||Jai Sri Gurudev||

S.J.C. Institute of Technology, Chickballapur

Department of Aeronautical Engineering

Subject : Measurement And Metrology

Subject Code: 18AE36

1. Identify the basic measuring instruments used in aircraft and explain briefly it's working principle.(10marks)

***This has to submitted in the form of REPORT**

At the End of the report put the URL's which you have referred to collect the information

		Marks
A	All the relevant information is obtained and information source is valid	5
B	Explanation with diagrams(Pictures)	3
C	Presentation	2

V 22/08/19

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||JAI SRI GURUDEV||

S.J.C. INSTITUTE OF TECHNOLOGY
DEPARTMENT OF AERONAUTICAL ENGINEERING

Case Study Report

Subject code: 18AE36
Subject : Measurement and Metrology

Submitted by,

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VINAY P
Assistant Professor
Department of Aeronautical Engineering
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Abstract

Content – 12 – Calibri font

Main heading – 16 – Calibri font – bold

Sub heading – 14- Calibri font – bold

Citation and reference in Harvard style

Sub heading – 14- Calibri font – bold

||JAI SRI GURUDEV||

S.J.C. INSTITUTE OF TECHNOLOGY
DEPARTMENT OF AERONAUTICAL ENGINEERING

CASE STUDY REPORT

Subject code: 18AE36
Subject : MEASUREMENT AND METROLOGY

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INTRODUCTION TO FLIGHT INSTRUMENTS

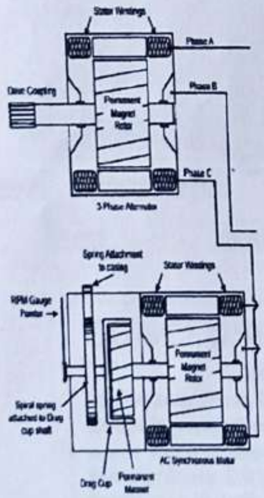
Flight instruments are the instruments in the cockpit of an aircraft that provide the pilot with information about the flight situation of that aircraft, such as altitude, airspeed, vertical speed, heading and much more other crucial information. They improve safety by allowing the pilot to fly the aircraft in level flight, and make turns, without a reference outside the aircraft such as the horizon. Visual flight rules require an airspeed indicator, an altimeter, and a compass or other suitable magnetic direction indicator. Instrument flight rules (IFR) additionally require a gyroscopic pitch-bank (artificial horizon), direction and rate of turn indicator, plus a slip-skid indicator, adjustable altimeter, and a clock. Flight into Instrument meteorological conditions (IMC) require radio navigation instruments for precise takeoffs and landings.

1.TACHOMETER

A tachometer is a device for counting. It is used to show the number of revolutions per minute (RPM) of the aircraft engine. An airplane needs one tachometer for each of its engines.

INTRODUCTION:

An airplane's engines often run faster than its propellers. For example, on one airplane, the most efficient engine speed is 3,000 RPM, while the most efficient propeller speed is about 1,500 RPM. A set of reduction gears permits the engine to run at 3,000 RPM while the propeller turns at 15,000 RPM. When this happens, the ratio of engine RPM to propeller RPM is two to one (2:1). Other ratios can range from 4:3 to 3:1.



WORKING:

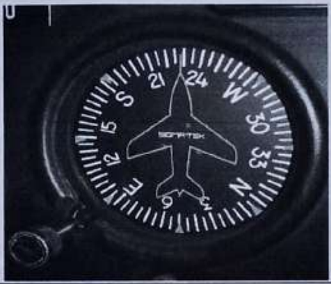
It works on the principle of a tachometer generator, which means when a motor is operated as a generator, it produces the voltage according to the velocity of the shaft. It is also known as revolution-counter, and its operating principle can be electromagnetic, electronic or optical Tachometers used in the aircraft are of three types. (a) electrical tachometer (b) mechanical tachometer (c) electrical tachometer

Conclusion:

Tachometer is an instrument used for measuring the rotation or revolution speed of objects, such as an engine or a shaft. The **tachometer** measures revolutions per minute (RPMs) of engines and is widely used in automobiles, airplanes, marine engineering field and many others

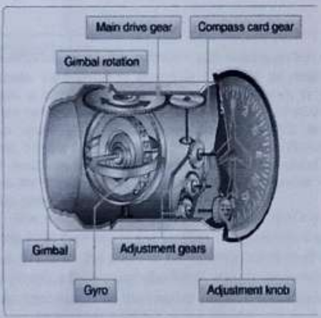
2.HEADING INDICATOR.

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



INTRODUCTION:

The primary means of establishing the heading in most small aircraft is the magnetic compass, which, however, suffers from several types of errors, including that created by the "dip" or downward slope of the Earth's magnetic field. Dip error causes the magnetic compass to read incorrectly whenever the aircraft is in a bank, or during acceleration or deceleration, making it difficult to use in any flight condition other than unaccelerated, perfectly straight and level. To remedy this, the pilot will typically manoeuvre the airplane with reference to the heading indicator, as the gyroscopic heading indicator is unaffected by dip and acceleration errors. The pilot will periodically reset the heading indicator to the heading shown on the magnetic compass.



WORKING:

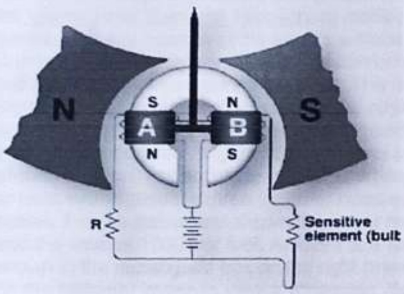
The heading indicator works using a gyroscope, tiec by an erection mechanism to the aircraft yawing plane, i. e. th plane defined by the longitudinal and the transverse axis of th aircraft. As such, any configuration of the aircraft yawing plan that does not match the local Earth horizontal results in 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 suctio pump (sometimes a pressure pump in high altitude aircraft) driven from the aircraft's engine. Because the Earth rotates (u 15° per hour, apparent drift), and because of small accumulated errors caused by imperfect balancing of the gyrc the heading indicator will drift over time (real drift), and must be reset using a magnetic compass periodically.

CONCLUSION:

Although it is possible to predict the drift, there will be minor variations from this basic model, accounted for by gimbal error (operating the aircraft away from the local horizontal), among others. A common source of error here is the improper setting of the latitude nut (to the opposite hemisphere for example). The table however allows one to gauge whether an indicator is behaving as expected, and as such, is compared with the realignment corrections made with reference to the magnetic compass. Transport wander is an undesirable consequence of apparent drift

3. RATIOMETER ELECTRICAL RESISTANCE THERMOMETER

Another way of indicating temperature when employing an electric resistance thermometer is by using a ratiometer. The Wheatstone-bridge indicator is subject to errors from line voltage fluctuation. The ratiometer is more stable and can deliver higher accuracy. As its name suggests, the ratiometer electrical resistance thermometer measures a ratio of current flows.

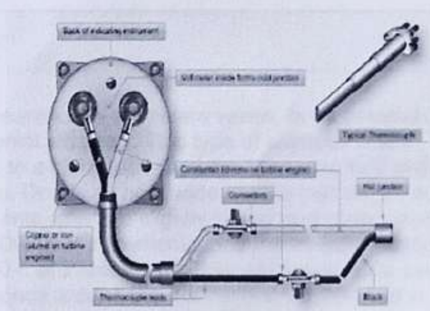


INTRODUCTION:

The use of electricity in measuring temperature is very common in aviation. The following measuring and indication systems can be found on many types of aircraft. Certain temperature ranges are more suitably measured by one or another type of system. **Another way of indicating temperature when employing an electric resistance thermometer is by using a ratiometer. The Wheatstone-bridge indicator is subject to errors from line voltage fluctuation. The ratiometer is more stable and can deliver higher accuracy.**

WORKING: The resistance bulb sensing portion of the ratiometer electric resistance thermometer is essentially the same as described above. The circuit contains a variable resistance and a fixed resistance to provide the indication. It contains two branches for current flow. Each has a coil mounted on either side of the pointer assembly that is mounted within the magnetic field of a large permanent magnet. Varying current flow through the coils causes different magnetic fields to form, which react with the larger magnetic field of the permanent magnet. This interaction rotates the pointer against the dial face that is calibrated in degrees Fahrenheit or Celsius, giving a temperature indication.

The magnetic pole ends of the permanent magnet are closer at the top than they are at the bottom. This causes the magnetic field lines of flux between the poles to be more concentrated at the top. As the two coils produce their magnetic fields, the stronger field interacts and pivots downward into the weaker, less concentrated part of the permanent magnet field, while the weaker coil magnetic field shifts upward toward the more concentrated flux field of the large magnet. This provides a balancing effect that changes



ONCLUSION:

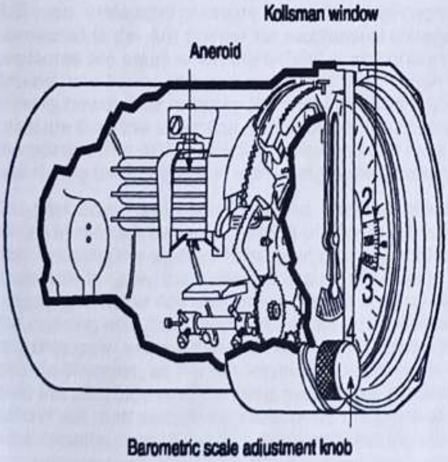
Ratiometer temperature measuring systems are used to measure engine oil, outside air, rburetor air, and other temperatures in many types of aircraft. They are especially in demand to easure temperature conditions where accuracy is important, or large variations of supply voltages are countered.

4.ALITIMETER.

The small hand is in thousands of feet, the larger hand is in hundreds of feet and the long thin hand is in tens of thousands of feet. The dial on the right side displays the set ground atmospheric pressure, which can be adjusted with the knob on the bottom left. Thus, this altimeter is displaying an altitude of 10,180 feet with a ground pressure of 29.92 inHg.

Introduction:

The altitude of an aircraft can be obtained by using a measurement of the static pressure of the surrounding atmosphere. A single pressure line from the static port is all that is required as input for the instrument. Although the rate of change of pressure with altitude is well known, based on an International Standard Atmosphere model, the ambient sea level pressure at any location of the earth's surface can vary from day to day due to meteorological conditions. The instrument will require zeroing before and sometimes during the flight. This is done by setting the instrument to the ambient pressure of the airport at the start of the flight and resetting as required. It is therefore important to remember that this instrument measures height above sea level and not height above current ground location. For accuracy of measurement the instrument usually has at least two sometimes three indicator needles operating on different scales. For the instrument shown the larger needle indicates 100's of feet and the smaller 1000's of feet. Ambient sea level pressure preset value is shown in the rectangular box on the right (measured in hectopascal). Click on the Altimeter image to view a schematic diagram showing its internal operation.



Working:

The appearance of altimeters varies, but a common one is known as a three-point altimeter. This type of altimeter has a background similar to a clock with numbers from zero to 9 and three needles on the face. One is a short, wide needle that shows height in 10,000-foot increments, one is a slightly longer and wider needle that depicts height in 1,000-foot increments, and the longest needle shows height in 100-foot increments. Older altimeters have only one needle that circles once around the dial for every 1,000 feet in altitude.

Conclusion:

The position of static ports lends itself to disrupted airflow during certain maneuvers, phases of flight, and wind conditions. Disturbed airflow over the static port can cause erroneous readings on the altimeter.

5.*AIRSPEED INDICATOR:*

The airspeed indicator shows the aircraft's speed (usually in knots) relative to the surrounding air. It works by measuring the ram-air pressure in the aircraft's Pitot tube relative to the ambient static pressure.

Introduction:

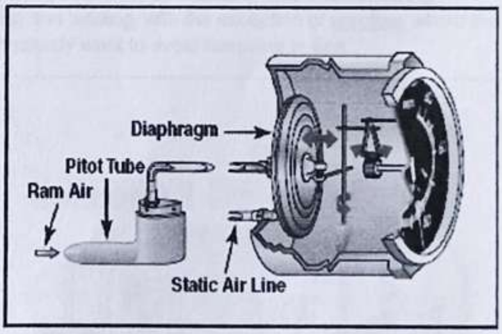
The indicated airspeed (IAS) must be corrected for nonstandard pressure and temperature in order to obtain the true airspeed (TAS). The instrument is color coded to indicate important airspeeds such as the stall speed, never-exceed airspeed, or safe flap operation speeds

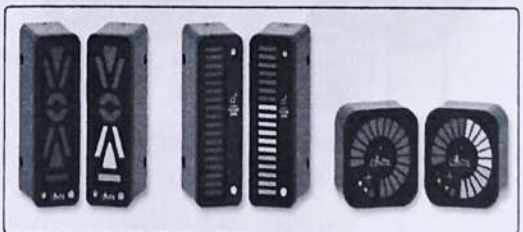
An airplane can stall at any speed, so monitoring the ASI alone will not prevent a stall. The critical angle of attack (AOA) determines when an aircraft will stall. For a particular configuration, it is a constant independent of weight, bank angle, temperature, density altitude, and the center of gravity of an aircraft

Working:

The ASI is the only flight instrument that uses both the static system and the pitot system. Static pressure enters the ASI case, while total pressure flexes the diaphragm, which is connected to the ASI pointer via mechanical linkage. The pressures are equal when the aircraft is stationary on the ground, and hence shows a reading of zero. When the aircraft is moving forward, air entering the pitot tube is at a greater pressure than the static line, which flexes the diaphragm, moving the pointer. The ASI is checked before takeoff for a zero reading, and during takeoff that it is increasing appropriately.[1]:8-10[3][4]

The pitot tube may become blocked, because of insects, dirt or failure to remove the pitot cover. A blockage will prevent ram air from entering the system. If the pitot opening is blocked, but the drain hole is open, the system pressure will drop to ambient pressure, and the ASI pointer will drop to a zero reading. If both the opening and drain holes are blocked, the ASI will not indicate any change in airspeed. However, the ASI pointer will show altitude changes, as the associated static pressure changes. If both the pitot tube and the static system are blocked, the ASI pointer will read zero. If the static ports are blocked but the pitot tube remains open, the ASI will operate, but inaccurately





Conclusion:

The ASI has standard color-coded markings for the safe operation within the limitations of the aircraft. At a glance, the pilot can determine a recommended speed (V speeds) or if he needs to make any speed adjustments. Single and multi-engine aircraft have common markings. For instance, the green arc indicates the normal operating range of the aircraft, from V_{S1} to V_{NO}. The white arc indicates the flap operating range, V_{SO} to V_{FE}, used for approaches and landings.

6.VERTICAL SPEED INDICATOR(Variometer)

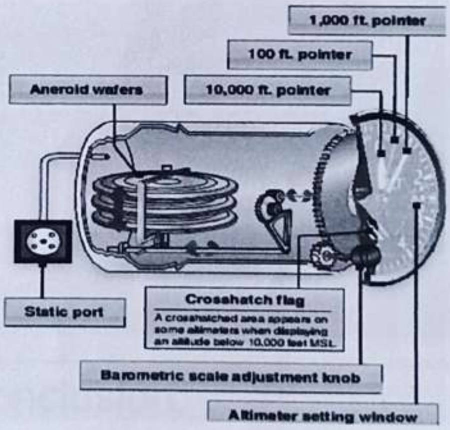
The VSI (also sometimes called a variometer, or rate of climb indicator) senses changing air pressure, and displays that information to the pilot as a rate of climb or descent in feet per minute, meters per second or knots

Introduction:

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.

Working:

The vertical speed indicator is made up of a diaphragm inside of an airtight instrument casing. The diaphragm is connected by linkage and gears to the needle on the face of the instrument. Static pressure lines are connected to both the inside of the diaphragm and the instrument casing. The casing surrounding the diaphragm has a metered leak, which helps reflect the rate of climb of descent. .Pressure changes are measured instantaneously within the diaphragm as it expands and contracts from the pressure. The metered leak in the surrounding instrument casing also measures the pressure change, but the leak provides an intentional lag, allowing the instrument to measure the pressure change more gradually than inside the diaphragm. This lag comes from the consistent pressure leak and the corresponding rate of climb or descent as it's measured on the instrument needle in feet per minute. After a few seconds of level flight, the two pressures equalize and the vertical speed indicator shows '0' feet per minute (fpm)..The result of a climb or descent is shown on the vertical speed indicator first as trend information (meaning, a sudden climb or descent) and then shown as rate information (for example, 400 fpm).

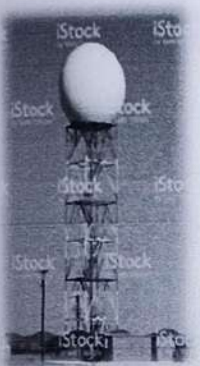


Conclusion:

The vertical speed indicator is inaccurate during turbulence and when maneuvering abruptly. The lag involved with the calibrated leak is about six to eight seconds, rendering the vertical speed indicator almost useless when turbulence is encountered.

7. NEXRAD or (Next-Generation Radar)

NEXRAD detects precipitation and atmospheric movement or wind. It returns data which when processed can be displayed in a mosaic map which shows patterns of precipitation and its movement.



Introduction:

The radar system operates in two basic modes, selectable by the operator – a slow-scanning *clear-air mode* for analyzing air movements when there is little or no activity in the area, and a *precipitation mode*, with a faster scan for tracking active weather. NEXRAD has an increased emphasis on automation, including the use of algorithms anc automated volume scans. It is a network of 159 high-resolution S-band Doppler weather1 radars operated by the National Weather Service (NWS), an agency of the National Oceanic and Atmospheric Administration (NOAA) within the Department of Commerce, the Federal Aviation Administration (FAA) within the Department of Transportation, and the Air Force within the Department of Defense. Its technical name is WSR-88D (*Weather Surveillance Radar, 1988, Doppler*).

Working:

It works the same way any radar works. An antenna broadcasts a pulse of energy and listens for its reflection and interprets the power of the reflection to calculate the reflectivity factor Z, expressed in decibels dBZ (helpful because return power varies across many orders of magnitude). Weather radar can see water, hail, bugs, birds, bats and bigger things, and the ground but not clouds. Higher return power can mean more objects or bigger objects. A basic single-polarization radar cannot tell the difference between a tons of small rain drops and a fewer big raindrops

Airplane radars are generally in the X-band*. X-band can see smaller particles than S-band but attenuates easier. This means if a big storm is in front of you, the energy doesn't penetrate far into the storm and may not show you the whole storm. These are great short range radars and work well in airborne applications as long as you are aware of the issue with attenuation.

Airplane radar displays typically only display information from the on-board radar and do not downlink any additional information from ground stations. Onboard radar are usually adjustable in the vertical by the pilots, so they can point the radar up or down as needed

Conclusion:

Just like using your eyes, except the radar can see further through haze and other clouds. Typically this is useful for finding embedded thunderstorms , but it can also be usefu0l to find areas of potential turbulence

8.Enhanced Ground Proximity Warning System(EGPWS)

EGPWS software enhancements include SmartRunway® and SmartLanding® systems, developed to help flight crews avoid potential runway incursions and excursions.

Introduction:

The Enhanced Ground Proximity Warning System (EGPWS) reduces the risk of controlled flight into terrain by providing flight crews with timely, accurate information about terrain and obstacles in the area. The system uses various aircraft inputs and an internal database to predict anc warn flight crews of potential conflicts with obstacles or terrain.

Working:

The unreliability and limitation of the first generation GPWS was cited where GPWS was plagued by false and nuisance warnings, causing pilots to distrust the equipment when actual hazardous conditions existed. Subsequently, generations of GPWS have become more reliable. A number of studies have examined pilot response times to GPWS alerts and indicate that alerts and warnings in the final 5 seconds of a flight would not give sufficient time for the flight crew and aircraft to respond effectively. This issue has been addressed with EGPWS, which provides the pilot with a greater time to respond to an alert and take avoiding action.

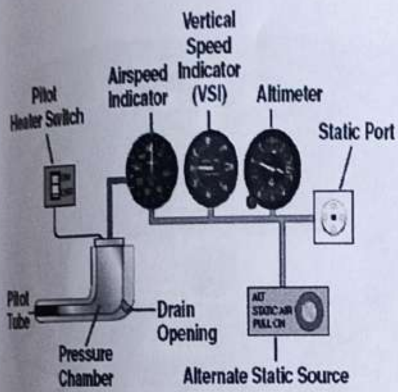
Appropriate response procedures for flight crew are determined by the aircraft type performance capability. They must be clearly defined by operators and defined in an applicable airplane flight manual (AFM). In the case of a warning, flight crew should follow the warnings without hesitation as soon as triggered. During night or in instrument meteorological conditions (IMC), apply the procedures immediately in response to caution and warning level alerts. Do not delay reaction for diagnosis. During daylight or in visual meteorological conditions (VMC), take positive corrective action until the alert stops or a safe trajectory is ensured.

Conclusion:

The introduction of terrain awareness technologies, sucl as the EGPWS / TAWS, have directly or indirectly, contributed to a reduction in the number of CFIT accidents. With such technology, the flight crew gets improved situational awareness and is able to counter a potential CFIT accidents sooner. For the system to worl as designed, aircraft operators should keep the software and terrain/obstacle/runway database up to date. The proper and timely responses to EGPWS warnings can result in significantly reducing the risk of a CFIT accident. To achieve this objective, the pilot should demonstrate taking the correct action and perform appropriate recovery maneuvers needed in response to caution and warning.

9.PITOT -STATIC SYSTEM

The pitot-static system of instruments uses the principle of air pressure gradient. It works by measuring pressures or pressure differences and using these values to assess the speed and altitude.[1] These pressures can be measured either from the static port (static pressure) or the pitot tube (pitot pressure). The static pressure is used in all measurements, while the pitot pressure is used only to determine airspeed.



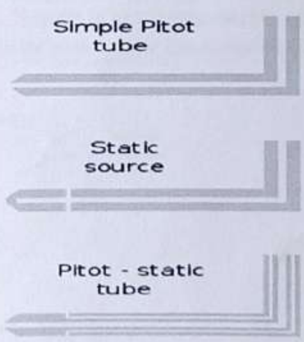
Introduction:

A **pitot-static system** is a system of pressure-sensitive instruments that is most often used in aviation to determine an aircraft's airspeed, Mach number, altitude, and altitude trend. A pitot-static system generally consists of a pitot tube, a static port, and the pitot-static instruments.

Other instruments that might be connected are air data computers, flight data recorders, altitude encoders, cabin pressurization controllers, and various airspeed switches. Errors in pitot-static system readings can be extremely dangerous as the information obtained from the pitot static system, such as altitude, is potentially safety-critical

Working:

The pitot-static system obtains pressures for interpretation by the pitot-static instruments. While the explanations below explain traditional, mechanical instruments, many modern aircraft use an air data computer (ADC) to calculate airspeed, rate of climb, altitude and Mach number. In some aircraft, two ADCs receive total and static pressure from independent pitot tubes and static ports, and the aircraft's flight data computer compares the information from both computers and checks one against the other. There are also "standby instruments", which are back-up pneumatic instruments employed in the case of problems with the primary instruments.

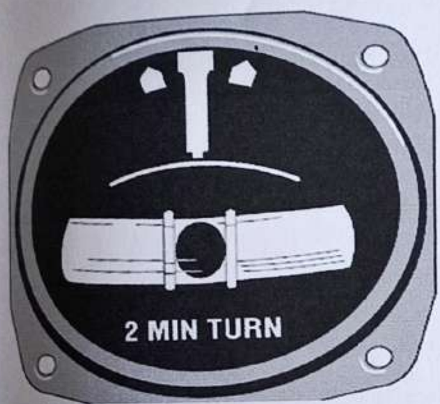


Conclusion:

A pitot tube, also known as pitot probe, is a flow measurement device used to measure fluid . Aircraft use pitot tubes to measure airspeed. A *pitot-static system* is a *system* of pressure-sensitive *instruments* that is most often used in *aviation*

10.TURN SLIP INDICATOR

The turn and slip indicator can be referred to as the turn and bank indicator, although the instrument does not respond directly to bank angle. Neither does the turn coordinator, but it does respond to roll rate, which enables it to respond more quickly to the start of a turn



Introduction:

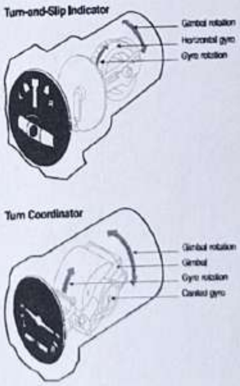
In aviation, the **turn and slip indicator** (**T/S**, a.k.a. **turn and bank indicator**) and the **turn coordinator** (TC) variant are essentially two aircraft flight instruments in one device. One indicates the rate of turn, or the rate of change in the aircraft's heading; the other part indicates whether the aircraft is in coordinated flight, showing the slip or skid of the turn. The turn and slip indicator can be referred to as the turn and bank indicator, although the instrument does not respond directly to bank angle. Neither does the turn coordinator, but it does respond to roll rate, which enables it to respond more quickly to the start of a turn. The slip indicator is actually an inclinometer that at rest displays the angle of the aircraft's transverse axis with respect to horizontal, and in motion displays this angle as modified by the acceleration of the

Working:

Slipping and skidding within a turn is sometimes referred to as a sloppy turn, due to the perceptive discomfort it can cause to the pilot and passengers. When the aircraft is in a balanced turn (ball is centered), passengers experience gravity directly in line with their seat (force perpendicular to seat). With a well balanced turn, passengers may not even realize the aircraft is turning unless they are viewing objects outside the aircraft.

The turn indicator is a gyroscopic instrument that works on the principle of precession. The gyro is mounted in a gimbal. The gyro's rotational axis is in-line with the transverse (pitch) axis of the aircraft, while the gimbal has limited freedom around the longitudinal (roll) axis of the aircraft.

The torque force against the spring reaches an equilibrium and the angle that the gimbal and gyro become positioned is directly connected to the display needle, thereby indicating the rate of turn. In the turn coordinator, the gyro is canted 30 degrees from the horizontal so it responds to roll as well as yaw..



Conclusion:

A simple alternative to the balance indicator used on gliders is a yaw string, which allows the pilot to simply view the string's movements as rudimentary indication of aircraft balance. The turn coordinator may be used as a performance instrument when the attitude indicator has failed. This is called "partial panel" operations. It can be unnecessarily difficult or even impossible if the pilot does not understand that the instrument is showing roll rates as well as turn rates

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CASE STUDY RUBRICS

Subject: MEASUREMENT & METROLOGY

Subject Code: 18AE36

Sl.No	USN	Name of the Student	A	B	C	TOTAL
1.	1SJ18AE001	ABDUL RAHMAN J	5	3	1	9
2.	1SJ18AE003	AKASH M	5	3	2	10
3.	1SJ18AE004	AKASH SIDDANGOUDA PATIL	5	3	1	9
4.	1SJ18AE006	ANNASAGARAM GOWTHAMI	5	3	2	10
5.	1SJ18AE007	ANUSHREE N	5	3	2	10
6.	1SJ18AE008	ARAVIND R NAIDU	5	3	1	9
7.	1SJ18AE009	ARJI BHARATH	5	3	1	9
8.	1SJ18AE011	BHAVANA A J	5	3	2	10
9.	1SJ18AE012	BINDUSHREE K	5	3	2	10
10.	1SJ18AE014	CHAVALI BHIMA SANKARAM	5	3	2	10
11.	1SJ18AE015	CHIDANANDA	5	2	1	8
12.	1SJ18AE016	DHANUSH KUMAR B K	5	3	1	9
13.	1SJ18AE017	DURGAPRASAD N S	5	3	2	10
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15.	1SJ18AE019	GIRISH N	5	3	0	8
16.	1SJ18AE021	HARSHA D S	5	2	0	7
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31.	1SJ18AE037	MYTHRI C	5	3	1	9
32.	1SJ18AE038	NAGAMANI J V	5	3	2	10
33.	1SJ18AE039	NAGESH D R	5	3	2	10
34.	1SJ18AE040	PRAJAKTA S LOKHANDE	5	3	0	8
35.	1SJ18AE041	PRAMODGOWDA T S	5	3	2	10
36.	1SJ18AE042	PRASAD BELGUNDKAR	5	3	2	10
37.	1SJ18AE043	RACHANA J	5	3	1	9
38.	1SJ18AE044	RAHUL P	5	3	2	10
39.	1SJ18AE045	RAKESH S	5	3	2	10
40.	1SJ18AE046	RAMYAKRISHNA K	5	3	0	8
41.	1SJ18AE048	RAVINDRA SREE CHENDAN SAI	5	3	2	10
42.	1SJ18AE049	SAI KEERTHAN B L	5	3	2	10
43.	1SJ18AE050	SAMPRUTHA A R	5	3	2	10
44.	1SJ18AE051	SOWBHAGYA M R	5	3	2	10
45.	1SJ18AE052	SRIDHAR K R	5	3	1	9
46.	1SJ18AE053	UJWAL N	5	2	1	8
47.	1SJ18AE054	UMESH RANA	5	3	2	10
48.	1SJ18AE055	USHA G	5	3	2	10
49.	1SJ18AE056	VAISHAK M	5	3	1	9
50.	1SJ18AE057	VARUN M	5	3	2	10
51.	1SJ18AE058	VEERESH	5	3	2	10
52.	1SJ18AE059	VIGNESH GOWDA P	5	3	2	10
53.	1SJ18AE060	YASHWANTH R	5	3	2	10
54.	1SJ18AE061	YASHWANTH S	5	3	2	10
55.	1SJ18AE062	YASHWANTH T H	5	3	2	10
56.	1SJ18AE064	NARINDER KUMAR	5	3	2	10
57.	1SJ18AE065	MOHAN REEDY	5	3	0	8

A	All the relevant information is obtained and information source is valid	5
B	Explanation with diagrams(Pictures)	3
C	Presentation	2

(V Rajan)
21/11/19.

21/11/19