ENGINE INSTRUMENTS SYSTEM (EIS)
AT BOEING 737-300/400/500

INTERNSHIP REPORT
PT GMF AERO ASIA

13th July – 13th August 2009

Submitted by :

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Faculty Of Industrial Technology

Institut Teknologi Bandung

2009

APPROVAL SHEET

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Has been evaluated and argeed by :

PT. GMF Aero Asia	Cengkareng, August. 2009
Technical Training Manager	Mentor
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523094	517076

ABSTRACT

In this internship report, I will describe my study about engine monitoring, known as Engine Instrument System. The sensor on the engine is monitoring condition in the engine, like the temperature, speed, vibration, fuel flow, etc. The engine instrument system (EIS) is microprocessor-controlled instrument panels which display parameters of engines and hydraulic systems to monitor airplane engines and hydraulic systems operation. It also displays total air temperature and engine thrust mode annunciation messages. The EIS is composed of two adjacent independent, solid state integrated displays: a Primary Display and a Secondary Display.

Keywords : engine instrument system (EIS), tachometers, N1, N2, fuel flow, exhaust gas temperature (EGT), airborne vibration, oil monitoring, hydraulic monitoring,

PREFACES

Alhamdulillah, all prayer just for Allah SWT that has given blessing to study and internship in PT GMF AERO ASIA. It was amazing experience to become a part of PT GMF AERO ASIA team and I am so grateful of its. This internship is needed to make a young engineer familiar with their world. With all of these, a future young engineer hopefully will be ready to perform jobs in their scope of work.

This report is consists of everything that I have seen, learned, and analyzed during my On Job Training. This report is made to fulfill the study requirement at Department of Engineering physics, Bandung Institute of Technology. Besides, the company where I got the internship needs to know about the progresses.

Thank you again to Allah that has given the best people who always supported me when I was there. And I want to say thank you to the people who helped me by their hands, hearts, and minds to transfer so many knowledge to me. Some of them are :

1. My Lovely Family (Dad, Mom, Inge), who always give supports, prays, and loves every single time. Who always teach and guide with patience and love until I become like this. I love you full!!
2. Mr. Deddy Kurniady As Head of Physics Engineering who has given me guidances and spirit to become a great person, thank you sir!
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15. All BPH GAMAIS 2009, my trusty to you that make me can do this internship with composure, and you proven my trusty. Thanks for everything.
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Bandung, 27th Agust. 2009

Panji Prabowo

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CHAPTER I
INTRODUCTION

1.1 Background

In industrialization era that become more competitive nowadays, everyone who want to win the competition in the world of industry would give full attention to the quality. A full attention to a quality would give positive results not just for the company but would useful for themselves, family and community. Quality is a requisite for nation to advance, to achieve their dreams and to make their people prosperous.

To develop and build the student to be a person who have good personality and quality and to prepare student facing the global warning in the job opportunity and lead the student aware to what they are going to do in the future, department of Physics Engineering, the faculty of Industrial Technology, Bandung Institute of Technology try to prepare the student by implementing an internship program in a company.

Internship is an activity where students acquire more knowledge on real job world. The students are permitted to jump to the job world from the university department, and then the training begins when the training participants start working at the office, the participants have someone called mentors. Before you work at the office, of course you have to know about the directions and objectives, and this is the duty of the mentors. During the training, the participants will get so many advices from the mentors, and those are the most precious things. Because, they will not be obtained from the class or during lecture.

The job world is a very different world if we compare to university lecturing world. In the job world someone should be able to solve the entire problem related to their discipline, not only by theory but also by practice. Often many improvisations should be made to make an important decision. And intuitions will be the part of making a decision too. If we talk about intuition, that is the thing that we could not obtain from the class too. It is obtained from the work experiences. The more experiences, the better quality of the employee, that is the intention of the internship.

After doing internship, students are hoped get deeper understanding about their knowledge. And in other hand, the companies that receive the students can get evaluation and suggestion about their current system that would make an improvement in the future. It will make a great synchronization between educational institution and the company where both of them get the advantage.

1.2 Problem Boundary

Airplane system is complex. Every single information such as temperature, altitude, pressure, engine condition, vibration, angel of the body, oil and fuel flow, etc, having an affect on airplane condition. The complexity of the system lacked for precision monitoring. Monitoring to know the condition and to control it to state condition.

Speak of monitoring mean that speak of sensor. On a airplane implanted more than 500 kind of sensor. That useful to know every condition that affect to airplane. In this short paper, I discussed about sensor that implanted in engine, usually know Engine Instrument System. The sensor on the engine is monitoring condition in the engine, like the temperature, speed, vibration, fuel flow, etc. This is very important, because if the sensor have a trouble then the decision the pilot maybe wrong and make the flight have a disturbance.

1.3 Direction and Objectives

The direction of this internship is to study about Engine Instrument System (EIS) on Boeing 737 series.

1.4 Writing Methodologies

Methods used in this internship report writing are :

- **Literature Study**

  The study consists of everything connected with Engine Instrument System. The literature reference that involved in this internship report could be found in AMM (Aircraft Maintenance Manual) P.T. GMF Aero Asia.

- **Data Collecting**

  Data used in this report are collected from the work that I have done when I was in internship.

- **Discussion with mentor**

  With this discussion, I was given so many advices from the mentor so this internship report would be better in writing.

CHAPTER II
PT GMF AERO ASIA

2.1 Corporate Profile

PT. Garuda Maintenance Facility Aero Asia (GMF) was established based on deed No. 93 dated April 26th, 2002 of Notary Arry Supratno, SH. PT Garuda Maintenance Facility (GMF) Aero Asia is an aircraft's, including engine, component and other supporting services maintenance and refurbish company that puts Product Quality, Reliability, On Time Delivery and Affordability at its highest standard. In order to build up its reputation, GMF is fully supported by 2,395 skillful and highly motivated professionals, who have strong determination to ensure that the aircraft maintenance and refurbishment work are performed with minimum "ground time" and high efficiency.

GMF is located in a 115 acres of production area in Soekarno-Hatta International Airport, considered as the biggest in Asia, complete with infrastructure facilitates such as aircraft hangar, component workshop, engine workshop, material dock, water and waste management center, management office, and others. The Company ensures that all these facilities have to agree utilized in the most optimal way possible final objective is to achieve total customer satisfaction.

GMF feels confident in its various services performances started from Line Maintenance to Overhaul, engine and component maintenance and refurbishment, modification process and refurbishment. During its four years establishment, GMF has successfully achieved some national as well as international certifications have been awarded to GMF. That all help strengthening GMF's position and reputation as a world standard aircraft maintenance and refurbishment company.

In 2003, GMF expanded its line this boosted of business to aircraft modification, GMF's position one of a few able to performance of aircraft maintenance companies who has been considered as competent in performing major aircraft modification using a state-of the-art technology and equipment.

2.2 Corporate Vision

To become a World Class MRO of Customers' Choice by 2012

2.3 Corporate Mission

To provide integrated and reliable maintenance, repair and overhaul solutions for a safer sky and secured quality of life of mankind.

2.4 Corporate Strategy

To face future business challenges and to reach to goals set for of the second five years period, the Company formulated the Corporate Strategy to be executed by 8 Strategic Initiatives Teams as follows:

2.4.1 Financial Restructuring & Hair dressing

Strategic Initiative # 1 is expected to play a critical role in the following priority programs: Cost structure re-engineering, Cash optimization as well as Covenant & Legal Judiciary Settlement. The projected milestones are: the establishment of AR collection period less than 45 days, sufficient working capital, the settlement of GA's covenant, the completion of IPO process, the capitalization of market reach IDR or Combined sales hit USD 300 mio.

2.4.2 High-yield Portfolio & Market Development

Strategic Initiative # 2 is expected to play a critical role in the following priority programs: Star-alliance/world class operator Partnership Development, B737 & Wide body (747) Airframe Business Development and Component & Engine Revenue Enhancement. The projected milestones are: establish partnership with 747 HMV, the commercialization of JO/JV with world class MRO, gain first long term contract for engine & component shops.

2.4.3 Garuda-aligned Capacity & Capability Adjustment

Strategic Initiative # 3 is expected to play a critical role in the following priority program: GA's New Fleet Technical & Engineering Deployment. The projected milestones are: reach100% meets SLA with GA, gain more than 30% 737 NG in house component capability and CFM 56-7 split, built up & test capability.

2.4.4 Capability & Capacity Optimization

Strategic Initiative # 4 is expected to play a critical role in the following priority programs: Capacity Planning Practice Improvement, Domestic & International Capability Establishment and Facility Extension at Current Base. The projected milestones are: gain more than 90% capacity utilization, the establishment of 2nd and 3rd domestic facilities and 1st overseas facility as well as CKG expansion for N/B.

2.4.5 Product Quality Improvement

Strategic Initiative # 5 is expected to play a critical role in the following priority programs: Lean Six Sigma Extension, QCD Related Compliance & Work Value Management (from contract to redelivery) and financially backed Supply chain Enhancement. The projected milestones are: the implementation of TAT & D/R focused lean six sigma, the compliance of TAT & D/R to the industry standard, gain more than 90% consignment material /JIT and 100% compliance to purchasing agreement with key vendors.

2.4.6 Accelerated World Class Talent Deployment

Strategic Initiative # 6 is expected to play a critical role in the following priority programs: Extensive Talent Retention & Rehiring, Global multinational Talent Sourcing and Apprenticeship & Int'l Certified Training (with influence to local authority). The projected milestones are: gain 50% average retention rate for retiring staff, the employment of 1st batch multi national talent, the deployment of leadership talent pool, the establishment of cross culture workforce established, the deployment of 1400 skilled front liners and additional 1400 skilled front liners.

2.4.7 Safety Management System Implementation

Strategic Initiative # 7 is expected to play a critical role in the following priority programs: Safety Policy Management, Safety Assurance & Risk Management and Safety Promotion & Training Development. The projected milestone is: the total implementation of SMS.

2.4.8 IT Intensification Extension

Strategic Initiative # 8 is expected to play a critical role in the following priority programs: Total ERP Implementation, Web based Collaborative Information System, Organizational IT Management Shift. The projected milestone is: the implementation of total SAP solution & features.

2.5 GMF Organizational Structure

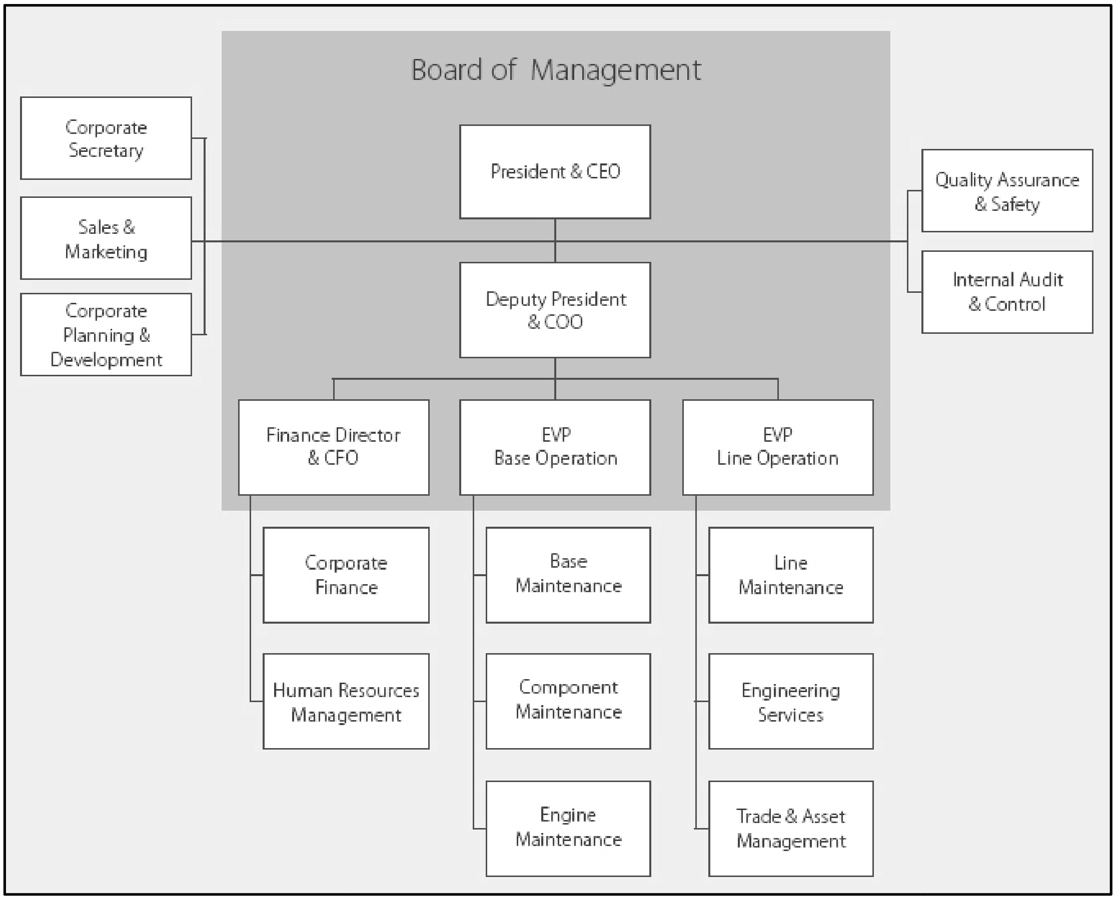

Figure 2.1 GMF Aero Asia Organizational Structure

2.6 Production Units

2.6.1 Base Maintenance

Equipped with 2 hangars, cabin workshop and sheet metal workshop, Base Maintenance’s capability in aircraft maintenance includes: major structure repair, major modification, aircraft exterior paint job, cabin refurbishment as well as airplane maintenance and overhaul.

2.6.2 Component Maintenance

As a total aircraft maintenance provider, GMF is equipped with several workshops including Avionics Workshop; Electro Mechanical and Oxygen Workshop; Ground Support Equipment Workshop; Calibration and Non Destructive Test (NDT) Workshop

2.6.3 Engine Maintenance

Engine Maintenance performs maintenance for the following engine types:

Table 2.1 Aircraft Type and Maintenance Type

Aircraft Type	Maintenance Type
Engine Spey 555	Overhaul
Engine CFM 56-3	
Auxiliary Power Unit (APU) GTCP 36	Overhaul
APU GTCP 85	
APU TSCP 700	Overhaul
Engine JT8D, JT9D-7/-59A and CF6-50/-80	

2.6.4 Line Maintenance

Headquartered at Soekarno-Hatta international Airport in Cengkareng, Line Maintenance Unit owns several branch offices which perform line maintenance process for several types of aircraft for domestic and international airlines.

Line Maintenance's customers are Garuda Indonesia, JAL, Korean Air, Air China, MAS, Saudia, Yemenia, Air Asia, and Sriwijaya Air among others. The unit also gained certifications from DSKU, FAA, EASA and from other countries.

2.6.5 Engineering Services

Engineering Service unit provides the following services:

- Standard maintenance program
- Modification and its control
- Reliability control program
- Data communication service from aircraft to ground
- Management and distribution of aircraft maintenance manual
- Expert service

2.6.6 Trade & Asset Management

Trade and Asset Management unit provides the following services:

- Spare part supplier
- Aircraft component management
- Warehousing
- Logistics and distribution
- Material transaction
- Bonded area facilities

Other than to Garuda Indonesia, Trade & Asset Management also provides the aforementioned services to several airlines. In 2008, the unit gained DGCA certification as Distributor of Aeronautical Product with approval no. 57/0130.

CHAPTER III
BASE THEORY

3.1 Brayton Cycle

The Brayton cycle was first proposed by George Brayton. George Brayton applied for a patent for his Ready Motor. The engine used a separate piston compressor and expander. The compressed air was heated by internal fire as it entered the expander cylinder. Today the term Brayton cycle is used for gas turbines only where both the compression and expansion processes take place in rotating machinery,that generally associated with the gas turbine even though Brayton never built anything other than piston engines.

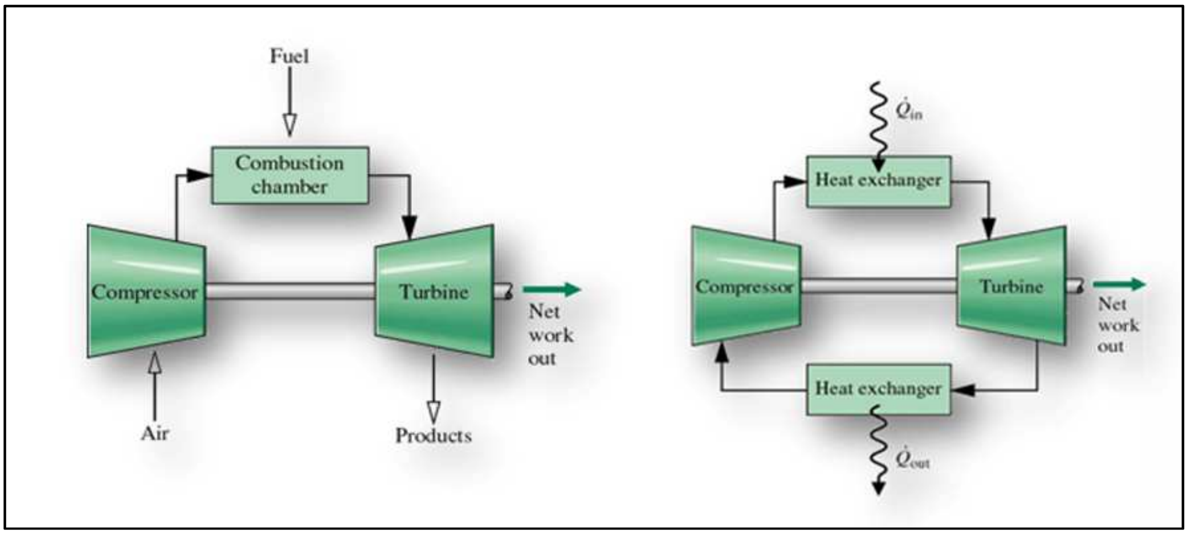

Figure 3.1 open-cycle gas turbine engine (right), closed-cycle gas turbine engine (left)

The Brayton cycle depicts the air-standard model of a gas turbine power cycle. A simple gas turbine is comprised of three main components: a compressor, a combustor, and a turbine (see **Figure 3.1**). According to the principle of the Brayton cycle, air is compressed in the compressor. The air is then mixed with fuel, and burned under constant pressure conditions in the combustor. The resulting hot gas is allowed to expand through a turbine to perform work. Most of the work produced in the turbine is used to run the compressor and the rest is available to run auxiliary equipment and produce power.

A schematic of the Brayton (simple gas turbine) cycle is given in **Figure 3.1** Low-pressure air is drawn into a compressor (state 1) where it is compressed to a higher pressure (state 2). Fuel is added to the compressed air and the mixture is burnt in a combustion chamber. The resulting hot gases enter the turbine (state 3) and expand to state 4. The Brayton cycle consists of four basic processes:

- 1 - 2 : Isentropic Compression
- 2 - 3 : Reversible Constant Pressure Heat Addition
- 3 - 4 : Isentropic Expansion
- 4 – 1 : Reversible Constant Pressure Heat Rejection (Exhaust and Intake in the open cycle)

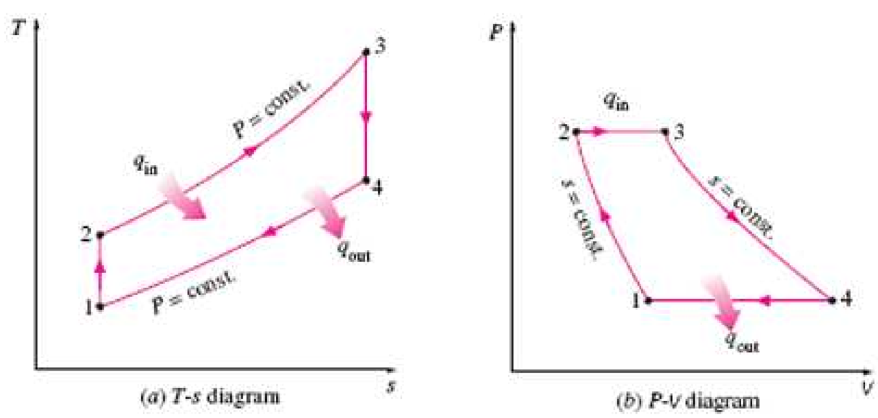

Figure 3.2 T-s and P-v Diagram for Brayton Cycle

The *T-s* and *P-v* diagrams of an ideal Brayton cycle are shown in **Figure 3.2**. Notice that all four processes of the Brayton cycle are executed in steadyflow devices; thus, they should be analyzed as steady-flow processes. When the changes in kinetic and potential energies are neglected, the energy balance for a steady-flow process can be expressed, on a unit–mass basis, as

$$(q_{in} - q_{out}) + (w_{in} - w_{out}) = (h_{ex} - h_{inlet}) \quad (3.1)$$

Therefore, heat transfers to and from the working fluid are

$$q_{in} = h_3 - h_2 = C_p(T_3 - T_2) \quad (3.2)$$

and

$$q_{out} = h_4 - h_1 = C_p(T_4 - T_1) \quad (3.3)$$

Then the thermal efficiency of the ideal Brayton cycle under the cold-airstandard assumptions becomes

$$\eta_{th.Brayton} = \frac{w_{net}}{q_{in}} = 1 - \frac{q_{out}}{q_{in}} \quad (3.4)$$

and the pressure ration is

$$r_p = \frac{P_2}{P_1} \quad (3.5)$$

The two major application areas of Brayton cycle are *aircraft propulsion* and *electric power generation.* When it is used for aircraft propulsion, the gas turbine produces just enough power to drive the compressor and a small generator to power the auxiliary equipment. The high-velocity exhaust gases are responsible for producing the necessary thrust to propel the aircraft. Gas turbines are also used as stationary power plants to generate electricity as stand-alone units or in conjunction with steam power plants on the high-temperature side. In these plants, the exhaust gases of the gas turbine serve as the heat source for the steam. The gas-turbine cycle can also be executed as a closed cycle for use in nuclear power plants. This time the working fluid is not limited to air, and a gas with more desirable characteristics (such as helium) can be used.

3.2 Engine Overview

Achieving a high propulsive efficiency for a jet engine is dependent on designing it so that the exiting jet velocity is not greatly in excess of the flight speed. At the same time, the amount of thrust generated is proportional to that very same velocity excess that must be minimized. This set of restrictive requirements has led to the evolution of a large number of specialized variations of the basic turbojet engine, each tailored to achieve a balance of good fuel efficiency, low weight, and compact size for duty in some band of the flight speed–altitude–mission spectrum.

There are two major general features characteristic of all the different engine types, however. First, in order to achieve a high propulsive efficiency, the jet velocity, or the velocity of the gas stream exiting the propulsor, is matched to the flight speed of the aircraft—slow aircraft have engines with low jet velocities and fast aircraft have engines with high jet velocities. Second, as a result of designing the jet velocity to match the flight speed, the size of the propulsor varies inversely with the flight speed of the aircraft—slow aircraft have very large propulsors, as, for example, the helicopter rotor—and the relative size of the propulsor decreases with increasing design flight speed—turboprop propellers are relatively small and turbofan fans even smaller.

3.2.1. Turbojet Engine

The basic idea of the turbojet engine is simple. Air taken in from an opening in the front of the engine is compressed to 3 to 12 times its original pressure in compressor. Fuel is added to the air and burned in a combustion chamber to raise the temperature of the fluid mixture to about 1,100°F to 1,300° F. The resulting hot air is passed through a turbine, which drives the compressor. If the turbine and compressor are efficient, the pressure at the turbine discharge will be nearly twice the atmospheric pressure, and this excess pressure is sent to the nozzle to produce a high-velocity stream of gas which produces a thrust. Substantial increases in thrust can be obtained by employing an afterburner. It is a second combustion chamber positioned after the turbine and before the nozzle. The afterburner increases the temperature of the gas ahead of the nozzle. The result of this increase in temperature is an increase of about 40 percent in thrust at takeoff and a much larger percentage at high speeds once the plane is in the air.

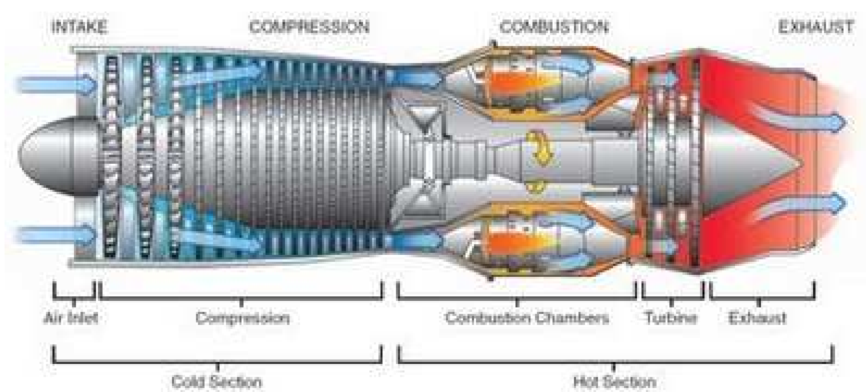

Figure 3.3 Turbojet Engine

The turbojet engine is a reaction engine. In a reaction engine, expanding gases push hard against the front of the engine. The turbojet sucks in air and compresses or squeezes it. The gases flow through the turbine and make it spin. These gases bounce back and shoot our of the rear of the exhaust, pushing the plane forward.

3.2.2. Turboprop Engine

A turboprop engine is a jet engine attached to a propeller. The turbine at the back is turned by the hot gases, and this turns a shaft that drives the propeller. Some small airliners and transport aircraft are powered by turboprops.

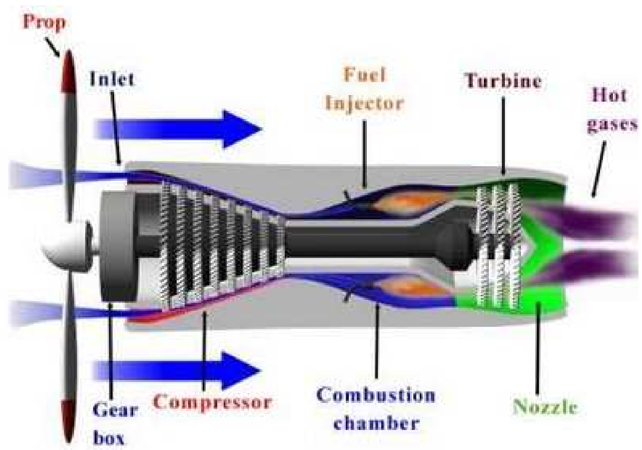

Figure 3.4 Turboprop Engine

Like the turbojet, the turboprop engine consists of a compressor, combustion chamber, and turbine, the air and gas pressure is used to run the turbine, which then creates power to drive the compressor. Compared with a turbojet engine, the turboprop has better propulsion efficiency at flight speeds below about 500 miles per hour. Modern turboprop engines are equipped with propellers that have a smaller diameter but a larger number of blades for efficient operation at much higher flight speeds. To accommodate the higher flight speeds, the blades are scimitar-shaped with swept-back leading edges at the blade tips. Engines featuring such propellers are called propfans.

Hungarian, Gyorgy Jendrassik who worked for the Ganz wagon works in Budapest designed the very first working turboprop engine in 1938. Called the Cs-1, Jendrassik's engine was first tested in August of 1940; the Cs-1 was abandoned in 1941 without going into production due to the War. Max Mueller designed the first turboprop engine that went into production in 1942.

3.2.3. Turbofan Engine

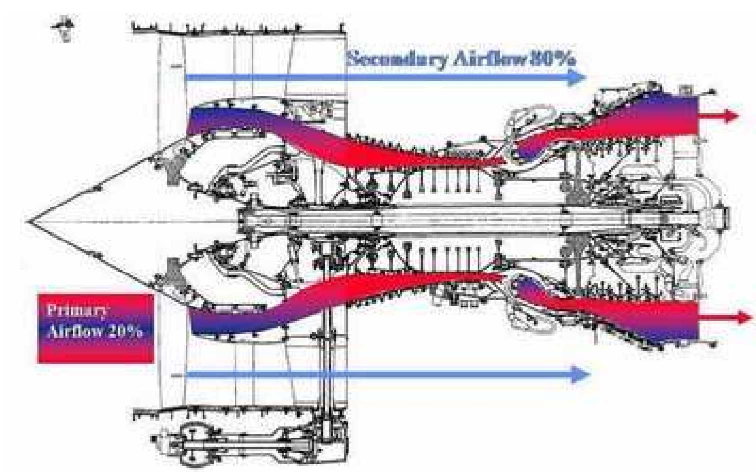

Figure 3.5 Turbofan Engine

A turbofan engine has a large fan at the front, which sucks in air. Most of the air flows around the outside of the engine, making it quieter and giving more thrust at low speeds. Most of today's airliners are powered by turbofans. In a turbojet all the air entering the intake passes through the gas generator, which is composed of the compressor, combustion chamber, and turbine. In a turbofan engine only a portion of the incoming air goes into the combustion chamber. The remainder passes through a fan, or low-pressure compressor, and is ejected directly as a "cold" jet or mixed with the gas-generator exhaust to produce a "hot" jet. The objective of this sort of bypass system is to increase thrust without increasing fuel consumption. It achieves this by increasing the total air-mass flow and reducing the velocity within the same total energy supply.

3.3 Sensor and Signal

This world is divided into natural and man-made objects. The natural sensors, like those found in living organisms, usually respond with signals, having an electrochemical character; that is, their physical nature is based on ion transport, like in the nerve fibers (such as an optic nerve in the fluid tank operator). In man-made devices, information is also transmitted and processed in electrical form—however, through the transport of electrons. Sensors that are used in artificial systems must speak the same language as the devices with which they are interfaced. This language is electrical in its nature and a man-made sensor should be capable of responding with signals where information is carried by displacement of electrons, rather than ions. Thus, it should be possible to connect a sensor to an electronic system through electrical wires, rather than through an electrochemical solution or a nerve fiber.

A sensor is a device that receives a stimulus and responds with an electrical signal. The stimulus is the quantity, property, or condition that is sensed and converted into electrical signal. The purpose of a sensor is to respond to some kind of an input physical property (stimulus) and to convert it into an electrical signal which is compatible with electronic circuits. We may say that a sensor is a translator of a generally nonelectrical value into an electrical value. When we say “electrical,” we mean a signal which can be channeled, amplified, and modified by electronic devices. The sensor’s output signal may be in the form of voltage, current, or charge. These may be further described in terms of amplitude, frequency, phase, or digital code. This set of characteristics is called the *output signal format*. Therefore, a sensor has input properties (of any kind) and electrical output properties.

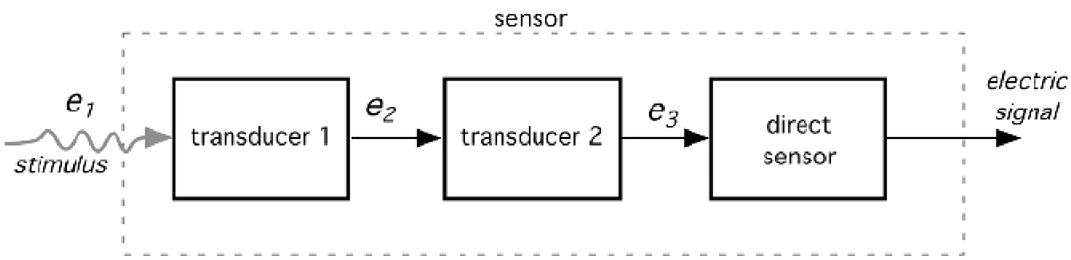

Figure 3.6 A Sensor may incorporate several transducers

In summary, there are two types of sensors: *direct* and *complex*. A direct sensor converts a stimulus into an electrical signal or modifies an electrical signal by using an appropriate physical effect, whereas a complex sensor in addition needs one or more transducers of energy before a direct sensor can be employed to generate an electrical output.

A sensor does not function by itself; it is always a part of a larger system that may incorporate many other detectors, signal conditioners, signal processors, memory devices, data recorders, and actuators. The sensor's place in a device is either intrinsic or extrinsic. It may be positioned at the input of a device to perceive the outside effects and to signal the system about variations in the outside stimuli. Also, it may be an internal part of a device that monitors the devices' own state to cause the appropriate performance. A sensor is always a part of some kind of a data acquisition system. Often, such a system may be a part of a larger control system that includes various feedback mechanisms.

CHAPTER IV
ENGINE INSTRUMENT SYSTEM

4.1 General Description

The engine instrument system (EIS) is microprocessor-controlled instrument panels which display parameters of engines and hydraulic systems to monitor airplane engines and hydraulic systems operation. It also displays total air temperature and engine thrust mode annunciation messages. The EIS is composed of two adjacent independent, solid state integrated displays: a Primary Display and a Secondary Display. Both displays are installed on the pilots' center instrument panel P2-2. The left-hand side is the Primary Display and the right-hand side is the Secondary Display. The EIS receives 28v electrical power from the P6-2 LOAD CONTROL CENTER panel.

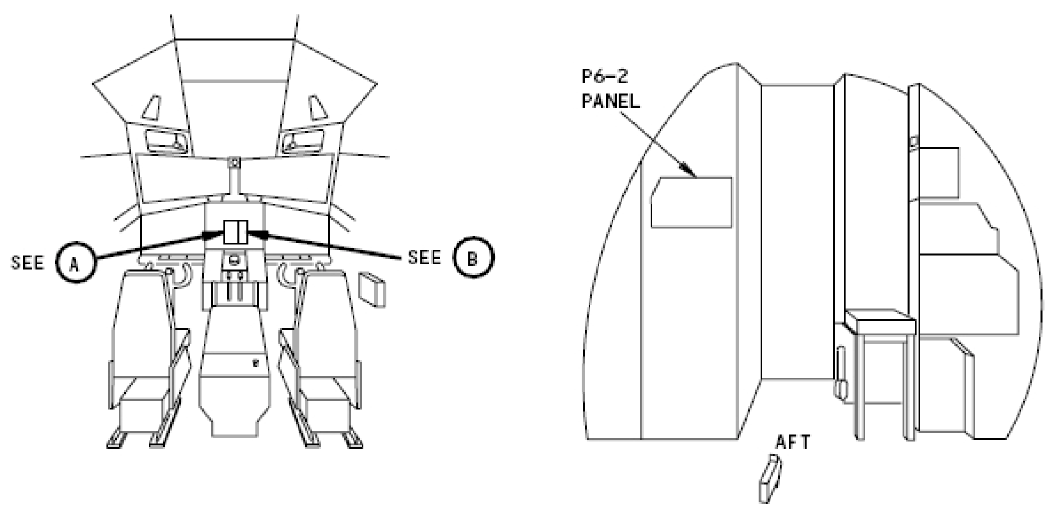

Figure 4.1 Cockpit

The EIS Primary Display receives, processes, and displays the primary engine parameters of N1 (both limit and actual), N2, exhaust gas temperature (EGT), and fuel flow/fuel used (FF/FU) for two engines. For EFIS configured airplanes, it also displays engine thrust mode annunciation (TMA) input data from the flight management computer (FMC). And the secondary display the engine parameters of engine oil pressure, engine oil temperature, engine oil quantity, engine vibration, hydraulic oil pressure, hydraulic oil quantity, and Total Air Temperature (TAT).

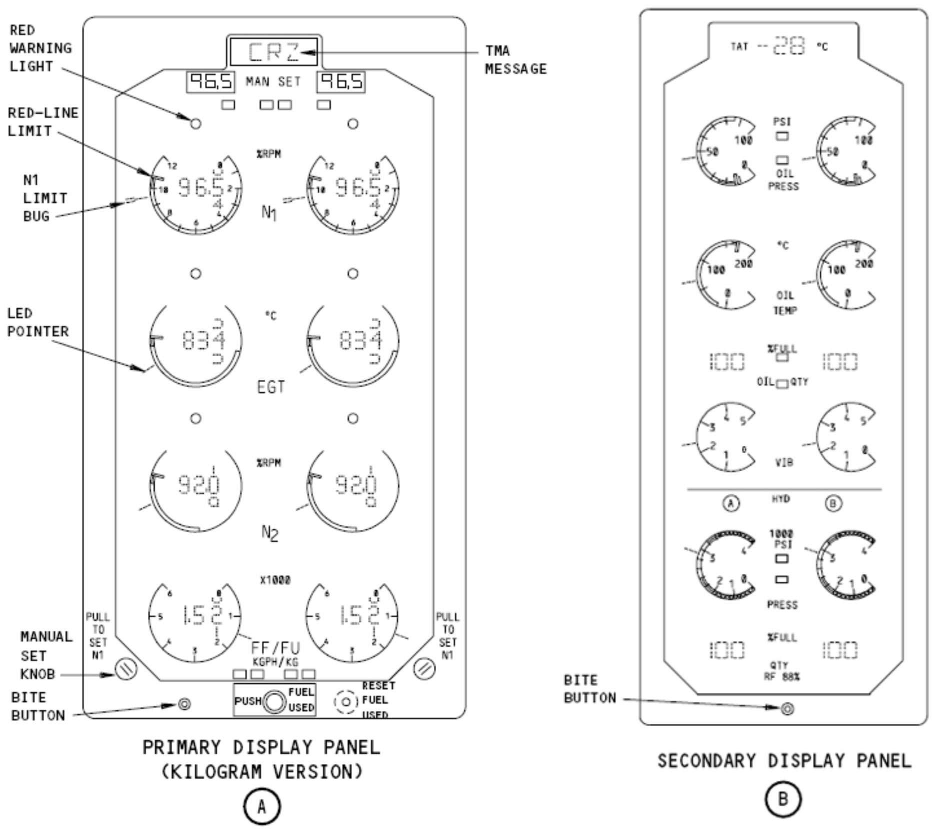

Figure 4.2 Primary Display and Secondary Display

4.2 EIS Component

4.2.1 Tachometer System

The revolutions-per-minute (rpm) of the engine rotor may be sensed by a mechanically-driven tachometer generator, mechanically-driven permanent magnet, or a pulse pick-up that senses passing compressor or fan blades or passing gear teeth. The output or signal from any of the above sensors is directed to an appropriate indicator in the cockpit, the indicator being calibrated to read directly in percent rpm.

Dual axial-flow compressor engines usually have two tachometers, one indicating low-pressure compressor (LPC) speed, called N1, and the other indicating high-pressure compressor (HPC) speed, called N2. The system consists of an N1 speed sensor, an N1 tachometer indicator, an N2 control alternator speed sensor, and an N2 tachometer indicator.

4.2.1.1 N1

The N1 speed sensor is a pulse counter that senses N1 rotor speed and provides signals to the N1 tachometer indicator and PMC. The sensor consists of a rigid metal tube with a mounting flange and two-connector receptacle. Within the tube is a elastomer damper and a magnetic head sensor with two protruding pole pieces (see **Figure 4.3**)

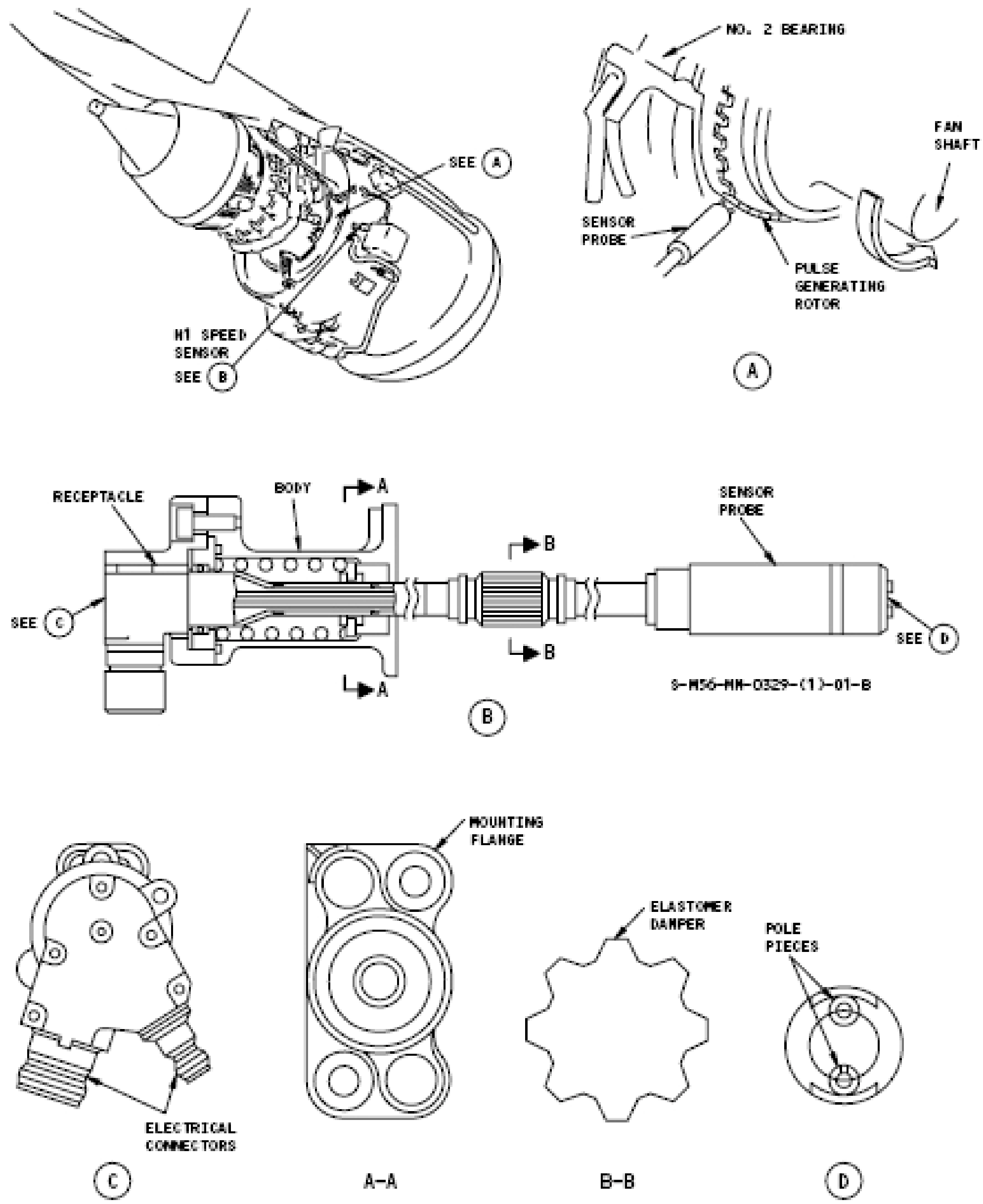

Figure 4.3 N1 Speed Sensor

The sensor incorporates dual sensing elements with ne element providing N1 signal or the PMC and the other element providing signal to the N1 tachometer indicator. A magnetic ring mounted on the fan shaft is provided with teeth. The passage of each tooth generates an alternating voltage in the sensor element proportional to actual N1 speed.

The indicator consists of a graduated dial face, main indicator pointer, index marker (bug), command N1 numerics, actual N1 numerics, overlimit warning light, manual set knob, and indicator circuits assembled in a case which is integrally lit and not hermetically sealed.

The N1 indicator is a microprocessor based instrument which performs its various functions under the control of a software program. With the software program, all indicator functions are regularly sampled thereby producing a continuous updating of actual N1% RPM pointer, numeric displays, and output functions. The N1 indication system is operative when 28v dc power is supplied by the EIS or N1 TACH IND circuit breakers on the P6 panel.

Actual N1 fan speed is measured by speed sensor elements which provide an ac voltage whose frequency is proportional to the fan speed. The sensor incorporates dual sensing elements with one element providing N1 signal for the power management control and the other element providing signal to the N1 tachometer indicator. A magnetic ring mounted on the fan shaft is provided with teeth. The passage of each tooth generates an alternating voltage in the sensor element proportional to actual N1 speed.

4.2.1.2 N2

The N2 speed sensor is an ac generator, whose frequency is directly proportional to rotor speed, that provides signals to the N2 tachometer indicator and electrical power for PMC. The sensor consists of rotor, stator, and case with two-insert electrical connectors located on and driven by the accessory gearbox shaft.

The sensor is spline-mounted to the gearbox shaft by a self-locking nut. The stator and case are completely separable and mount directly to the gearbox housing.

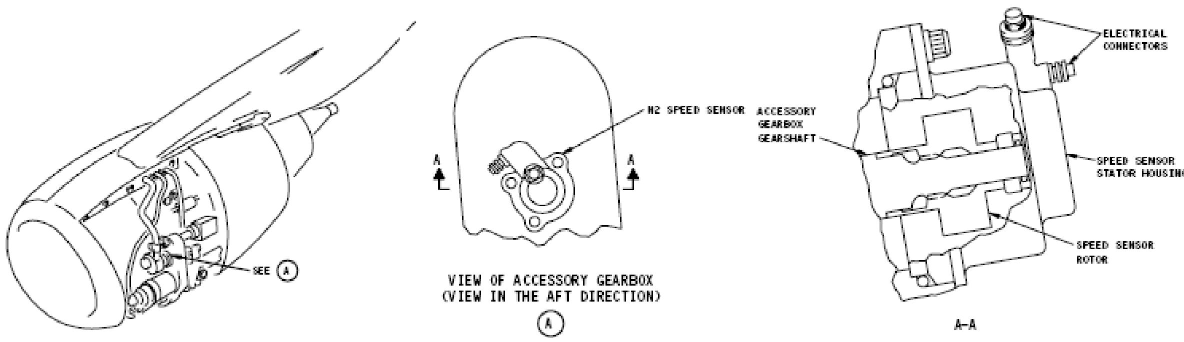

Figure 4.4 N2 Speed Sensor

The N2 tachometer indicator converts signals produced by the N2 speed sensor into both pointer and digital readouts. It includes a starter cutout relay which ensures starter disengagement at maximum starter run speed and prevents re-engagement at engine speeds that would damage starter or engine. The relay, when energized, also inhibits the PMC INOP indication.

The indicator is similar to N1 indicator consisting of dial face, main indicator pointer, over limit warning light, N2 numerical readout, power supply, and indicator circuits.

N2 rotor speed is measured by an alternator which provides an ac signal whose frequency is proportional to the core rotor speed. The alternator incorporates dual windings with one winding providing N2 speed signal to the PMC and the other winding to the N2 tachometer indicator.

The N2 tachometer indicator displays actual N2% RPM and operates in similar manner as the N1 indicator with pointer indication and numeric display of data, overlimit indication, and light sensitive cell for controlling LED intensity.

An internal switch in the indicator transmits a signal to the engine start circuit. This signal ensures starter disengagement at the maximum starter run speed (46.33%) and prevents starter re-engagement at engine speeds (above 30.43%) which could damage the starter or engine. This switch also inhibits the PMC INOP light.

4.2.2 Exhaust Gas Temperature (EGT) Indication System

Turbine engines may be instrumented for exhaust gas temperature indication at location before, between, or behind the turbine stages. In turbo-fan engines, turbine temperature is measured at a point between the high-pressure and low-pressure turbines. In such cases the parameter is called the fan turbine inlet temperature (FTIT).

Exhaust gas temperature is an engine operating limit and is used to monitor the mechanical integrity of the turbines, as well as to check engine operating conditions. Actually, the temperature at the turbine inlet is the important condition consideration because it is the most critical f all of the engine variables. However, it is impractical to measure turbine inlet temperature in most engines. Consequently, thermocouples are inserted at the turbine discharge instead, since this temperature provides a relative indication of temperature at the inlet. Although the temperature at this point is much lower than it is at the inlet, it enables the pilot to monitor the internal operating conditions of the engine

The exhaust gas temperature (EGT) indicating system provides a visual indication in the flight compartment of the total exhaust temperature monitored in the low pressure turbine inlet of each engine. EGT is measured by nine thermocouple probes installed in stage 2 LPT nozzle assembly. The signals transmitted by these probes are routed through rigid thermocouple harnesses, and one or three extension leads (9 probes EGT system) which make up the EGT thermocouple harness assembly and then to EGT trim box.

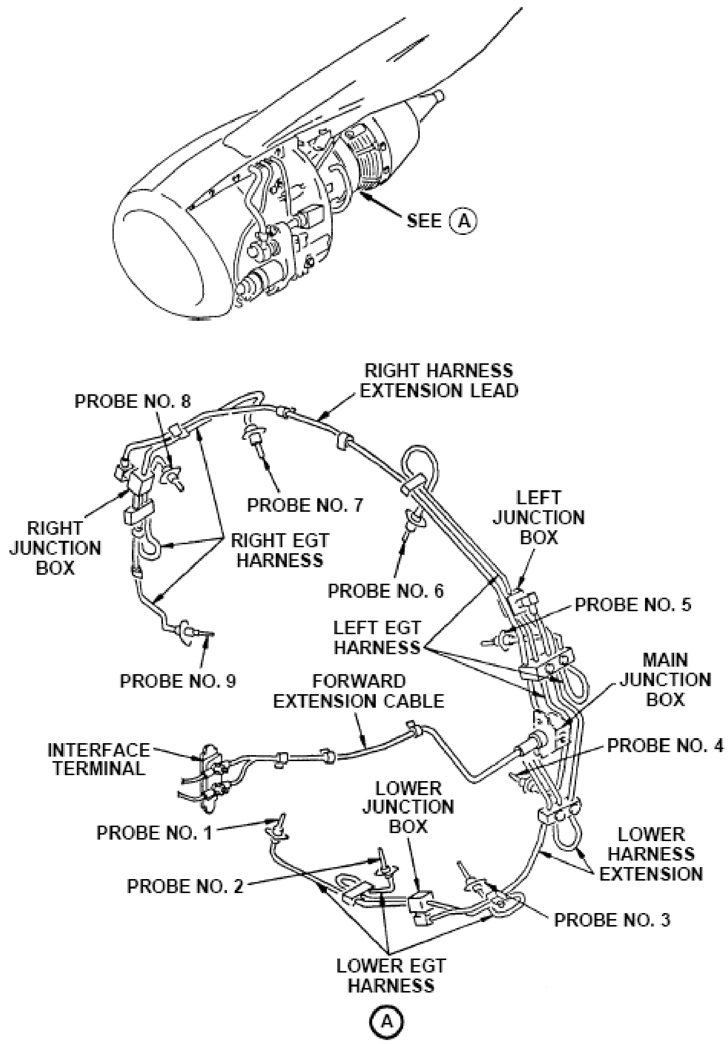

Figure 4.5 EGT Thermocouple Harness and Nine Probes

There are two identical and interchangeable left-hand thermocouple harness segments which consist of :

- A flange-mounted secondary junction box with a receptacle connector for connection with the main junction box extension lead
- Three rigid metal tubes, each of them provided with a flange-mounted chromel-alumel thermocouple probe, that are permanently mounted to the secondary junction box.

And the right-hand thermocouple harness segment consist of :

- A flange-mounted secondary junction box with a receptacle connector for connection with the main junction box extension lead
- Three rigid metal tubes, each of them provided with a flange-mounted chromel-alumel thermocouple probe, that are permanently mounted to the secondary junction box.

The main junction box and leads assembly (engine flange S) includes:

- A main junction box with 2 receptacle connectors for connecting with the right-hand harness segment extension lead and the forward extension lead.
- Two main junction box extension leads which are rigid metal tubes each one permanently affixed to the main junction box on one end with a mobile connector on the other end for connection to the left-hand secondary junction boxes.

The right-hand harness segment extension lead (engine flange S) is a rigid metal tube fitted with a mobile connector at each end: one for connection with the right-hand secondary junction box and the other for connection with the main junction box.

The Exhaust Gas Temperature (EGT) indicating system provides a visual indication in the flight compartment of an averaged exhaust gas temperature as it passes through the LPT of each engine. It can display temperatures over the range of -50ºC to 1150ºC.

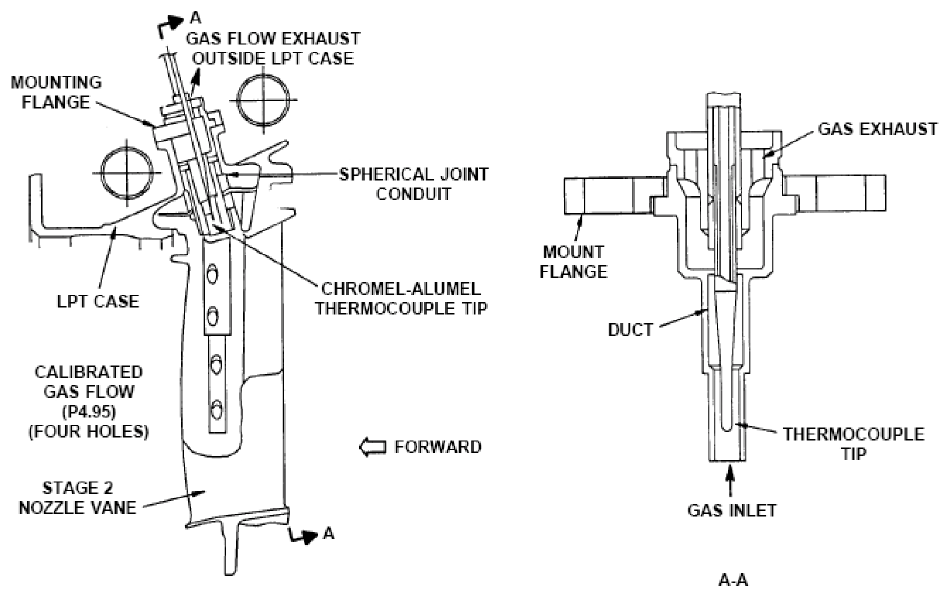

Figure 4.6 EGT Thermocouple

The thermocouple probes create a voltage that is proportional to the temperature around the chromel-alumel hot-junction. Parallel chromel-alumel leads connect the probes to the junction boxes. The junction boxes transfer an average of the voltage for delivery to the flight deck indicator.

4.2.3 Fuel Flow Indication System

The fuel flow indicator shows the fuel in pounds (or kilograms) per hour to the fuel nozzles. Fuel flow is of fundamental interest for monitoring inflight fuel consumption, for checking engine performance, and for inflight cruise control. The relationship of abnormal fuel flow to readings of the other instruments will provide one of the best indication as to the probable cause of an engine malfunction.

The rate of fuel flow to each engine is measured by a fuel flow transmitter found on each engine on the left side of the fan case, just above the transfer gearbox (TGB). The fuel flow transmitter uses the angular momentum of a rotor to measure the mass flow rate. It is made to minimize the drop in fuel pressure across the transmitter. External power is not necessary.

- Fuel goes in the transmitter and flows to a swirl generator. The swirl generator causes the fuel to swirl around or turn as the fuel goes through the angled fins.
- The swirling fuel causes the rotor to turn. The rotor has two magnets attached to its surface. One magnet on the rotor induces a start pulse in a coil each time the magnet passes the coil.

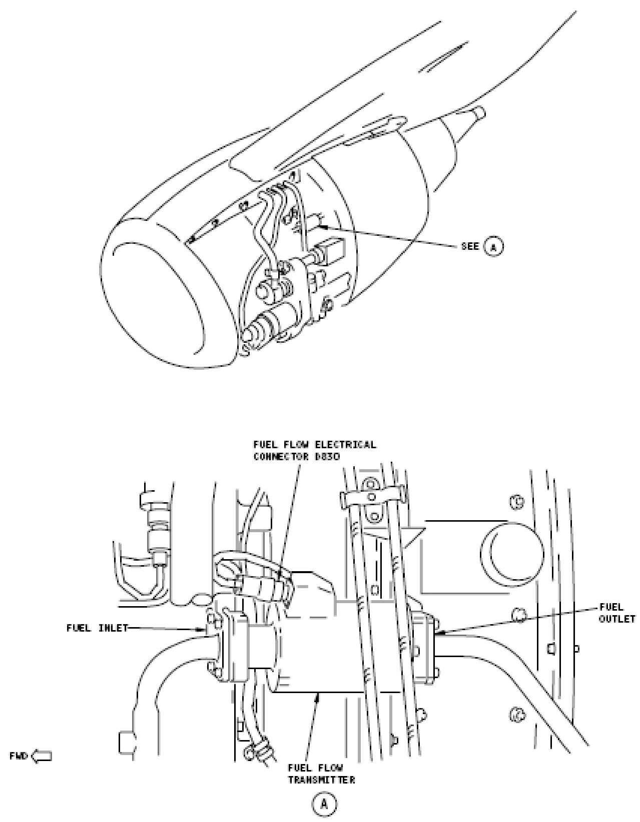

Figure 4.7 Fuel Flow transmitter Location

Fuel then flows to a spring restrained turbine. The turbine moves radially as the fuel passes through it. The turbine has a signal blade which protrudes back to the rotor. A stop pulse is induced each time the second magnet on the spinning rotor passes the signal blade.

The time interval between the start and stop pulses is measured by the fuel flow indicator and converted to a fuel flow rate. The resulting fuel flow is displayed on the fuel flow indicator found on the bottom of the pilots' center instrument panel.

The fuel flow/used indicator gives a continuous indication of fuel flow rate (FFR). To do this, the indicator uses the start and stop pulses from the fuel flow transmitter.

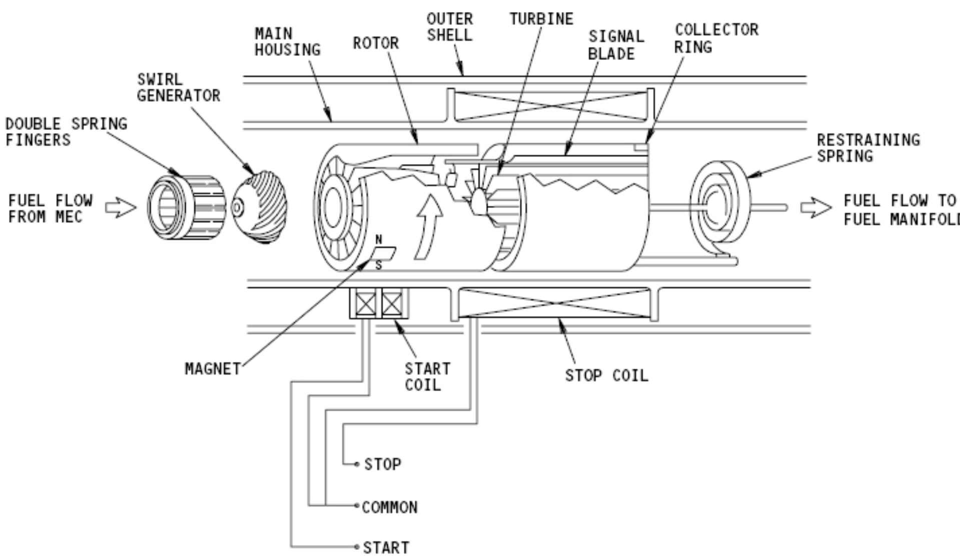

Figure 4.8 Fuel Flow Transmitter Diagram

4.2.4 Airborne Vibration Monitoring (AVM) System

The airborne vibration monitoring (AVM) system continuously shows the engine vibration level. The system consists of two accelerometers (vibration sensors) and a vibration indicator for each engine and an AVM signal conditioner. Power for the system is 115 volts ac supplied from transfer bus 1.

Abnormal engine vibration, sudden or progressive, is a positive indication of engine malfunction. Abnormal vibration can be caused by compressor or turbine blade damage, rotor imbalance, or other problems. Early warning of engine malfunction permits corrective action before extensive damage results.

With the engine operating, the engine accelerometers generate signals proportional to engine motion in radial direction. These signals are received by the AVM signal conditioner, where they are converted to signals suitable for indicator operation. Signals are then sent to the vibration indicator

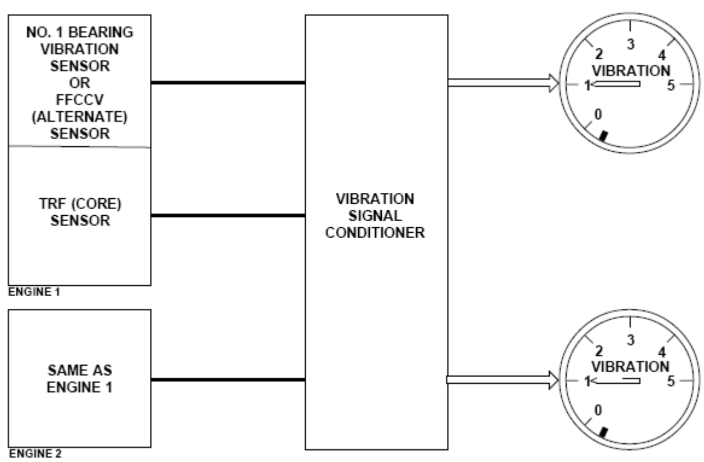

Figure 4.9 Airborne Vibration Monitoring (AVM) System

4.2.4.1 Engine Vibration Sensor

The engine accelerometers sense engine vibration in terms of engine acceleration in a radial direction and generate electrical signals proportional to the engine acceleration. The accelerometers are of the piezoelectric type.

The turbine rear frame (TRF) vibration (core) sensor is mounted on the forward flange of the turbine rear frame. The TRF vibration (core) sensor has a charge sensitivity of 50 pc/G. The No. 1 Bearing (NOB) vibration (fan) sensor is mounted on the number one bearing housing. This sensor senses low speed rotor motion.

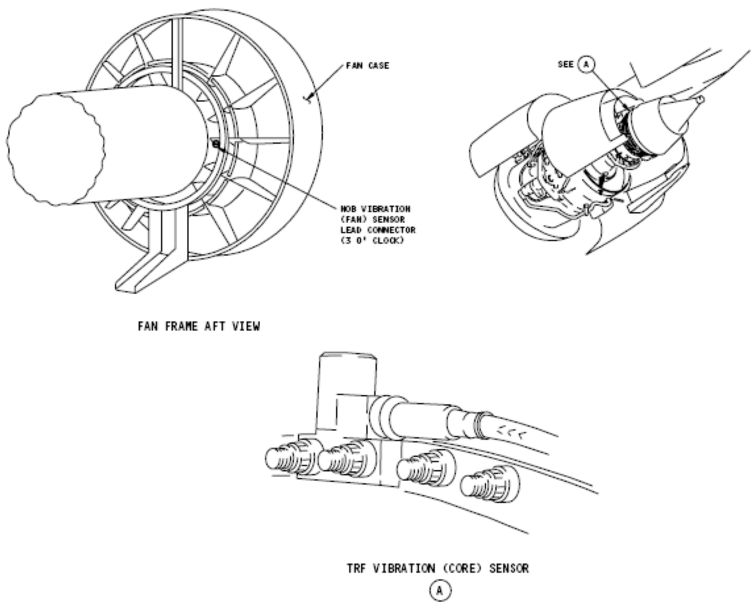

Figure 2.10 AVM System Location and Component

4.2.4.2 AVM Signal Conditioner

The AVM signal conditioner processes inputs from vibration sensors, N1 and N2 speed sensors. The monitor unit is programmed to determine the N1 and N2 rotor vibration from the fan and core sensors. The unit is a microprocessor with BITE, self-test and flight data history functions

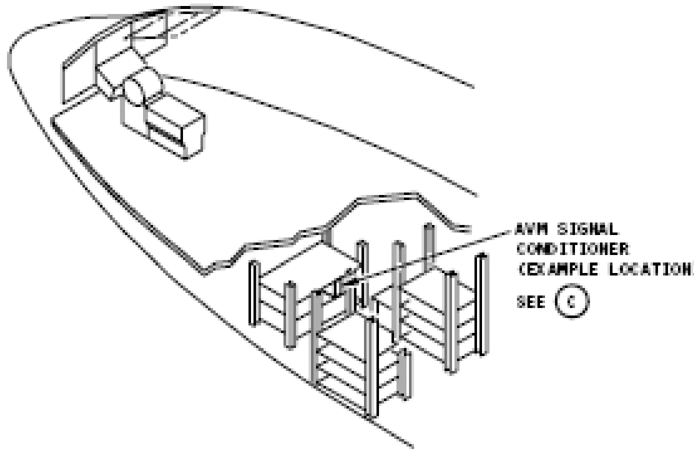

Figure 4.11 AVM Signal Conditioner location

4.2.5 Oil Monitoring System

4.2.5.1 Oil Quantity Indicating

The oil quantity indicating system gives a visual indication of the usable oil quantity in each engine oil tank. The system consists of the oil quantity transmitter and the oil quantity indication.

The oil quantity transmitter is a variable capacitance type. Two concentric tubes form the plates of the capacitor. The inner tube is profiled varying the distance between the tubes to make allowances for variations in tank cross-sectional area. A compensator probe is found at the bottom of the transmitter.

The oil quantity transmitter acts as a variable capacitor. The level of oil in the transmitter tube establishes a dielectric value between the inner and outer tube. The dielectric value between the tubes determines the capacitance and establishes an indicator bridge signal. The compensator probe measures the dielectric constant of the oil such that the capacitance is independent of temperature or the type of oil used.

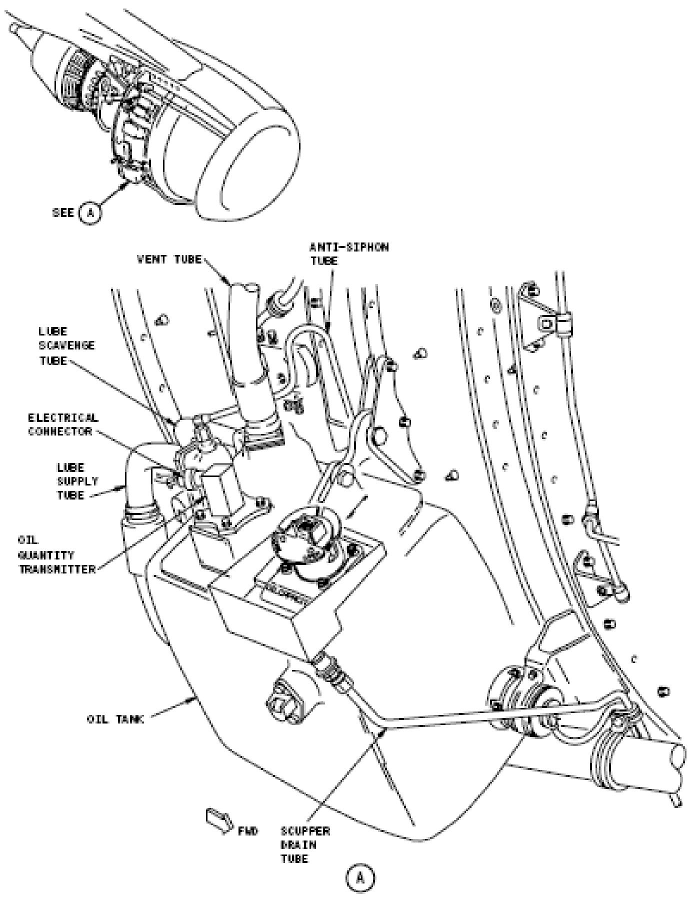

Figure 4.12 Oil Quantity Indicating – Component Location

4.2.5.2 Oil Pressure Indicating

To guard against engine failures resulting from inadequate lubrication and cooling of the various engine parts, the oil supply to critical areas must be monitored. The oil pressure indicating system provides a visual indication of pressure measured in the engine oil distribution system. The oil pressure indicating system consists of the oil pressure transmitter and the oil pressure indication.

The oil pressure transmitter is a variable reluctance type using a pressure sensitive diaphragm coupled to a transformer. The oil pressure transmitter is connected to a pressure tap on the forward sump oil supply tube and the TGB (transfer gearbox) vent.

The oil pressure indication provides a dial/pointer display of the oil pressure. Two displays, one for each engine are located on the pilots' center instrument panel, P2, as part of the Secondary Engine Hydraulics Display. The dial face is calibrated from 0 to 100 psig with the following ranges:

- Red Line 13 psig
- Amber 13 to 26 psig
- Green 26 to 87 psig

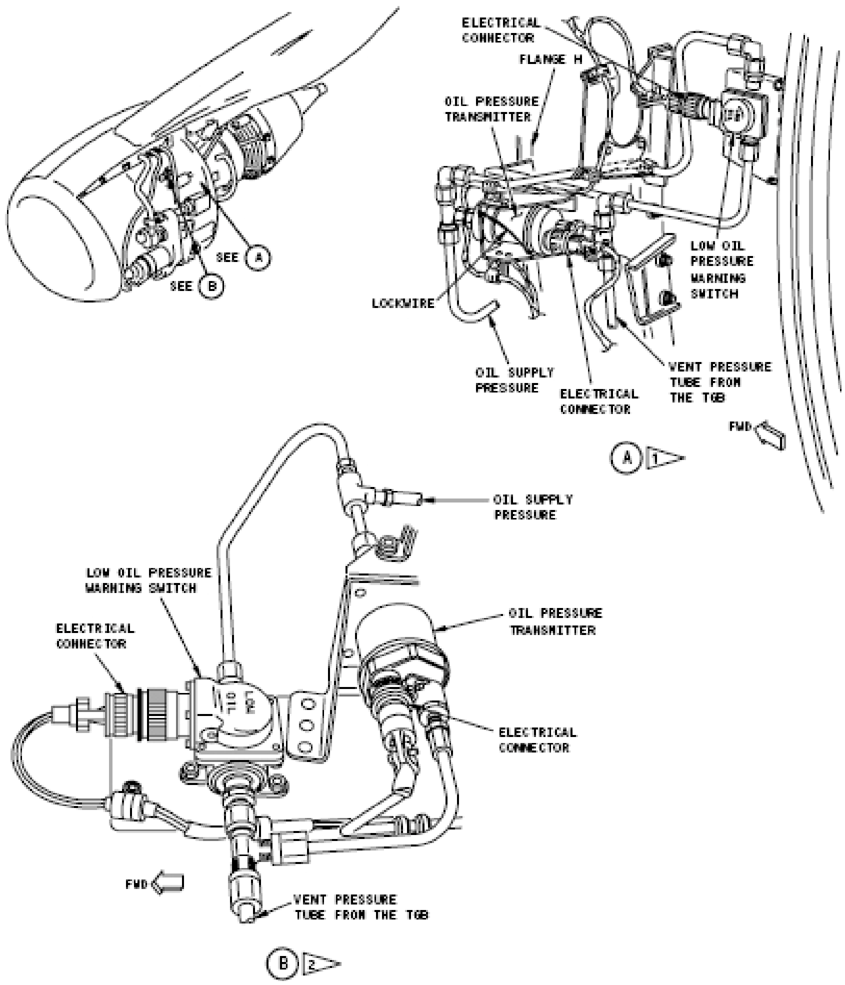

Figure 4.13 Oil Pressure Indicating – Component Location

4.2.5.3 Oil Temperature Indicating

The ability of the engine oil to perform its job of lubricating and cooling is a function of the temperature of the oil, as well as the amount of oil supplied to the critical areas. An oil inlet temperature indicator is provided to show the temperature of the oil as it enters the bearing compartments. Oil inlet temperature also helps to monitor proper operation of the engine oil cooler.

The oil temperature indicating system consists of the oil temperature bulb and the oil temperature indication. The oil temperature bulb is a temperature sensitive resistance element enclosed in a metal case. The resistance of the element varies with oil temperature. It is mounted in a boss on the oil scavenge filter and measures the temperature of the oil leaving the oil scavenge filter. The oil temperature indicator provides a dial/pointer indication of the oil temperature. Two indicators, one for each engine are located on the pilots' center instrument panel, P2. The oil temperature indicator consists of a stationary coil, a moving coil, a pointer attached to the moving coil and a dial face graduated from -50ºC to 200ºC.

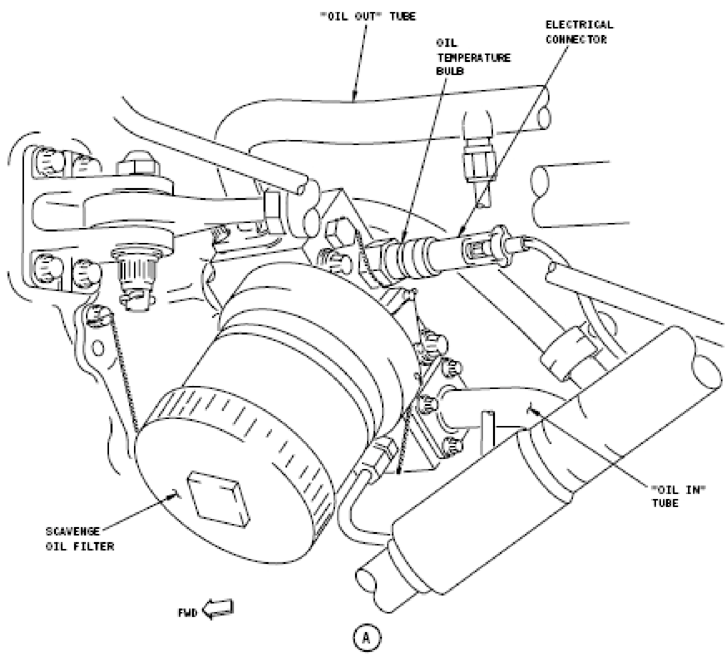

Figure 4.14 Oil Temperatur Indicating – Component Location

Oil temperature is measured by the temperature sensitive resistance element in the oil temperature bulb. The resistance element is one leg of a wheatstone bridge circuit that controls current flow to the moving coil in the oil temperature indicator. The moving coil with the attached pointer rotates in proportion to the applied current.

The oil temperature indication provides a dial/pointer display of the oil temperature. Two displays, one for each engine, are located on the pilots' center instrument panel, P2, as part of the Secondary Engine and Hydraulics Display. The oil temperature display consists of a dial face graduated from -50ºC to 200ºC. The range markings are as follows:

- Green: 10 to 160ºC
- Amber: 160 to 165ºC
- Red Line: 165ºC

4.2.6 Hydraulic Monitoring System

4.2.6.1 Hydraulic Pressure Indicating

The hydraulic pressure indicating system shows the pressure that is in the two main hydraulic systems to the pilots. The pilots see the pressure on the pressure indicators. The pressure indicators get their signals electrically from the pressure transmitters. The system uses 28 volt ac electrical power from the transfer bus through the circuit breakers on the P6 panel.

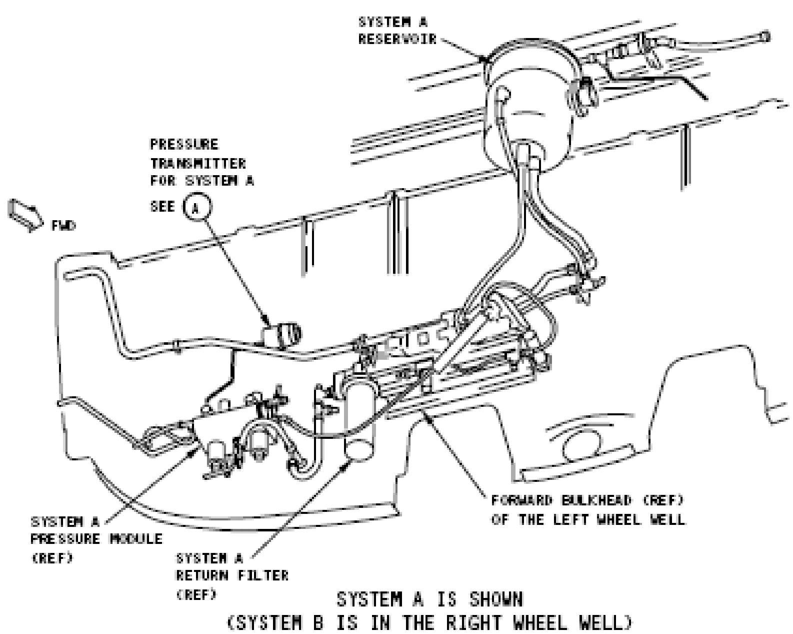

Figure 4.15 Pressure Transmitter Installation

There is a pressure transmitter on the left and right side of the forward bulkhead of the main wheel well. The pressure transmitters are downstream of the A and B system pressure modules, thus they read the system pressure. The transmitter changes the pressure into an electrical signal and sends the signal to the pressure indicator.

The dual needle pressure indicator (gage) (on airplanes without engine instrument system) is on the lower part of the P3 panel. The two digital pressure indicators (on airplanes with engine instrument system) are on the P2 panel. The pressure indicator shows from 0 to 4000 psi. The pressure indicator gets its signal from the pressure transmitter and shows the applicable system A or B pressure.

4.2.6.2 Hydraulic Fluid Quantity Indicating

The hydraulic fluid quantity indicating system shows the quantity of fluid in the A and B reservoirs. There are indicators in the control cabin for the pilots and indicators in the main wheel well (on the side of the reservoirs) for the ground crew. The standby reservoir has a low quantity switch that makes a warning light come on. The indicating systems use 28 volt dc power.

There is a transmitter on the side of each hydraulic reservoir. It uses a float to find the fluid level in the reservoir. The float mechanically moves the indicator that is on the transmitter. The float also moves a synchro which gives a signal equal to the fluid level in the reservoir. The indicator in the control cabin gets the signal from the transmitter and shows the fluid level. The transmitters for system A and B are calibrated differently because the capacities of the reservoirs are different. The mounting holes for the two transmitters are different.

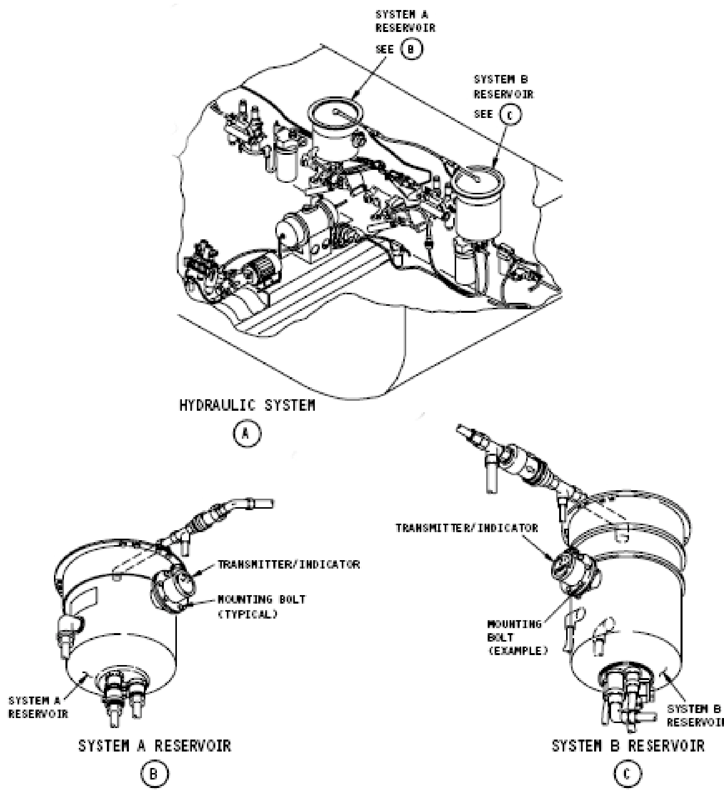

Figure 4.16 Hydraulic Transmitter/Indicator Installation

CHAPTER V
CLOSING

5.1 Conclusion

The modern airplane are using instrument that displayed digitally on the cockpit. This is make a airplane system are very complex. And all aspect that contribute to the airplane condition is need to be precisely monitoring. The engine is the one most important to monitor. This sensor does not function by itself; it is always a part of a larger system that may incorporate many other detectors, signal conditioners, signal processors, memory devices, data recorders, and actuators.

The engine instrument system (EIS) is microprocessor-controlled instrument panels which display parameters of engines and hydraulic systems to monitor airplane engines and hydraulic systems operation. It also displays total air temperature and engine thrust mode annunciation messages. The EIS is composed of two adjacent independent, solid state integrated displays: a Primary Display and a Secondary Display

5.2 Suggestion

Engine Instrument System very useful to monitoring engine condition. So hopefully every passenger aircraft use this system, because it is safety and comfortable And hopefully everyone improve upon the treatment and maintenance of this EIS.

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APPENDIX A

APPENDIX B