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CASE STUDY REPORT

On

Various Systems of instruments in BOEING 747 Aircraft

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Aircraft Instrument Systems

Aircraft instruments are the means of supplying the pilot with information about the aircraft and its operation could be useful and lead to safer flight. They provide reliable, accurate & continuous information to the pilot by means of direct reading on dial with pointer or with the help of counters and also provides certain information/warning by means of audio and visual signal. instrument systems now exist to provide information on the condition of the aircraft, engine, components, the aircraft's attitude in the sky, weather, cabin environment, navigation, and communication.

The ability to capture and convey all of the information a pilot may want, in an accurate, easily understood manner, has been a challenge throughout the history of aviation. As the range of desired information has grown, so too have the size and complexity of modern aircraft, thus expanding even further the need to inform the flight crew without sensory overload or overcluttering the cockpit. As a result, the old flat panel in the front of the cockpit with various individual instruments attached to it has evolved into a sophisticated computer-controlled digital interface with flat-panel display screens and prioritized messaging.

There are usually two parts to any instrument or instrument system. One part senses the situation and the other part displays it. In analog instruments, both of these functions often take place in a single unit or instrument (case). These are called direct-sensing instruments. Remote-sensing requires the information to be sensed, or captured, and then sent to a separate display unit in the cockpit. Both analog and digital instruments make use of this method. [Figure 1]

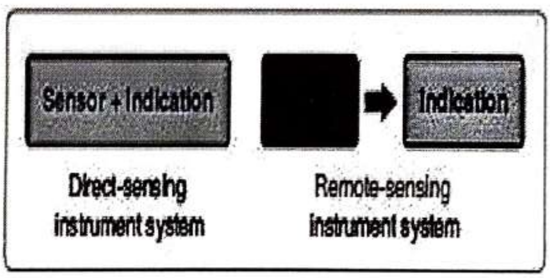


Figure : There are two parts to any instrument system-the sensing mechanism and the display mechanism

Classification of Aircraft Instruments :

There are three basic kinds of instruments classified by the job they perform: flight instruments, engine instruments, and navigation instruments. There are also miscellaneous gauges and indicators that provide information that do not fall into these classifications, especially on large complex aircraft. Flight control position, cabin environmental systems, electrical power, and auxiliary power units (APUs), for example, are all monitored and controlled from the cockpit via the use of instruments systems. All may be regarded as position/condition instruments since they usually report the position of a certain moveable component on the aircraft, or the condition of various aircraft components or systems not included in the first three groups.

Classification based on function present in Boeing 747 aircraft

1. Flight instruments (Shows aircraft flight characteristics)
2. Navigation instruments (Guides pilot along flight course)
3. Engine instruments (Provides information about the engine)
4. System instruments (Provides system operation status)

Main instruments in Aircraft cockpit

Flight Instruments	Navigation Instruments	Engine Instruments	Systems Instruments
• Airspeed Indicator • Altimeter • Attitude Indicator • Vertical Speed Indicator • Turn Coordinator	• Heading Indicator • Compass • VOR Receiver • Glide Slope	• Oil pressure indicator • Oil temperature indicator • Exhaust Gas Temperature • Fuel Flow Indicator • Fuel Gauge • Tachometer	• Hydraulic pressure indicator • Vacuum gauge • Ammeter

Fig a) Boeing 747

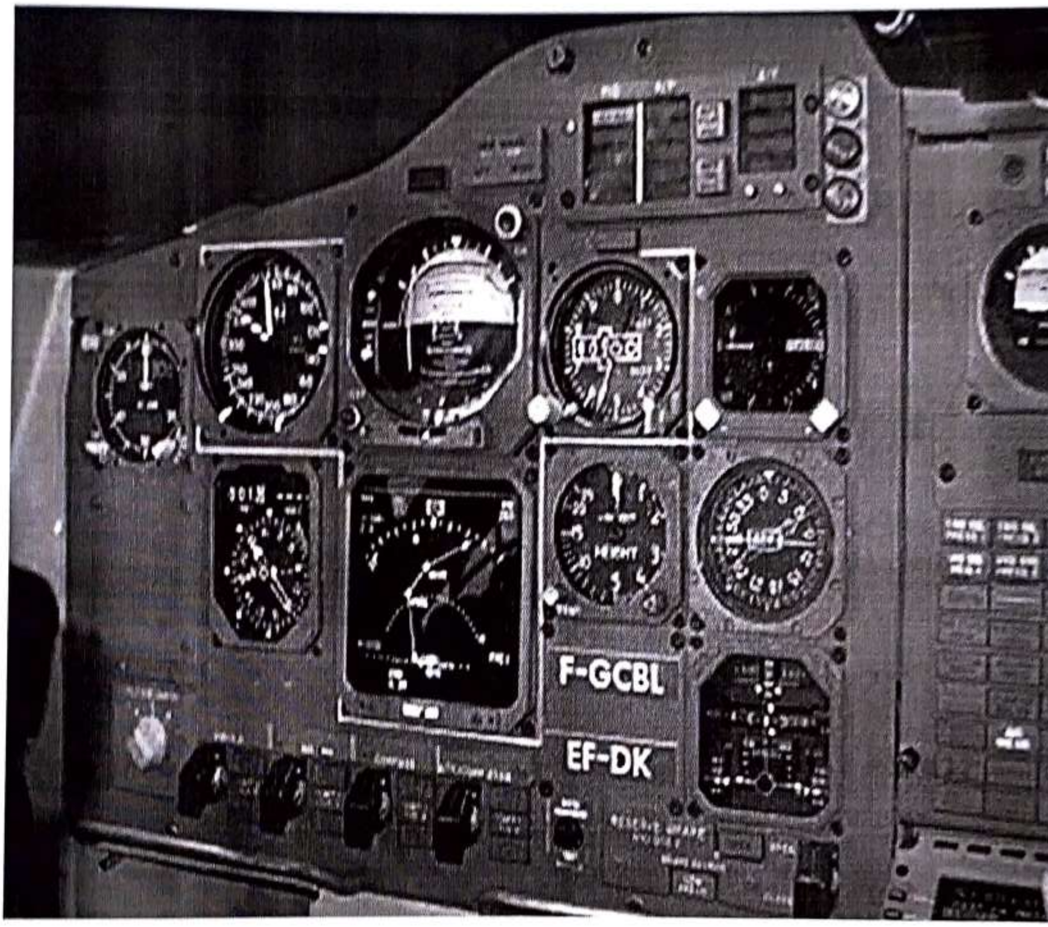


Fig b) cockpit of boeing747

1.Flight instruments:

The instruments used in controlling the aircraft's flight attitude are known as the flight instruments. There are basic flight instruments, such as the altimeter that displays aircraft altitude; the airspeed indicator; and the magnetic direction indicator, a form of compass. Additionally, an artificial horizon, turn coordinator, and vertical speed indicator are flight instruments present in most aircraft. Over the years, flight instruments have come to be situated similarly on the instrument panels in most aircraft. This basic T arrangement for flight instruments is shown in Figure 2.

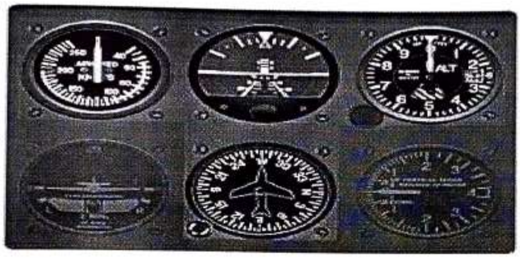


Figure 1.a The basic T arrangement of analog flight instruments. At the bottom of the T is a heading indicator that functions as a compass but is driven by a gyroscope and not subject to the oscillations common to magnetic direction indicators

Original analog flight instruments are operated by air pressure and the use of gyroscopes. This avoids the use of electricity, which could put the pilot in a dangerous situation if the aircraft lost electrical power. Development of sensing and display techniques, combined with advanced aircraft electrical systems, has made it possible for reliable primary and secondary instrument systems that are electrically operated. Nonetheless, often a pneumatic altimeter, a gyro artificial horizon, and a magnetic direction indicator are retained somewhere in the instrument panel for redundancy. [Figure 3]

Figure 1b. This electrically operated flat screen display instrument panel, or glass cockpit, retains an analog airspeed indicator, a gyroscope-driven artificial horizon, and an analog altimeter as a backup should electric power be lost, or a display unit fails

Flight instruments present in Boeing 747

- ❖ Airspeed indicator
- ❖ Altimeter
- ❖ Attitude indicator
- ❖ Vertical speed indicator
- ❖ Turn coordinator

1.1 AIRSPEED INDICATOR:

Fig.1.1 a) airspeed indicator

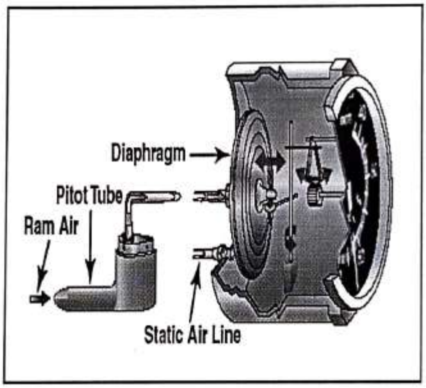


Fig 1.1 b) cross section view of airspeed indicator

Maximum operating airspeed indicator which Indicates maximum operating airspeed .Indicated airspeed pointer which indicates airspeed derived pneumatically from pitot static pressure .Command airspeed bug which sets by auto throttle (A/T)Speed indicator .the figure 1.1a) is image of airspeed indicator.

A figure Below show, the airspeed indicator is another primary flight instrument that is also a differential pressure gauge. Ram air pressure from the aircraft's pitot tube is directed into a diaphragm in an analog airspeed instrument case. Static air pressure from the aircraft static vent(s) is directed into the case surrounding the diaphragm. As the speed of the aircraft varies, the ram air pressure varies, expanding or contracting the diaphragm. Linkage attached to the diaphragm causes a pointer to move over the instrument face, which is calibrated in knots or miles per hour (mph).

Airspeed indicators work by measuring the difference between static pressure, captured through one or more static ports; and stagnation pressure due to "ram air", captured through a pitot tube. This difference in pressure due to ram air is called impact pressure. The static ports are located on the exterior of the aircraft, at a location chosen to detect the prevailing atmospheric pressure as accurately as possible, that is, with minimum disturbance from the presence of the aircraft. Icing is a problem for pitot tubes when the air temperature is below freezing and visible moisture is present in the atmosphere, as when flying through cloud or precipitation. Electrically heated pitot tubes are used to prevent ice forming over the tube.

1.2 ALTIMETER:

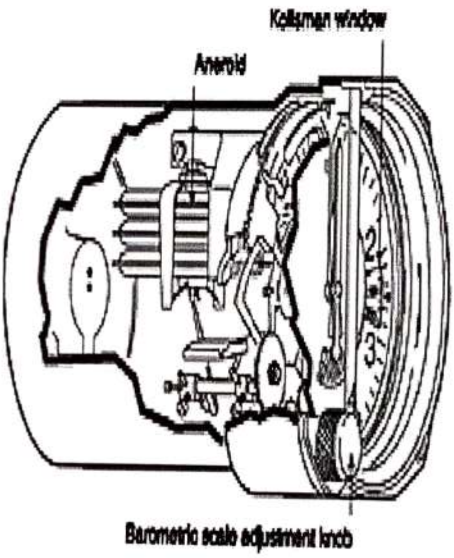


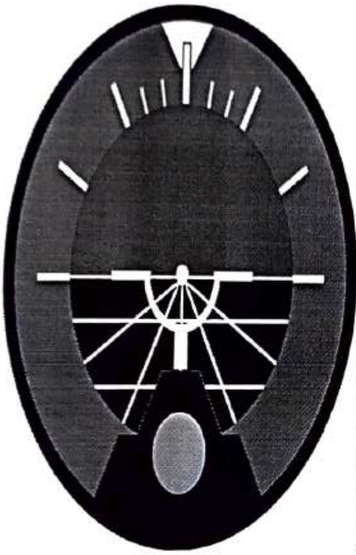
Fig 1.2 a) altimeter

fig 1.2 b) interior of altimeter

An altimeter or an altitude meter is an instrument used to measure the altitude of an object above a fixed level. The measurement of altitude is called altimetry, which is related to the term bathymetry, the measurement of depth under water. The most common unit for altimeter calibration worldwide is hectopascals (hPa), except for North America and Japan where inches of mercury(inHg) are used.

An altimeter is a device that measures altitude, the distance of a point above sea level. Altimeter are important navigation instruments for aircraft and spacecraft pilots who monitor their height above the earth's surface
Barometric Setting Indicator in both Millibars and Inches of Mercury.
Mode Switch:
CADC - Raw altitude information from the static system is corrected for static source position error by the CADC.
STBY - Raw altitude information is displayed.
Altitude Numerical Counter: Displays altitude in thousands and hundreds of feet.
Barometric Setting Control: Rotation of the control adjusts the barometric setting on the millibar (MB) and inches of mercury (HG) indicators.

1.3 ALTITUDE INDICATOR:



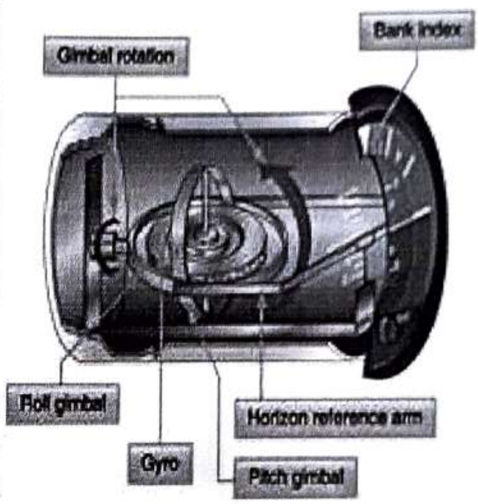


Fig 1.3 a)attitude indicator fig 1.3 b) interior of attitude indicator

The attitude indicator (AI), formerly known as the gyro horizon or artificial horizon, is a flight instrument that informs the pilot of the aircraft orientation relative to Earth's horizon, and gives an immediate indication of the smallest orientation change. It is a primary instrument for flight in instrument meteorological conditions.

The essential components of the AI include a symbolic miniature aircraft mounted so that it appears to be flying relative to the horizon. An adjustment knob, to account for the pilot's line of vision, moves the aircraft up and down to align it against the horizon bar. The top half of the instrument is blue to represent the sky, while the bottom half is brown to represent the ground. The bank index at the top shows the aircraft angle of bank. Reference lines in the middle indicate the degree of pitch, up or down, relative to the horizon. The heart of the AI is a gyroscope (gyro) that spins at high speed, from either an electric motor, or through the action of a stream of air pushing on rotor vanes placed along its periphery. The stream of air is provided by a vacuum system, driven by a vacuum pump, or a venturi. Air passing through the narrowest portion of a venturi has lower air pressure through Bernoulli's Principle.

Attitude indicators are also used on manned spacecraft and are called Flight Director Attitude Indicators (FDAI), where they indicate the craft's yaw angle (nose left or right), pitch (nose up or down), roll, and orbit relative to a fixed-space inertial reference frame from an Inertial Measurement Unit (IMU). The FDAI can be configured to use known positions relative to Earth or the stars, so that the engineers, scientists and astronauts can communicate the relative position, attitude, and orbit of the craft. Attitude and Heading Reference Systems (AHRS) are able to provide three-axis information based on ring laser gyroscopes, that can be shared with multiple devices in the aircraft, such as "glass cockpit" primary flight displays (PFDs). Rather than using a spinning gyroscope, modern AHRS use solid-state electronics, low-cost inertial sensors, rate gyros, and magnetometers. With most AHRS systems, if an aircraft's AIs have failed there will be a standby AI located in the center of the instrument panel, where other standby basic instruments such as the airspeed indicator and altimeter are also available. These mostly mechanical standby instruments may be available even if the electronic flight instruments fail, though the standby attitude indicator may be electrically driven and will, after a short time, fail if its electrical power fails.

The Attitude Direction Indicator (ADI), or Flight Director Indicator (FDI), is an AI integrated with a Flight Director System (FDS). The ADI incorporates a computer that receives information from the navigation system, such as the AHRS, and processes this information to provide the pilot with a 3-D flight trajectory cue to maintain a desired path. The cue takes the form of V steering bars.

1.4. VERTICAL SPEED INDICATOR:

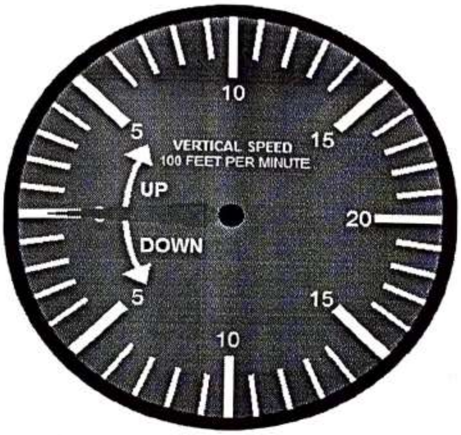


Fig 1.4 a) vertical speed indicator

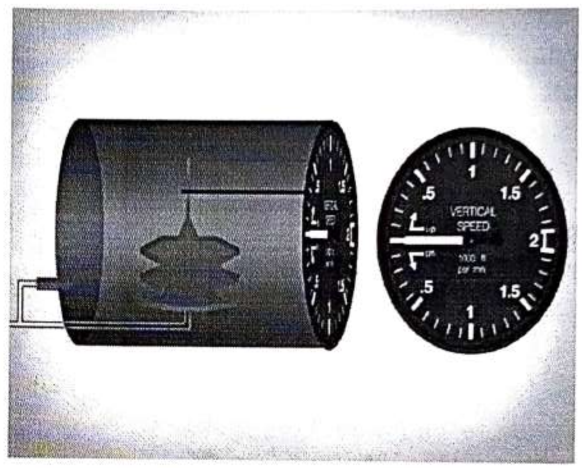


Fig 1.4 b) interior of vertical speed indicator

Displays aircraft rate of climb or descent. principle of operation is sensing changing air pressure .units in feet per minutes, meters per second or knots.

A variometer – also known as a rate of climb and descent indicator (RCDI), rate-of-climb indicator, vertical speed indicator (VSI), or vertical velocity indicator (VVI) – is one of the flight instruments in an aircraft used to inform the pilot of the rate of descent or climb.[1] It can be calibrated in meters per second, feet per minute (1 ft/min = 0.00508 m/s) or knots (1 KN ≈ 0.514 m/s), depending on country and type of aircraft. It is typically connected to the aircraft's external static pressure source.

In powered flight the pilot makes frequent use of the VSI to ascertain that level flight is being maintained, especially during turning maneuvers. In gliding, the instrument is used almost continuously during normal flight, often with an audible output, to inform the pilot of rising or sinking air. It is usual for gliders to be equipped with more than one type of variometer. The simpler type does not need an external source of power and can therefore be relied upon to function regardless of whether a battery or power source has been fitted. The electronic type with audio needs a power source to be operative during the flight. The instrument is of little interest during launching and landing, with the exception of aerotow, where the pilot will usually want to avoid releasing in sink.

A simple variometer can be constructed by adding a large reservoir (a thermos bottle) to augment the storage capacity of a common aircraft rate-of-climb instrument. In its simplest electronic form, the instrument consists of an air bottle connected to the external atmosphere through a sensitive air flow meter. As the aircraft changes altitude, the atmospheric pressure outside the aircraft changes and air flows into or out of the air bottle to equalise the pressure inside the bottle and outside the aircraft. The rate and direction of flowing air is measured by the cooling of one of two self-heating thermistors and the difference between the thermistor resistances will cause a voltage difference; this is amplified and displayed to the pilot. The faster the aircraft is ascending (or descending), the faster the air flows. Air flowing out of the bottle indicates that the altitude of the aircraft is increasing. Air flowing into the bottle indicates that the aircraft is descending.

1.5 TURN COORDINATOR:

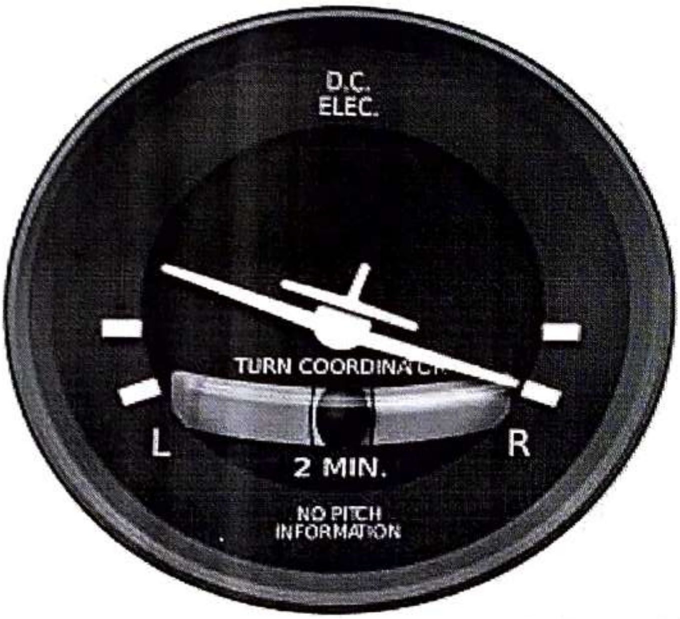


Fig 1.5 Turn coordinator

This unassuming instrument is really quite useful for refining your flying, and also understanding what the aircraft is doing in poor visibility or instrument flying conditions.

The turn coordinator, as the name suggests, shows the level of bank of your wings by tilting the small plane left or right. What appears like straight and level flight to your eyes may actually be a turn when you reference this instrument, even in good visibility.

The markings on the edge of the indicator show the rate of turn, with the first mark indicating straight-and-level, and the second mark Rate 1. You can use this to time a turn if you want to make a new heading (useful if you need to make a 180 degree U-turn) – simply bank the aircraft until the wings on the turn coordinator line up with the Rate 1 mark. Then time the number of seconds you have been turning. It takes 30 seconds to turn 90 degrees, 1 minute to turn 180 degrees, or 2 minutes to do a full 360 degree turn. Also shown on the turn coordinator is a balance ball in a small white box. This shows whether the aircraft is travelling efficiently and in balance, or whether it is slipping or skidding in a turn. You should aim to keep the ball in the centre, especially during turns, by pressing the rudder pedal in the direction the ball has moved.

As well as making your turns more efficient, it will also make the flight more comfortable for you and your passengers.

2.Navigation Instruments

Navigation instruments are those that contribute information used by the pilot to guide the aircraft along a definite course. This group includes compasses of various kinds, some of which incorporate the use of radio signals to define a specific course while flying the aircraft route from one airport to another. Other navigational instruments are designed specifically to direct the pilot's approach to landing at an airport. Traditional navigation instruments include a clock and a magnetic compass. Along with the airspeed indicator and wind information, these can be used to calculate navigational progress. Radios and instruments sending locating information via radio waves have replaced these manual efforts in modern aircraft. Global position systems (GPS) use satellites to pinpoint the location of the aircraft via geometric triangulation. This technology is built into some aircraft instrument packages for navigational purposes. Many of these aircraft navigational systems are discussed in this site. [Figure 6]

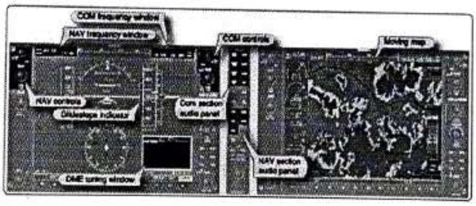


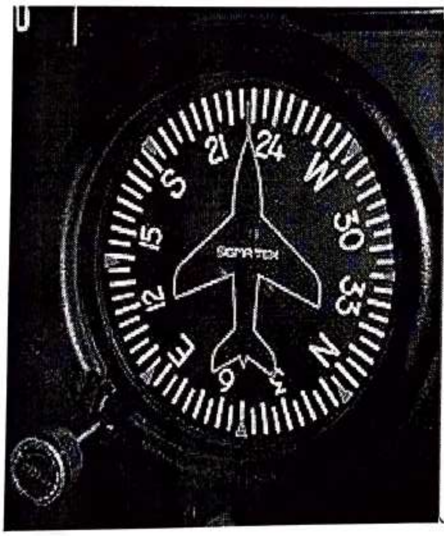
Figure 2. Navigation instruments

To understand how various instruments work and can be repaired and maintained, they can be classified according to the principle upon which they operate. Some use mechanical methods to measure pressure and temperature. Some utilize magnetism and electricity to sense and display a parameter. Others depend on the use of gyroscopes in their primary workings. Still others utilize solid state sensors and computers to process and display important information. In the following sections, the different operating principles for sensing parameters are explained. Then, an overview of many of the engine, flight, and navigation instruments is given.

Navigation instruments present in Boeing 747

- Heading indicator
- Very high frequency omni directional range
- Compass
- Visual glide slope indicator

2.1 HEADING INDICATOR :



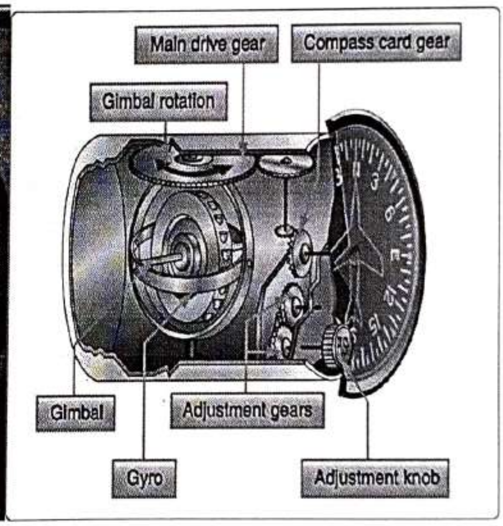


Fig 2.1 a) Heading indicator

Fig 2.1 b) interior of heading indicator

The heading indicator (also called an HI) is a flight instrument used in an aircraft to inform the pilot of the aircraft's heading. It is sometimes referred to by its older names, the directional gyro or DG, and also (UK usage) direction indicator or DI.

The heading indicator works using a gyroscope, tied by an erection mechanism to the aircraft yawing plane, i. e. the plane defined by the longitudinal and the transverse axis of the aircraft. As such, any configuration of the aircraft yawing plane that does not match the local Earth horizontal results in an indication error. The heading indicator is arranged such that the gyro axis is used to drive the display, which consists of a circular compass card calibrated in degrees. The gyroscope is spun either electrically, or using filtered air flow from a suction pump (sometimes a pressure pump in high altitude aircraft) driven from the aircraft's engine. Because the Earth rotates (ω, 15° per hour, apparent drift), and because of small accumulated errors caused by imperfect balancing of the gyro, the heading indicator will drift over time (real drift), and must be reset using a magnetic compass periodically. The apparent drift is predicted by ω sin Latitude and will thus be greatest over the poles. To counter for the effect of Earth rate drift a latitude nut can be set (on the ground only) which induces a (hopefully equal and opposite) real wander in the gyroscope. Otherwise it would be necessary to manually realign the direction indicator once each ten to fifteen minutes during routine in-flight checks. Failure to do this is a common source of navigation errors among new pilots. Another sort of apparent drift exists in the form of transport wander, caused by the aircraft movement and the convergence of the meridian lines towards the poles. It equals the course change along a great circle (orthodrome) flight path.

2.2 VERY HIGH FREQUENCY OMNI DIRECTIONAL RANGE (VOR):

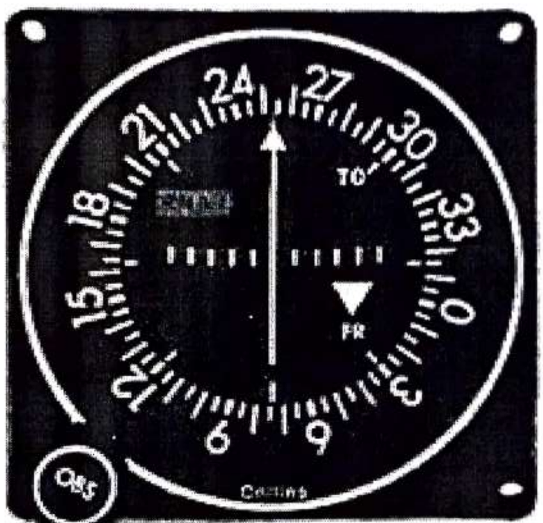


Fig 2.2 very high frequency omni direction range

Very high frequency omni-directional range (VOR) is a type of short-range radio navigation system for aircraft, enabling aircraft with a receiving unit to determine its position and stay on course by receiving radio signals transmitted by a network of fixed ground radio beacons. It uses frequencies in the very high frequency (VHF) band from 108.00 to 117.95 MHz.

2.3 COMPASS:

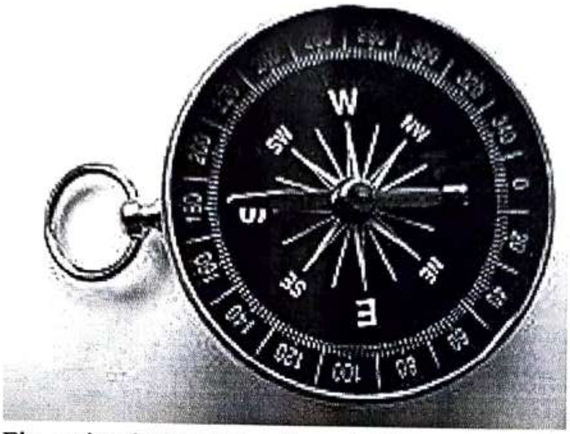


Fig a simple dry magnetic portable compass

A compass is an instrument used for navigation and orientation that shows direction relative to the geographic cardinal directions (or points). Usually, a diagram called a compass rose shows the directions north, south, east, and west on the compass face as abbreviated initials. When the compass is used, the rose can be aligned with the corresponding geographic directions; for example, the "N" mark on the rose points northward. Compasses often display markings for angles in degrees in addition to (or sometimes instead of) the rose. North corresponds to 0°, and the angles increase clockwise, so east is 90° degrees, south is 180°, and west is 270°. These numbers allow the compass to show magnetic North azimuths or true North azimuths or bearings, which are commonly stated in this notation. If magnetic declination between the magnetic North and true North at latitude angle and longitude angle is known, then direction of magnetic North also gives direction of true North.

The magnetic compass is the most familiar compass type. It functions as a pointer to "magnetic north", the local magnetic meridian, because the magnetized needle at its heart aligns itself with the horizontal component of the Earth's magnetic field. The magnetic field exerts a torque on the needle, pulling the North end or pole of the needle approximately toward the Earth's North magnetic pole, and pulling the other toward the Earth's South magnetic pole.[8] The needle is mounted on a low-friction pivot point, in better compasses a jewel bearing, so it can turn easily. When the compass is held level, the needle turns until, after a few seconds to allow oscillations to die out, it settles into its equilibrium orientation.

2.4 VISUAL GLIDE SLOPE INDICATOR :

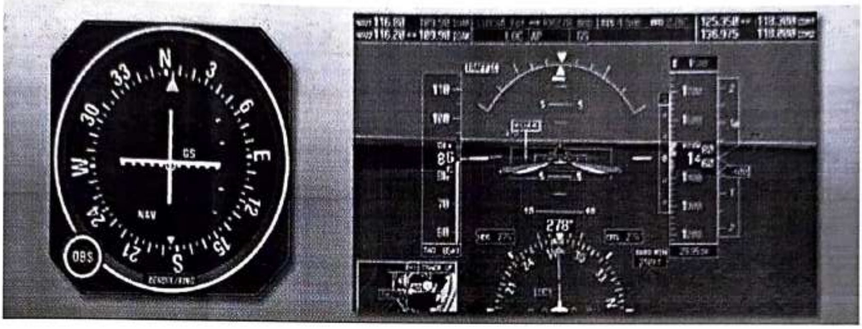


Fig 2.4 visual glide slope indicator

Visual Glide Slope Indicator or Visual Glideslope Indicator (VGSI) is a ground device that uses lights to assist a pilot in landing an airplane at an airport. The lights define a vertical approach path during the final approach to a runway and can help the pilot determine if the airplane is too high or too low for an optimum landing. Glide slope: The glide slope (or glide path) is an imaginary line that travels from the approach end of the runway upwards to the aircraft that is about to land. The VGSI, if installed, is listed immediately after each runway and is coded to indicate the type and specific implementation.

3.Engine instruments

Engine instruments are those designed to measure operating parameters of the aircraft's engine(s). These are usually quantity, pressure, and temperature indications. They also include measuring engine speed(s). The most common engine instruments are the fuel and oil quantity and pressure gauges, tachometers, and temperature gauges. Figure 4 contains various engine instruments found on reciprocating and turbine-powered aircraft.

Engine instrumentation is often displayed in the center of the cockpit where it is easily visible to the pilot and copilot. [Figure 5] On light aircraft requiring only one flight crewmember, this may not be the case. Multiengine aircraft often use a single gauge for a particular engine parameter, but it displays information for all engines through the use of multiple pointers on the same dial face.

Engine instruments present in Boeing 747

- Oil pressure indicator
- Oil temperature indicator
- Exhaust gas temperature
- Fuel flow indicator
- Fuel gauge
- Tachometer

3.1 OIL PRESSURE INDICATOR :

Fig 3.1 oil pressure indicator

Oil pressure is an important factor in the longevity of most internal combustion engines. With a forced lubrication system (invented by Frederick Lanchester), oil is picked up by a positive displacement oil pump and forced through oil galleries (passageways) into bearings, such as the main bearings, big end bearings and camshaft bearings or balance shaft bearings. Other components such as cam lobes and cylinder walls are lubricated by oil jets.

An instrument that indicates the pressure of the oil in the engine lubrication system. Oil pressure is higher when the engine is cold due to the increased viscosity of the oil, and also increases with engine speed until the relief valve in the oil pump opens to divert excess flow. Oil pressure is lowest under hot idling conditions, and the minimum pressure allowed by the manufacturer's tolerances is usually given at this point. Excessive oil pressure may indicate a blocked filter, blocked oil gallery or the wrong grade of oil. Low oil pressure indicates worn bearings or a broken oil pump.

3.2 OIL TEMPERATURE INDICATOR :

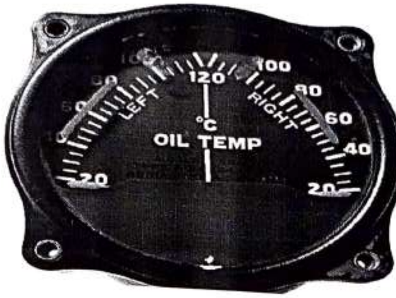


Fig 3.2 oil temperature indicator

This device is used to measure the top oil temperature. An oil temperature indicator or OTI is also used for protection of transformer.

Operating Principle of Oil Temperature Indicator:This device measures top oil temperature with the help of sensing bulb immersed in the pocket by using liquid expansion in the bulb through a capillary line to operating mechanism. A link and lever mechanism amplifies this movement to the disc carrying pointer and mercury switches. When volume of the liquid in operating mechanism changes, the bellow attached to end of capillary tube expands and contracts. This movement of bellow is transmitted to the pointer in temperature indicator of transformer through a lever linkage mechanism.

3.3 EXHAUST GAS TEMPERATURE GAUGE

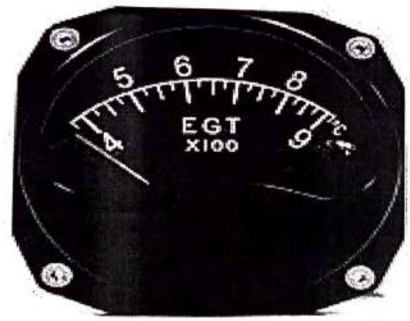


Fig 3.3 exhaust gas temperature gauge

An exhaust gas temperature gauge (EGT gauge) is a meter used to monitor the exhaust gas temperature of an internal combustion engine in conjunction with a thermocouple-type pyrometer. EGT gauges are found in certain cars and aeroplane . By monitoring EGT, the driver or pilot can get an idea of the vehicle's air-fuel ratio (AFR).

At a stoichiometric air-fuel ratio, the exhaust gas temperature is different from that in a lean or rich air-fuel ratio. At rich air-fuel ratio, the exhaust gas temperature either increases or decreases depending on the fuel. High temperatures (typically above 1,600 °F or 900 °C) can be an indicator of dangerous conditions that can lead to catastrophic engine failure.

3.4 FUEL FLOW INDICATOR

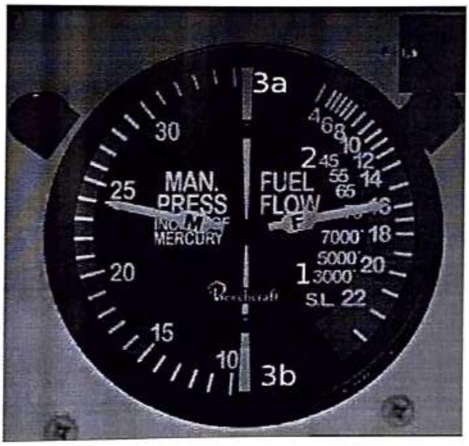


Fig 3.4 fuel flow indicator

When fuel flowed through a pipe ,it could be accurately measured via the aircraft electronic data managements system (EDMS).The out put could either be displayed as a bar graph or as a number (depending on the pilot preference).modern EDMS not only indicated fuel levels and fuel flow levels with ahigh degree of accuracy , they could provide other valuable information too such as, distance-to-empty and GPS plugged in ,they could even indicate whether the plane had enough fuel to make it to a specific destination .

3.5 FUEL GUGUE

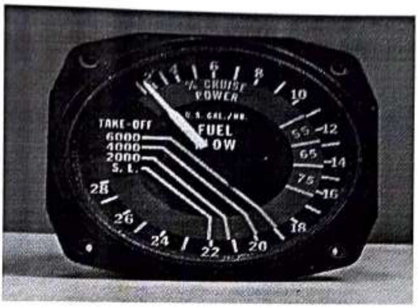


Fig 3.5 fuel gauge

a fuel gauge is an instrument used to indicate the amount of fuel in a fuel tank. Magnetoresistance type fuel level sensors, now becoming common in small aircraft applications, offer a potential alternative for automotive use. These fuel level sensors work similar to the potentiometer example, however a sealed detector at the float pivot determines the angular position of a magnet pair at the pivot end of the float arm. These are highly accurate, and the electronics are completely outside the fuel. The non-contact nature of these sensors address the fire and explosion hazard, and also the issues related to any fuel combinations or additives to gasoline or to any alcohol fuel mixtures. Magneto resistive sensors are suitable for all fuel or fluid combinations, including LPG and LNG. The fuel level output for these senders can be ratiometric voltage or preferable CAN bus digital. These sensors also fail-safe in that they either provide a level output or nothing.

3.6 TACHOMETER

Fig 3.6 tachometer

The tachometer, or tach, is an instrument that indicates the speed of the crankshaft of a reciprocating engine. It can be a direct- or remote-indicating instrument, the dial of which is calibrated to indicate revolutions per minutes (rpm). On reciprocating engines, the tach is used to monitor engine power and to ensure the engine is operated within certified limits.

Gas turbine engines also have tachometers. They are used to monitor the speed(s) of the compressor section(s) of the engine. Turbine engine tachometers are calibrated in percentage of rpm with 100 percent corresponding to optimum turbine speed. This allows similar operating procedures despite the varied actual engine rpm of different engines. In addition to the engine tachometer, helicopters use a tachometer to indicator main rotor shaft rpm. It should also be noted that many reciprocating-engine tachometers also have built-in numeric drums that are geared to the rotational mechanism inside. These are hour meters that keep track of the time the engine is operated. There are two types of tachometer system in wide use today: mechanical and electrical.

4.System instruments

System instruments present in Boeing 747

- Hydraulic pressure gauge
- Vacuum gauge

4.1 HYDRAULIC PRESSURE GAUGE :

Fig 4.1 Hydraulic pressure indicator

Numerous other pressure monitoring gauges are used on complex aircraft to indicate the condition of various support systems not found on simple light aircraft. Hydraulic systems are commonly used to raise and lower landing gear, operate flight controls, apply brakes, and more. Sufficient pressure in the hydraulic system developed by the hydraulic pump(s) is required for normal operation of hydraulic devices. Hydraulic pressure gauges are often located in the cockpit and at or near the hydraulic system servicing point on the airframe. Remotely located indicators used by maintenance personnel are almost always direct reading Bourdon tube type gauges. Cockpit gauges usually have system pressure transmitted from sensors or computers electrically for indication.

A hydraulic pressure transmitter senses and converts pressure into an electrical output for indication by the cockpit gauge or for use by a computer that analyzes and displays the pressure in the cockpit when requested or required.

4.2 VACUUM GAUGE

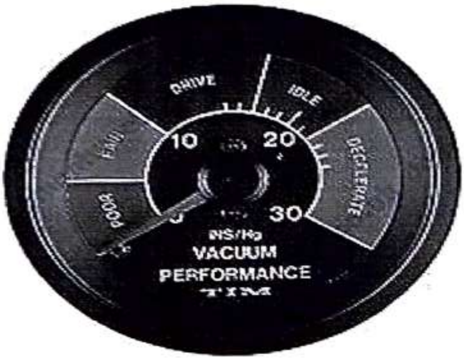


Fig 4.2 vacuum gauge

Gyro pressure gauge, vacuum gauge, or suction gauge are all terms for the same gauge used to monitor the vacuum developed in the system that actuates the air driven gyroscopic flight instruments. Air is pulled through the instruments, causing the gyroscopes to spin. The speed at which the gyros spin needs to be within a certain range for correct operation. This speed is directly related to the suction pressure that is developed in the system. The suction gauge is extremely important in aircraft relying solely on vacuum operated gyroscopic flight instruments. Vacuum is a differential pressure indication, meaning the pressure to be measured is compared to atmospheric pressure through the use of a sealed diaphragm or capsule. The gauge is calibrated in inches of mercury. It shows how much less pressure exists in the system than in the atmosphere. Vacuum suction gauge shows a suction calibrated in inches of mercury.

REFERENCE RESOURSES

1. **https://www.slideshare.net/mobile/Mahnil/aircraft-instrumentsystems**
2. **http://www.b747classic.co.uk/gallery-internal---cockpit**
3. **https://www.aircraftsystemstech.com/2017/04/aircraft-instrument-systems.html?m=1#:~:text=Aircraft%20instruments%20are%20the%20means,and%20lead%20to%20safer%20flight.&text=Electricity%20is%20often%20used%20by,Sometimes%20pneumatic%20lines%20are%20used**