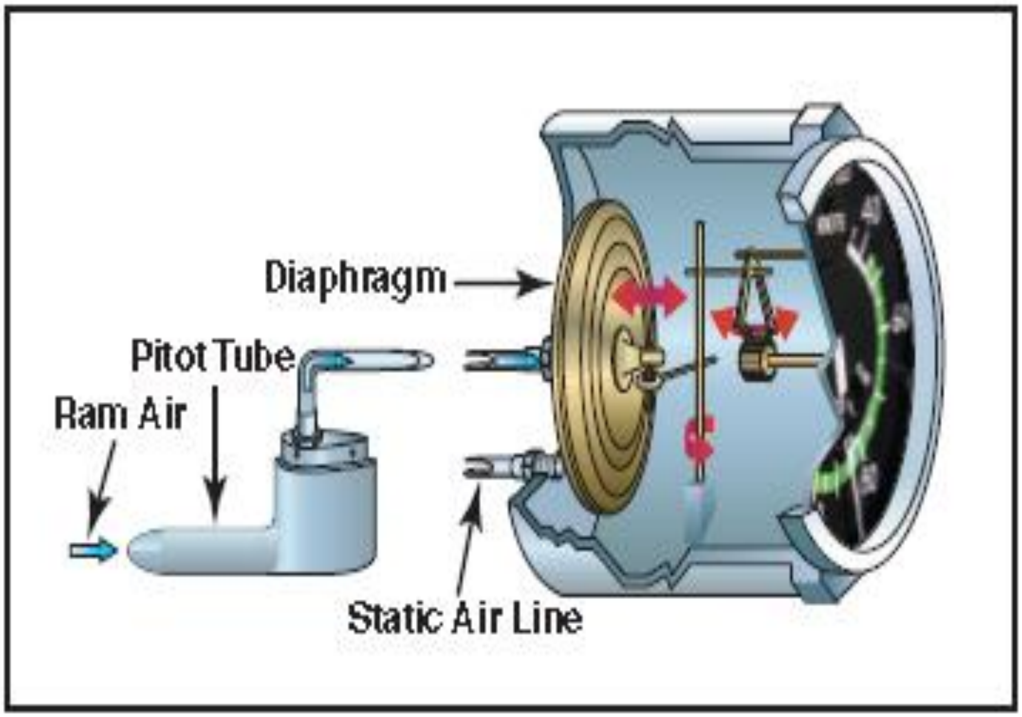
Absolute Altitude The vertical distance of an airplane above the terrain, or above ground level (AGL).

Pressure Altitude The altitude indicated when the altimeter setting window (barometric scale) is adjusted to 29.92.
This is the altitude above the standard datum plane, which is a theoretical plane where air pressure. (corrected to 15°C) equals 29.92 in. Hg. Pressure altitude is used to compute density altitude, true altitude, true airspeed, and other performance data.

AIRSPEED INDICATOR

1. The airspeed indicator is a sensitive, differential pressure gauge which measures and shows promptly the difference between pitot or impact pressure, and static pressure, the undisturbed atmospheric pressure at level flight.
2. These two pressures will be equal when the airplane is parked on the ground in calm air.
3. When the airplane moves through the air, the pressure on the pitot line becomes greater than the pressure in the static lines.

4. This difference in pressure is registered by the airspeed pointer on the face of the instrument, which is calibrated in miles per hour, **knots**, or both.



Pilots should understand the following speeds:

Indicated Airspeed (IAS)—The direct instrument reading obtained from the airspeed indicator, uncorrected for variations in atmospheric density, installation error, or instrument error.

Calibrated Airspeed (CAS)—Indicated airspeed corrected for installation error and instrument error. Although manufacturers attempt to keep airspeed errors to a minimum, it is not possible to eliminate all errors throughout the airspeed operating range.

True Airspeed (TAS)—Calibrated airspeed corrected for altitude and nonstandard temperature. Because air density decreases with an increase in altitude, an airplane has to be flown faster at higher altitudes to cause the same pressure difference between pitot impact pressure and static pressure.

Groundspeed (GS)—The actual speed of the airplane over the ground. It is true airspeed adjusted for wind. Groundspeed decreases with a headwind, and increases with a tailwind.

VERTICAL SPEED INDICATOR

1. The vertical speed indicator (VSI), which is sometimes called a vertical velocity indicator (VVI), indicates whether the airplane is climbing, descending, or in level flight.
2. The rate of climb or descent is indicated in feet per minute. If properly calibrated, the VSI indicates zero in level flight.

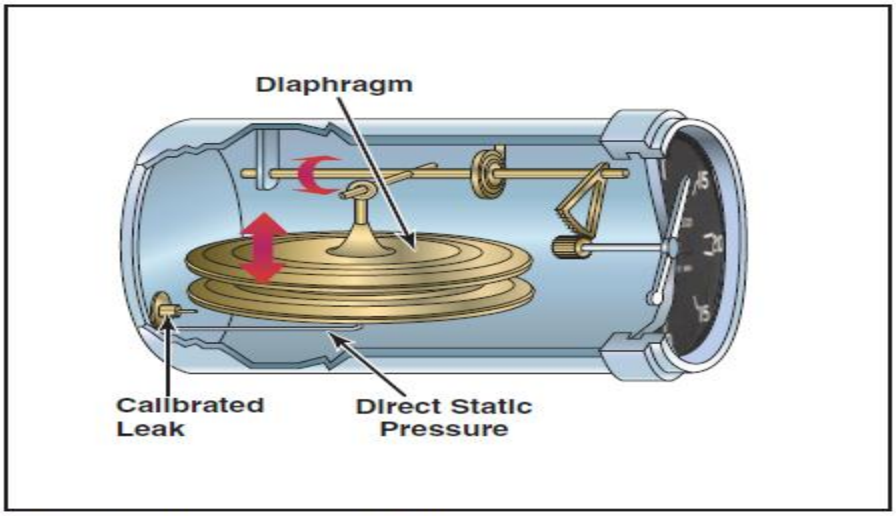


Figure 6-4. Vertical speed Indicator.

PRINCIPLE OF OPERATION

1. Although the vertical speed indicator operates solely from static pressure, it is a differential pressure instrument.
2. It contains a diaphragm with connecting linkage and gearing to the indicator pointer inside an airtight case.
3. The inside of the diaphragm is connected directly to the static line of the pitot-static system.
4. The area outside the diaphragm, which is inside the instrument case, is also connected to the static line, but through a restricted orifice (calibrated leak).
5. Both the diaphragm and the case receive air from the static line at existing atmospheric pressure.
6. When the airplane is on the ground or in level flight, the pressures inside the diaphragm and the instrument case remain the same and the pointer is at the zero indication.

7. When the airplane climbs or descends, the pressure inside the diaphragm changes immediately, but due to the metering action of the restricted passage, the case pressure remains higher or lower for a short time, causing the diaphragm to contract or expand.
8. This causes a pressure differential that is indicated on the instrument needle as a climb or descent.
9. When the pressure differential stabilizes at a definite ratio, the needle indicates the rate of altitude change.
10. The vertical speed indicator is capable of displaying two different types of information:
    - Trend information shows an immediate indication of an increase or decrease in the airplane's rate of climb or descent.
    - Rate information shows a stabilized rate of change in altitude.

PITOT-STATIC FLIGHT INSTRUMENTS

1. There are two major parts of the pitot-static system: the impact pressure chamber and lines, and the static pressure chamber and lines.
2. They provide the source of ambient air pressure for the operation of the altimeter, vertical speed indicator (vertical velocity indicator), and the airspeed indicator.

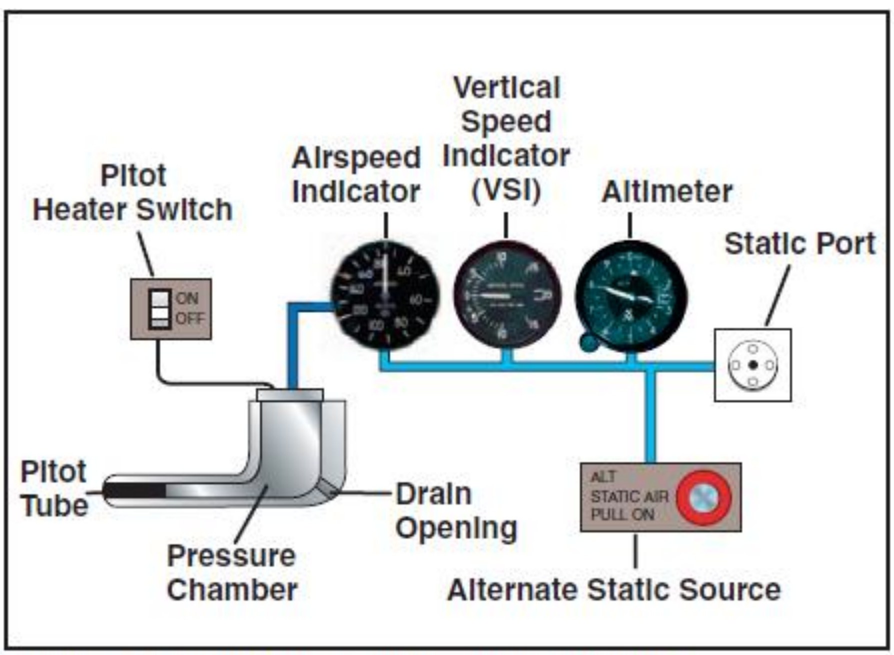


Figure 6-1. Pitot-static system and instruments.

IMPACT PRESSURE CHAMBER AND LINES

1. In this system, the impact air pressure (air striking the airplane because of its forward motion) is taken from a pitot tube
2. The static pressure (pressure of the still air) is usually taken from the static line attached to a vent or vents mounted flush with the side of the fuselage.
3. This compensates for any possible variation in static pressure due to erratic changes in airplane attitude.
4. The openings of both the pitot tube and the static vent must be checked during the preflight inspection to assure that they are free from obstructions.
5. Blocked or partially blocked openings should be cleaned by a certificated mechanic.
6. Blowing into these openings is not recommended because this could damage the instruments.
7. As the airplane moves through the air, the impact pressure on the open pitot tube affects the pressure in
   the pitot chamber.
8. Any change of pressure in the pitot chamber is transmitted through a line connected to the airspeed indicator, which utilizes impact pressure for its operation.

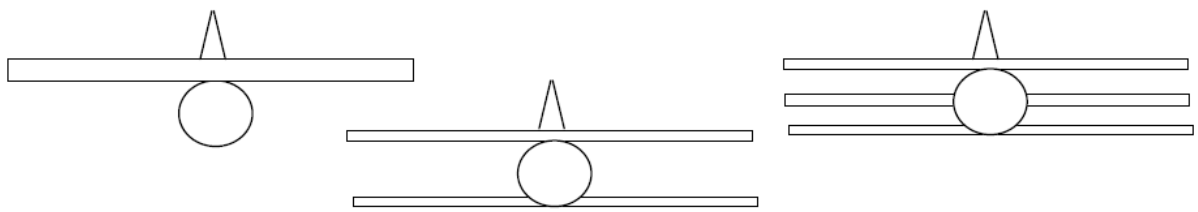
STATIC PRESSURE CHAMBER AND LINES

1. The static chamber is vented through small holes to the free undisturbed air, and as the atmospheric
   pressure increases or decreases, the pressure in the static chamber changes accordingly.
2. Again, this pressure change is transmitted through lines to the instruments which utilize static pressure.
3. An alternate source for static pressure is provided in some airplanes in the event the static ports become
   blocked.
4. This source usually is vented to the pressure inside the cockpit.
5. When the alternate static source is used, the following differences in the instrument indications usually occur: the altimeter will indicate higher than the actual altitude, the airspeed will indicate greater than the actual airspeed, and the vertical speed will indicate a climb while in level flight.
6. Consult the Airplane Flight Manual or Pilot’s Operating Handbook (AFM/POH) to determine the amount of error.

CLASSIFICATIONS OF FLIGHT VEHICLES (unit-3)

CLASSIFICATION BASED ON WINGS

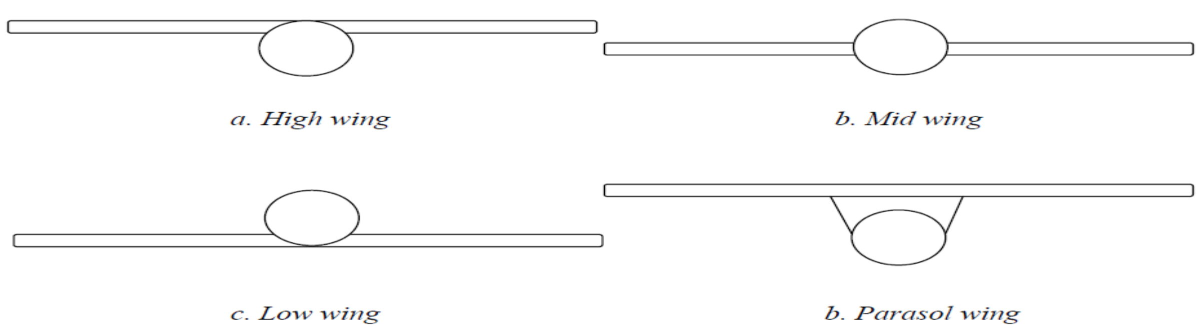
1. Monoplane (i.e. one wing)
2. Two wings (i.e. biplane)
3. Three wings



1. Monoplane   2. Biplane   3. triwing

- ❖ Nowadays, modern aircraft almost all have monoplane.
- ❖ Currently, there are a few aircraft that employ biplane
- ❖ In the past, the major reason to select more than one wing was the manufacturing technology limitations.
- ❖ A single wing usually has a longer wing span compared with two wings (with the same total area).
- ❖ Old manufacturing technology was not able to structurally support a long wing to stay level and rigid.
- ❖ With the advance in the manufacturing technology and also new aerospace strong materials; such as advanced light aluminum, and composite materials; this reason is not valid anymore.
- ❖ Another reason was the limitations on the aircraft wing span. Hence a way to reduce the wing span is to increase the number of wings.
- ❖ Several maneuverable aircraft in 1940s and 1950s had biplane and even three wings.
- ❖ The disadvantages of biplane are offer higher weight, lower lift, and pilot visibility limits.

CLASSIFICATION BASED ON WINGS POSITION



A. Advantages of High Wing

1. The aircraft structure is lighter when struts are employed
2. Increases the dihedral effect. It makes the aircraft laterally more stable
3. Increases the dihedral effect. It makes the aircraft laterally more stable
4. Increases the dihedral effect. It makes the aircraft laterally more stable
5. There is a lower possibility of human accident

Disadvantages:

1. The aircraft have more frontal area which increases drag.
2. The wing is producing more induced drag.
3. A high wing is structurally about 20% heavier than a low wing.
4. The aircraft lateral control is weaker compared with mid wing and low wing

B. Advantages of Low Wing

1. Aircraft frontal area is less.
2. The wing has less induced drag.
3. The tail is lighter; compared with a high wing configuration
4. The aircraft take off performance is better

Disadvantages of Low Wing

1. The aircraft has a lower landing performance
2. The wing generates less lift
3. The aircraft has lower airworthiness due to a higher stall speed.

C. Features of a mid-wing configuration

1. The aircraft structure is heavier
2. The mid wing is more expensive compared with high and low-wing configurations.
3. The mid wing is aerodynamically streamliner compared with two other configurations
4. The mid-wing has less interference drag than low-wing and high-wing.

CLASSIFICATION BASED ON MACH NUMBER

Aircraft are classified based on their maximum Mach number,

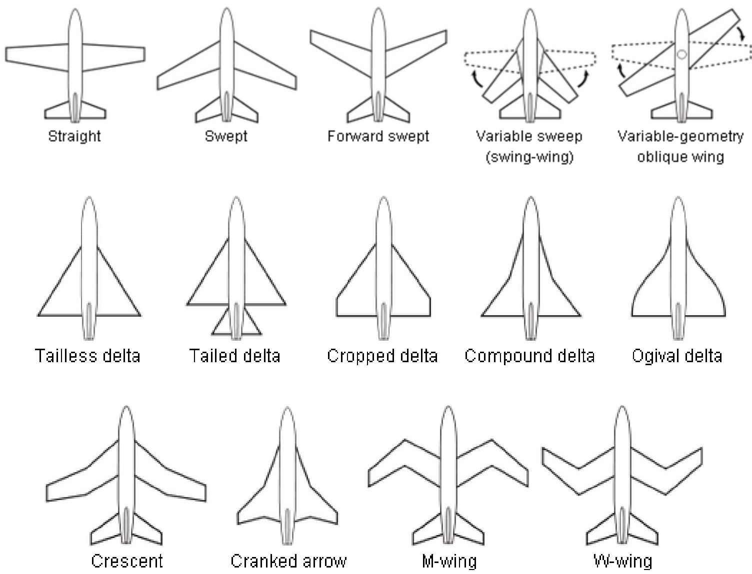
- Subsonic ($M<1$)
- Transonic ($M\sim1$)
- Supersonic ($M>1$)
- Hypersonic ($M>>1$)

CLASSIFICATION BASED ON PURPOSE

- Military aircraft

» Fighters
» Bombers
» Medical / Rescue Aircraft
» Spy / Reconnaissance Aircraft

SWEEP WING



CLASSIFICATION BASED ON PURPOSE

• Agricultural aircraft
• Sports aircraft
» Glider
» Recreational aircraft
» Man-powered aircraft

CLASSIFICATION BASED ON TYPE OF ENGINE

Aircraft with engine are classified based on the type of engine as follows,

• Propeller
• Turboprop
• Turbofan
• Turbojet
• Ramjet

CLASSIFICATION BASED ON RANGE

Aircraft are classified based on their range as follows,

• Short range (<500 km)
• Medium range (<3000km)
• Long range (>3000 km)