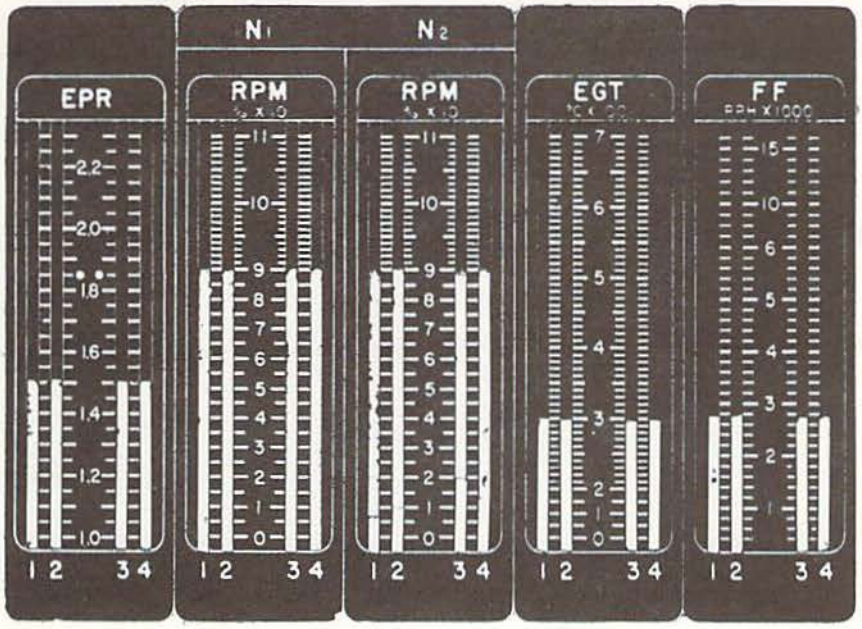
C141A

VERTICAL SCALE ENGINE INSTRUMENTS (VSEI)



443d TECHNICAL TRAINING SQUADRON

443d MILTARY AIRLIFT WING,TNG(MAC)

ALTUS AIR FORCE BASE, OKLAHOMA

23 Jun 77 GPO 500

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INTRODUCTION

This programmed text is designed to teach you the vertical scale engine instrument system, its components, and their locations.

This booklet is arranged in a series of pages in numerical sequence. On each page is a statement or definition concerning the vertical scale engine instrument system. After reading the information, proceed down the page and if required, answer the question on the subject covered. Following each answer or statement are directions to turn to a page number. Follow these directions throughout the program.

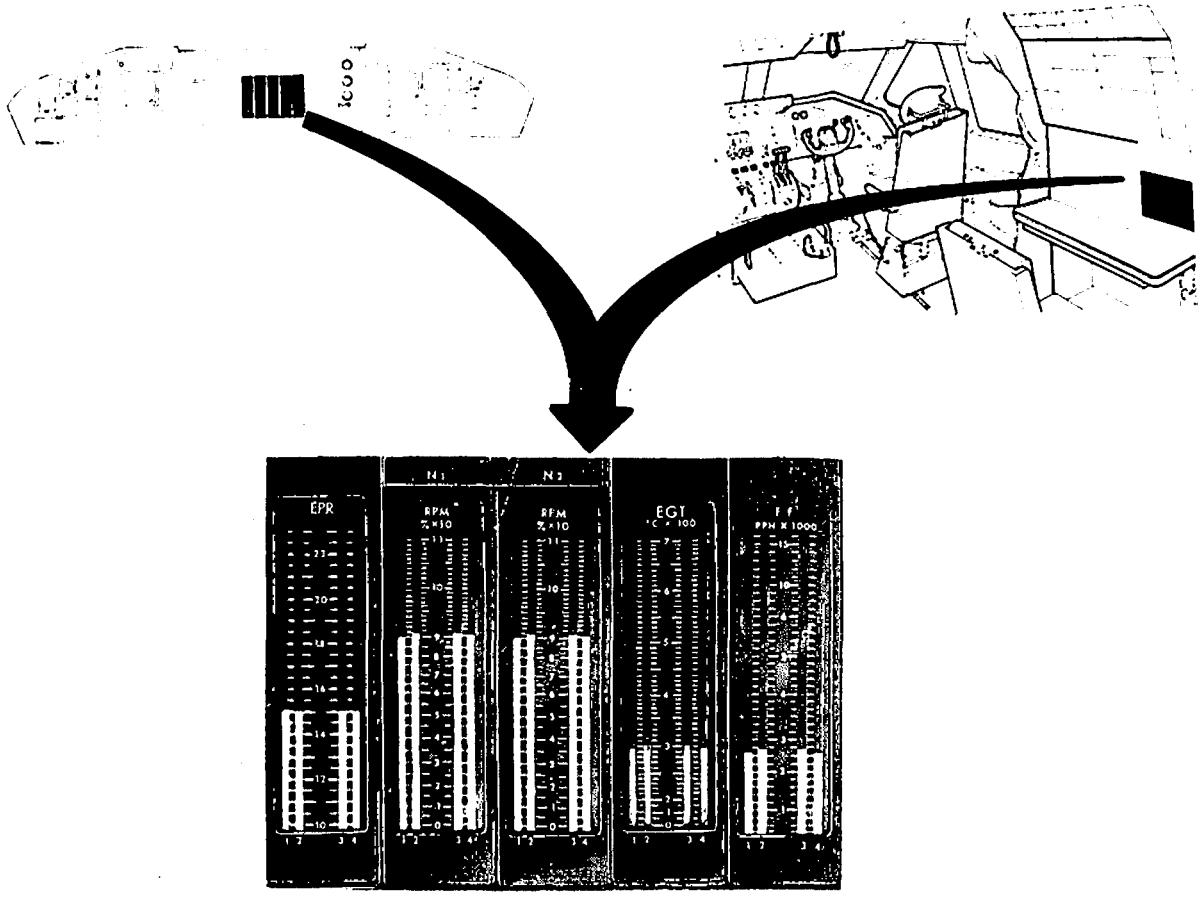
Turn to page B for the objectives of this program.

OBJECTIVES

Upon completion of this program, you will be able to:

1. Identify each vertical scale engine instrument.
2. Locate each vertical scale engine instrument.
3. State the location of the major components of the vertical scale engine instrument system.
4. State the function of the major components of the vertical scale engine instrument system.
5. Identify malfunctions of the vertical scale engine instrument system.
6. Identify the vertical scale engine instrument calibration.

The C-141 Vertical Scale Engine Instrument system (VSEI) is an electro-mechanical system. It uses vertically moving tapes to display a reading on a fixed vertical scale. There are two groups of VSEIs, one located on the pilot's center instrument panel, the other on the flight engineer's panel.



Each group of VSEIs contains five separate instruments. Each instrument contains four individual channels, each channel displaying the engine function for which it is designed. Each channel is electrically and mechanically isolated from the other.

There are other engine instruments used on the C-141 but we are concerned only with the vertical scale engine instruments (VSEIs). The VSEIs and their definitions are:

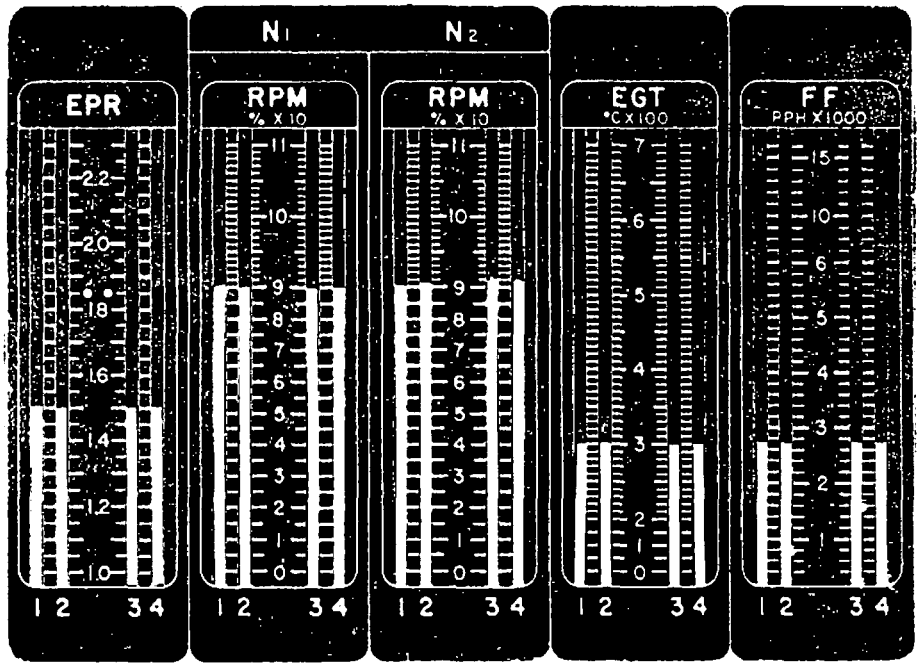
1. EPR - Engine Pressure Ratio - a measurement of engine power, a ratio of engine inlet pressure (Pt_0) to exhaust pressure (Pt_7).

2. N-1 RPM - The speed of the low pressure compressor in %.

3. N-2 RPM - The speed of the high pressure compressor in %.

4. EGT - Exhaust Gas Temperature in degrees C.

5. FF - The Fuel Flow in pounds per hour (PPH) the engine is consuming.



The instruments in each group are displayed at two places, at the pilot and engineer positions. Each position receives the same electrical transmitter signal and electrical power and contain the same protection circuit.

As stated before, the VSEIs are electro-mechanical systems. Each VSEI contains a SERVO MOTOR that will position its vertical tape against a fixed vertical scale in relation to electrical signals received from its transmitter.

The VSEI vertical tape is positioned by a SERVO MOTOR.

From page 3.

Servo motor

The vertical tape is wound on a spool. A spring attached to the spool keeps the tape taut. During normal operation, the servo motor overrides the spring tension and positions the tape.

The spring positions the tape during normal operations.

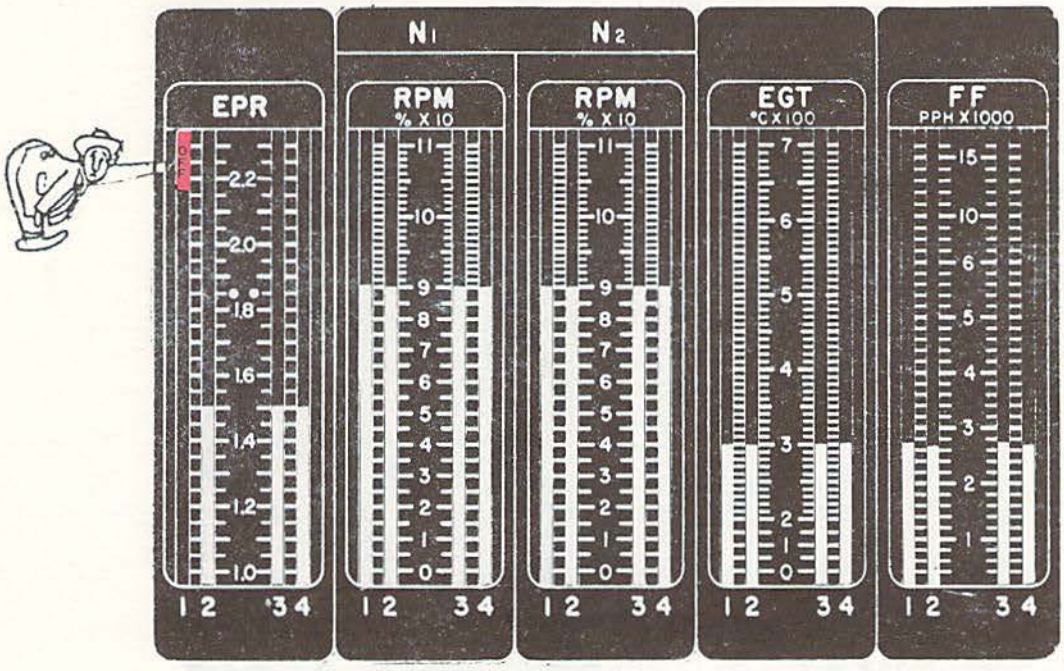
( ) True

(✓) False

(X) False

Okay, we know the VSEI tape is wound on a spool, a spring is attached to the spool and a servo motor overrides the spring to position the tape.

Another feature of the *spring* is to *rewind* the tape on the spool in case of ELECTRICAL failure to the instrument. In this case, spring tension will rewind the tape and expose the word "OFF" on a red portion at the top of the instrument.



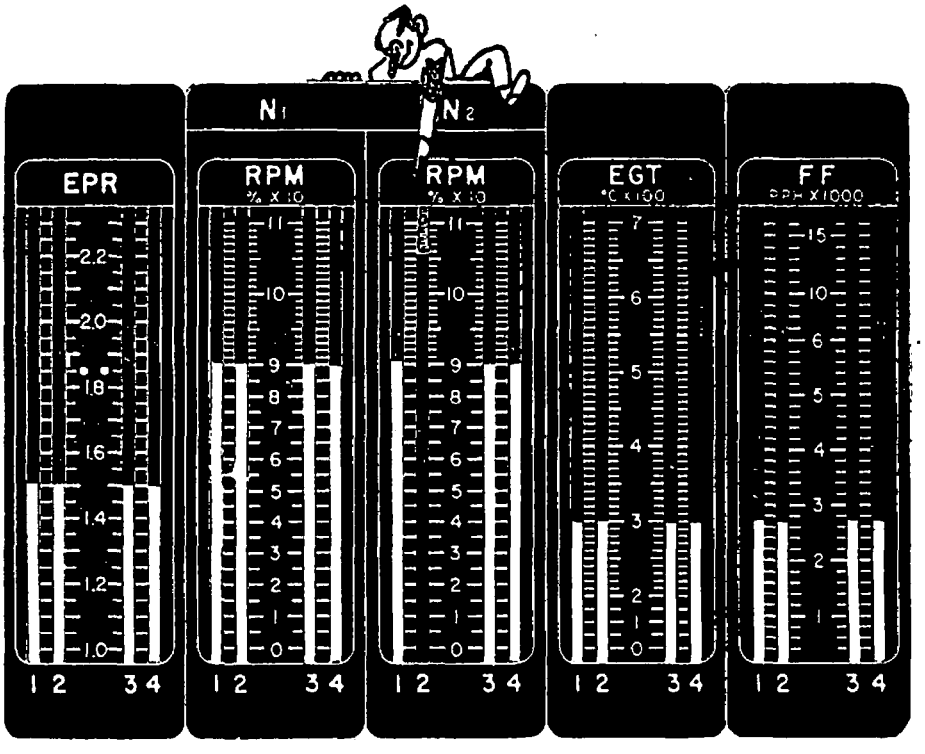
The word "OFF" on the red portion of the tape will appear at the top of the VSEI in event of Elec failure to the instrument.

(X) electrical

Electrical failure to the VSEI will be shown by the word "OFF" on the red portion of the tape in view at the top of the instrument.

The next item to consider is the GROUPING of the instruments. Notice the engine groupings on each individual instrument, i.e.; engines 1, 2, 3 and 4.

The diagram below is a normal engine running indication except for one instrument.



The above malfunction indicates:

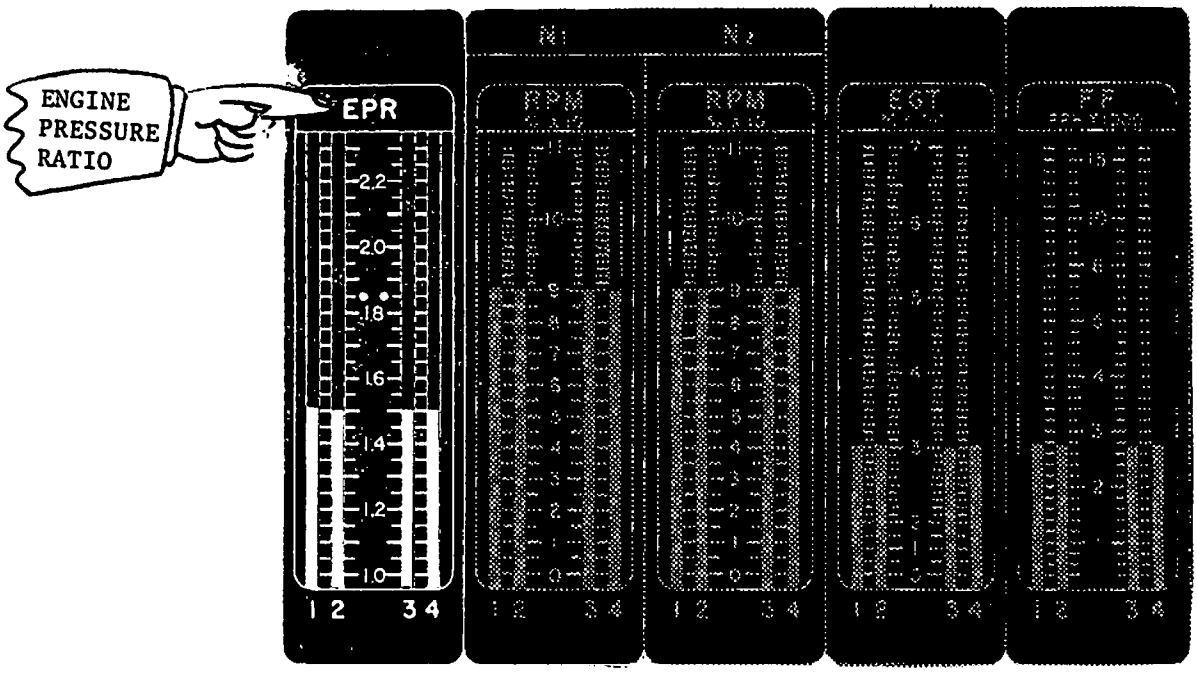
( ) electrical failure to N-2 RPM indicator, No. 1 engine.

(✓) electrical failure to N-2 RPM indicator, No. 2 engine.

(X) electrical failure to N-2 RPM indicator, No. 2 engine.

No. 2 engine N-2 RPM VSEI does have an electrical failure.

The first VSEI we'll discuss is the EPR. Remember EPR means ENGINE PRESSURE RATIO. This ratio is sensed between Pt_0 (inlet pressure) and Pt_7 (exhaust pressure) of the engine and is a measurement of engine thrust.



The ratio between inlet pressure and exhaust pressure is

( ) EGT

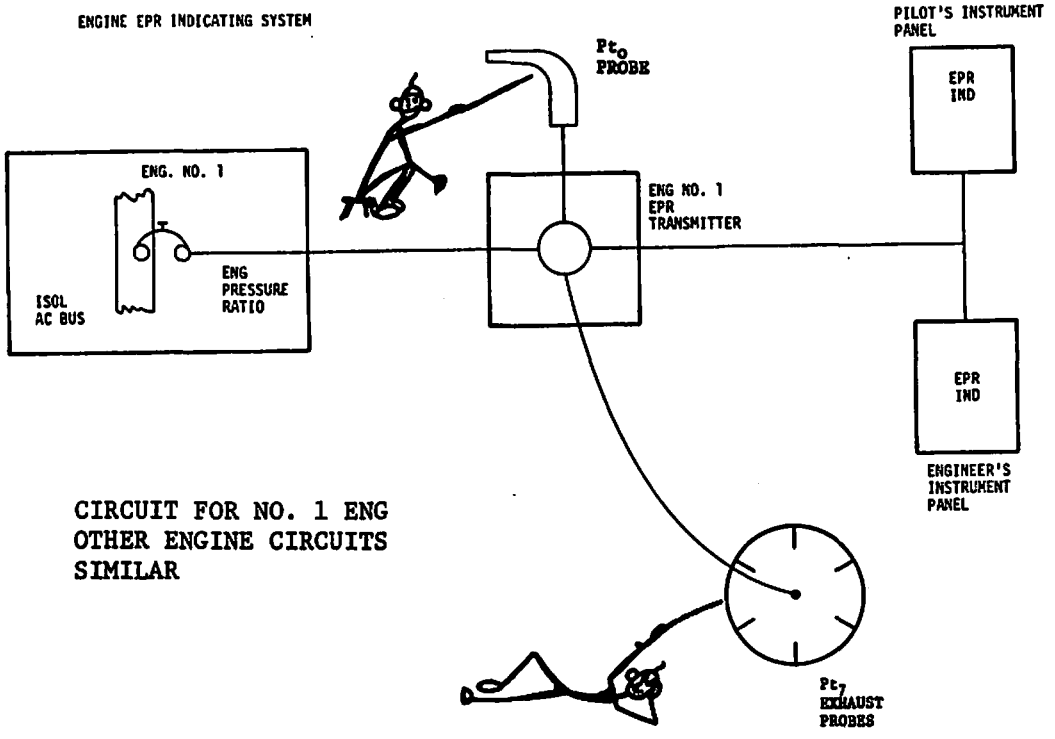
(✓) EPR

( ) RPM

(X) EPR

Now more on the EPR system.

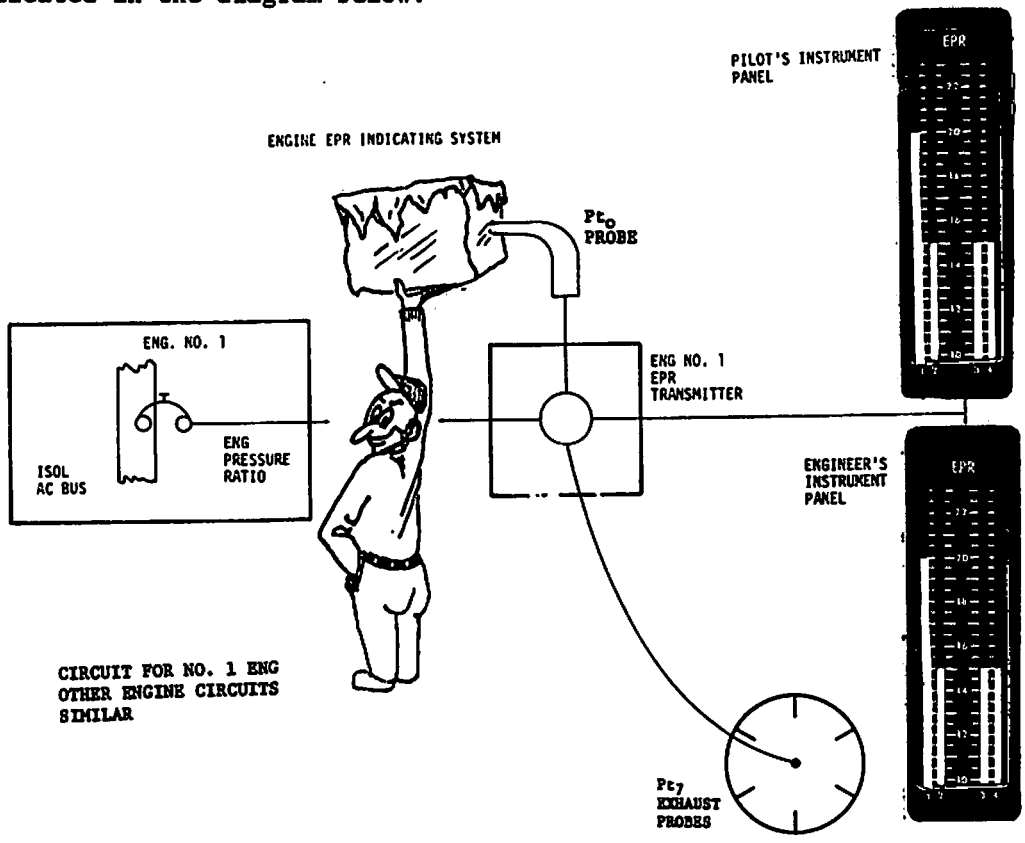
EPR means Engine Pressure Ratio. If this is true, we must have a means to measure this ratio. A probe mounted on each pylon senses the inlet pressure (Pt_0) and 6 probes in the exhaust section of the engine senses exhaust pressure (Pt_7). Hence, the inlet to outlet pressure ratio.



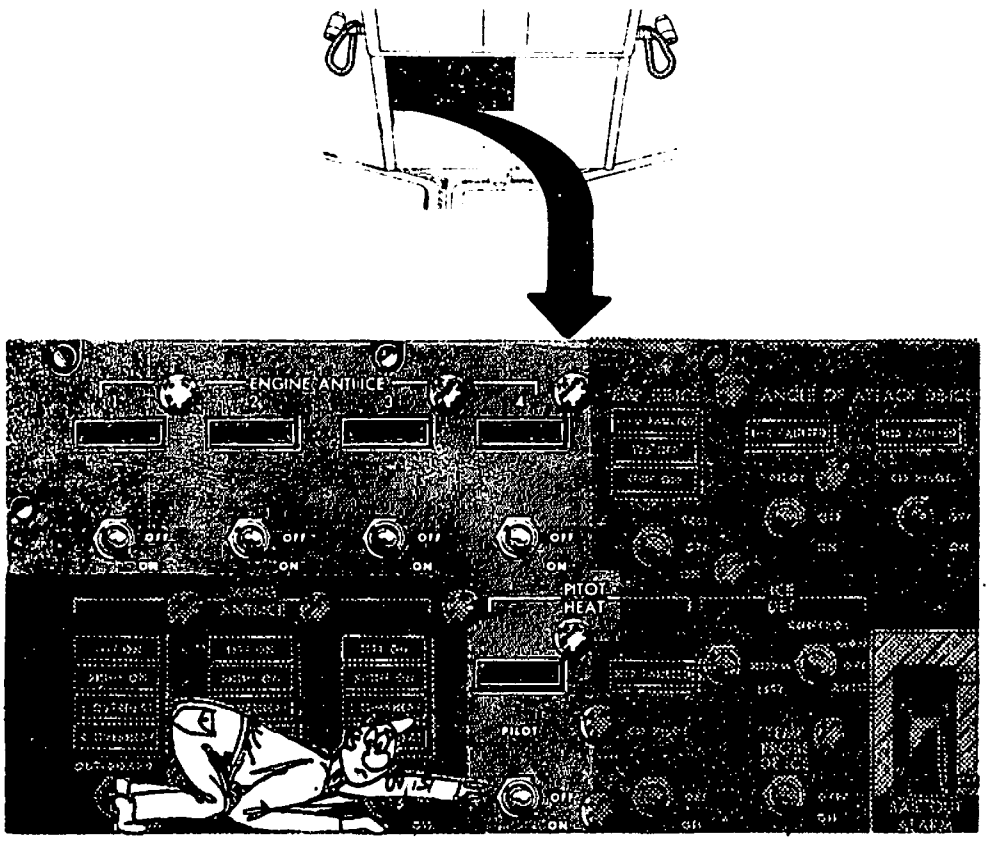
Inlet pressure of the engine is sensed by a pylon mounted probe; exhaust pressure is sensed by 6 probes in the exhaust section.

To prohibit icing, the inlet probes are electrically anti-iced. The exhaust probes, mounted in the exhaust section, do not require this protection.

You have just learned the EPR indication is a ratio of inlet pressure (Pt_0) to exhaust pressure (Pt_7). Should the inlet probe be blocked with a foreign particle such as ice, the inlet pressure would be lost and the only signal present would be exhaust pressure causing the EPR indication to rise to a higher than normal reading. If uncorrected, it would rise to a higher scale reading as indicated in the diagram below.



All the inlet probe heaters are actuated automatically when the PILOT PITOT HEAT switch is turned on. These heaters are also individually turned on when the pilot turns on the engine anti-ice switch for its respective engine. These switches are located on the pilot's overhead panel.



All the inlet probe heaters are actuated automatically by turning on the Pilot's Pitot Heat Switch and individually by its respective engine anti-icing switch.

(✓) True

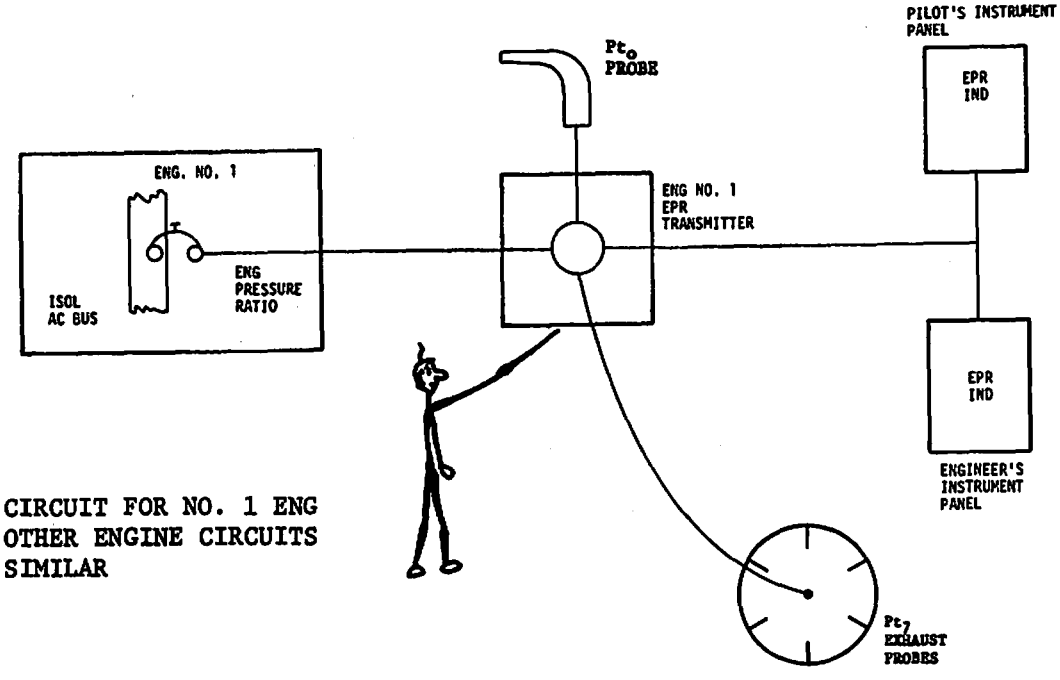
( ) False

(X) True

All the inlet probe heaters are turned on automatically by the pilot's pitot heat switch, and individually by its respective engine anti-icing switch.

You'll recall, each VSEI is positioned by a servo motor from signals it receives from its transmitter.

An EPR converter TRANSMITTER is located in each engine PYLON and contains its own ratio sensor and transmitting servo loop. It receives the inlet and exhaust pressure signals from the engine and sends the indication to its respective EPR indicators.



CIRCUIT FOR NO. 1 ENG
OTHER ENGINE CIRCUITS
SIMILAR

An EPR converter transmitter is located in each engine_____.

(✓) pylon

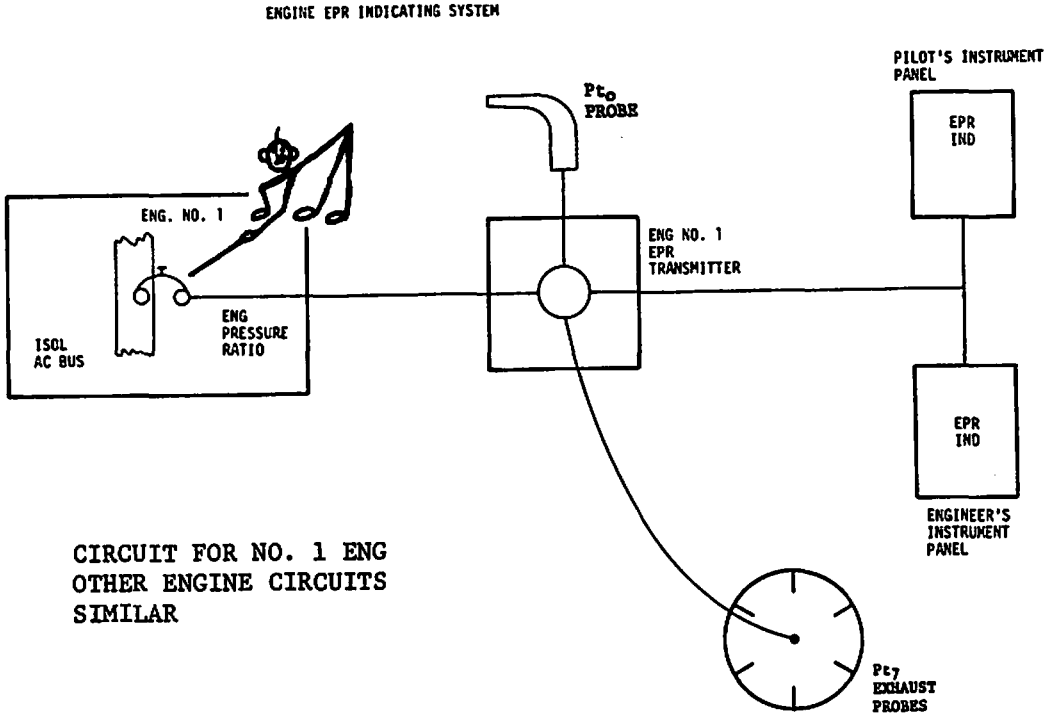
( ) section

(X) pylon

Yes, an EPR converter transmitter is located in each engine pylon.

Let's go on now.

The EPR system receives 115 VOLT, 400 CYCLE, SINGLE PHASE AC power from the Isolated AC Bus through an individual circuit breaker for each engine. The EPR system does not incorporate fuses; therefore, the circuit breaker is the only protection available.



The EPR system receives power through a circuit breaker for each engine from the essential AC bus.

( ) True

(✓) False

(X) False

This is an erroneous statement. The EPR system receives power for each engine system from the ISOLATED AC BUS.

We know the EPR system receives power from the isolated AC bus through an individual circuit breaker for each system. If the red "OFF" portion of an EPR tape is in view at both the pilot's and engineer's position for the same indicator, then we know there is an electrical loss common to both indicators. The most probable cause of this malfunction is an open EPR circuit breaker on the isolated AC bus.

PILOT EPR INDICATOR

ENGINEER EPR INDICATOR

The above EPR VSEIs indicate what probable malfunction?

( ) An open fuse on the isolated AC bus.

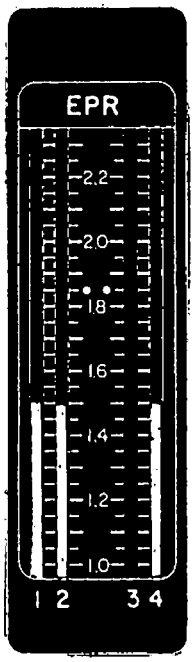
(✓) An open circuit breaker on the isolated AC bus.

(X) An open circuit breaker on the isolated AC bus.

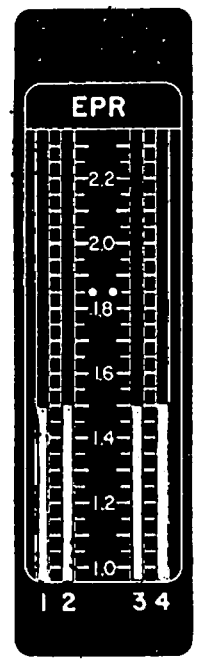
The circuit breaker is open on the isolated AC bus.

Another malfunction you may observe is the EPR indicators not indicating a reading at one or both of the EPR indicators. If there is not an indication at both the pilot's and engineer's like EPR tapes, it is indicative of a failed EPR transmitter. If only one indicator at either position does not indicate a reading, it indicates a mechanical failure of that individual indicator.

PILOT EPR INDICATOR



ENGINEER EPR INDICATOR



The above EPR VSEIs indicate:

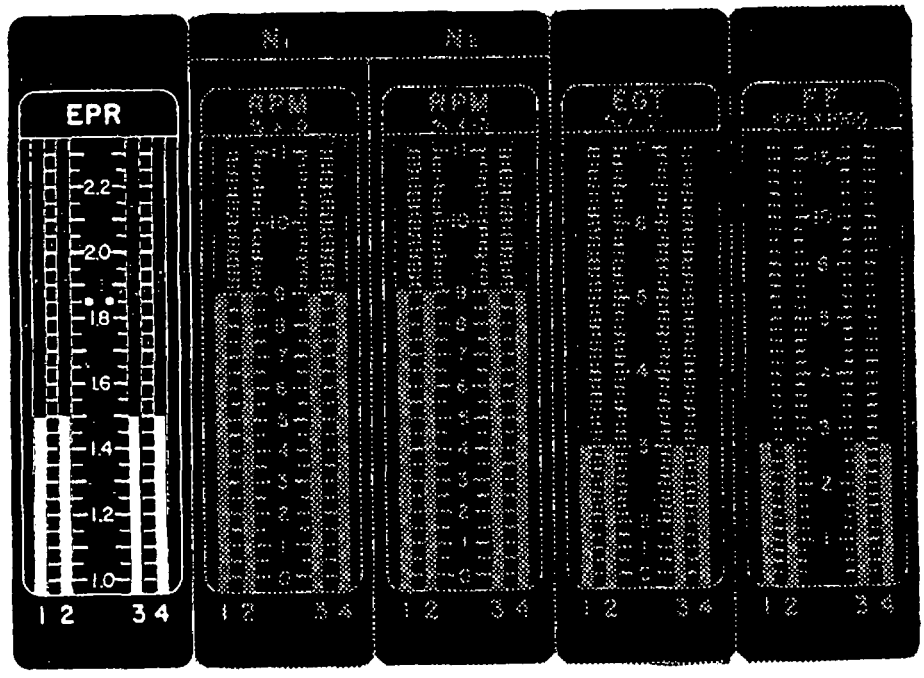
( ) Transmitter failure of the #3 EPR engine system.

(✓) Mechanical failure of the pilot's #3 engine EPR indicator.

With a mechanical failure of an individual indicator, there will not be a reading on the affected indicator.

Now for the EPR VSEI calibration.

The RANGE of the EPR indicator is 1.0 to 2.3 as shown below. Remember, this indicates the pressure ratio difference between the inlet (Pt_0) and outlet (Pt_7) pressure of the engine.



The EPR reading indicated above is

(✓) 1.5 EPR

( ) 1.05 EPR

(X) 1.5 EPR

Correct. You've done well with the EPR system.

Now for a review of what we have covered.

1. The VSEIs are as follows.

   a. EPR - Engine pressure ratio.

   b. N-1 RPM - Low compressor speed in %.

   c. N-2 RPM - High compressor speed in %.

   d. EGT - Exhaust Gas Temperature in degrees C.

   e. FF - Fuel Flow in pounds per hour (PPH).

2. The VSEIs are an electro-mechanical system.

3. There are two groups of VSEIs, one at the pilot's center instrument panel, the other at the engineer's panel.

4. Each group of VSEIs contain five individual instruments.

5. Each instrument contains 4 individual channels, each channel displaying the engine function for which it is designed on a movable, vertical tape against a fixed scale.

6. The servo motor overrides spring tension during normal operation.

7. A spring is attached to the spool to keep the tape taut and expose the red "OFF" portion of the tape upon elect power failure of the system.

8. Each vertical scale tape is positioned by a servo motor from signals it receives from its respective transmitter.

9. The EPR system is an indication of the ratio between inlet pressure (Pt_0) and outlet pressure (Pt_7) of the engine.

10. A probe mounted on the pylon senses inlet pressure (Pt_0) and 6 probes mounted in the exhaust section senses exhaust pressure (Pt_7).

11. The inlet probes contain electrical heaters to prohibit icing; the exhaust probes do not require icing protection.

12. All the engine inlet probe heaters are turned on automatically when the pilot turns on his pitot heater switch. Individual engine inlet probe heater actuation is accomplished whenever that individual engine anti-icing switch is turned on.

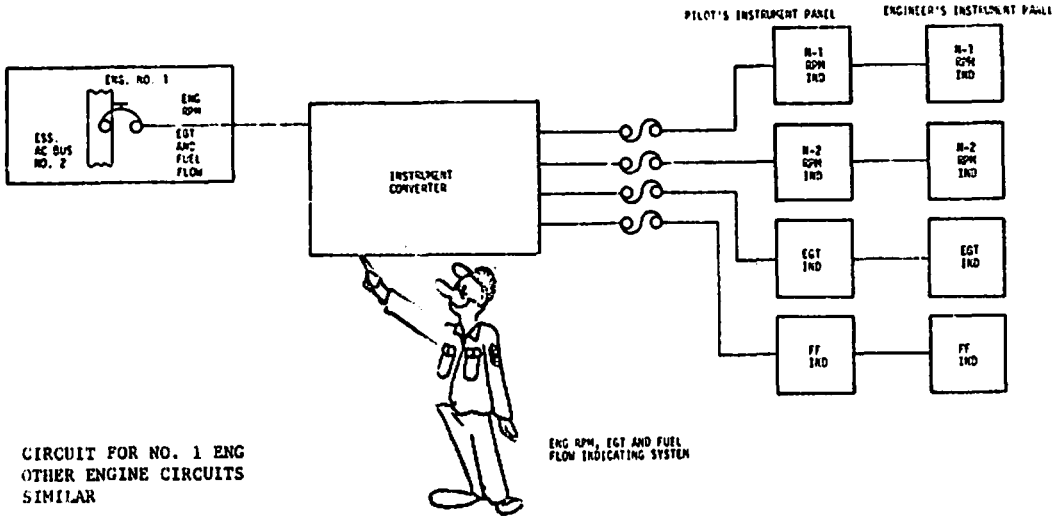
13. The EPR system contains its own EPR converter transmitter located in each engine pylon. It receives inlet (Pt_0) and outlet (Pt_7) signals and sends this indication to its respective EPR transmitters.

14. The EPR system receives 115 V, 1Ø, AC power from the Isolated AC Bus through a circuit breaker for each engine. This is the only protection available for the EPR system; <u>no fuses</u> are incorporated in this system.

15. The EPR system is calibrated from 1.0 to 2.3 EPR on the indicator.

Now, we'll go into the other VSEIs, the N-1 RPM, N-2 RPM, EGT, and FUEL FLOW. These VSEIs are constructed the same as the EPR indicators. Each has indicators that display all 4 engine indications for its particular mode, one indicator located at the pilot's position, the other at the engineer's panel.

The instrument converter serves all the N-1, N-2, EGT, and FF VSEIs. It receives input signals from each engine transmitter, amplifies and converts these signals to the VSEIs. The converter is located in the right underdeck area.



CIRCUIT FOR NO. 1 ENG
OTHER ENGINE CIRCUITS
SIMILAR

The instrument converter receives engine transmitter signals for all VSEIs with the exception of the EPR system.

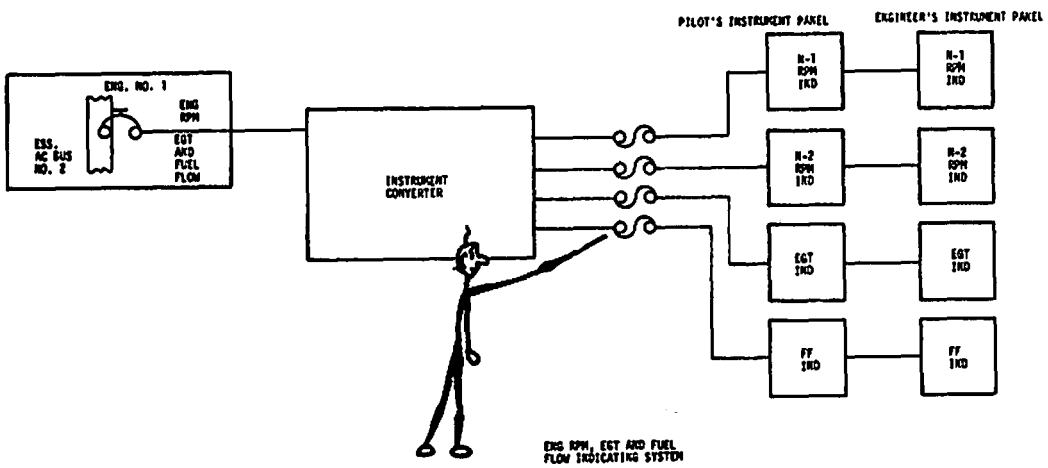
(✓) True

( ) False

(X) True

All the VSEIs utilize an instrument converter with the exception of the EPR system.

The instrument converter receives 4 different modes of signals from each engine, N-1 RPM, N-2 RPM, EGT and FF. This makes a total of 16 incoming signals from the engines. Each of the <u>indicators</u> are protected from malfunctions by an individual fuse located on the instrument converter.



CIRCUIT FOR NO. 1 ENG
OTHER ENGINE CIRCUITS
SIMILAR

The indicators are protected by:

(✓) fuses

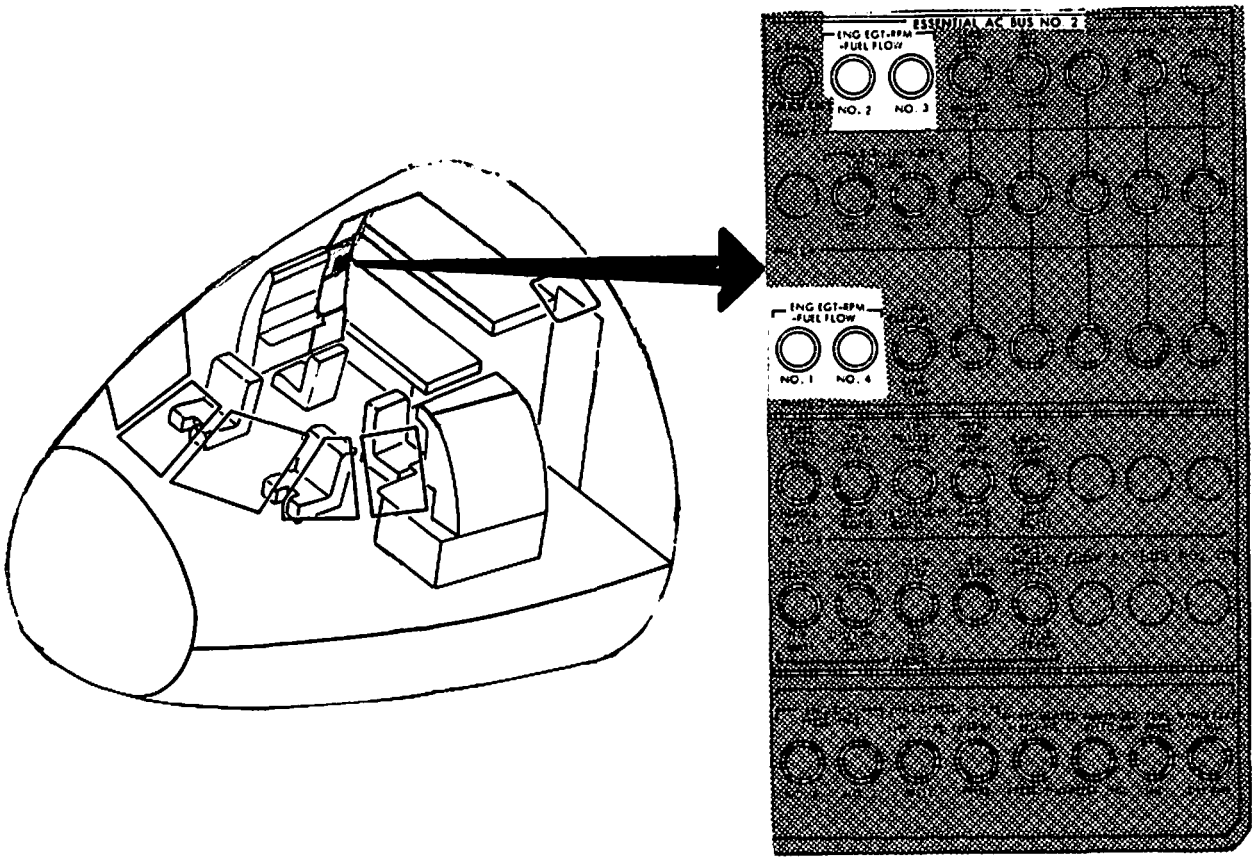
( ) no protection

( ) circuit breakers

(X) fuses

There are 16 fuses on the instrument converter.

The instrument converter receives 115 VOLT, 400 CYCLE, SINGLE PHASE power from the ESSENTIAL AC Bus #2. Four CIRCUIT BREAKERS are installed on this bus, one for each engine. Each circuit breaker protects the instrument CONVERTER for all 4 functions of each engine. They are labeled engine EGT, RPM, Fuel Flow. This is provided for each engine. We can say then, we have group protection.



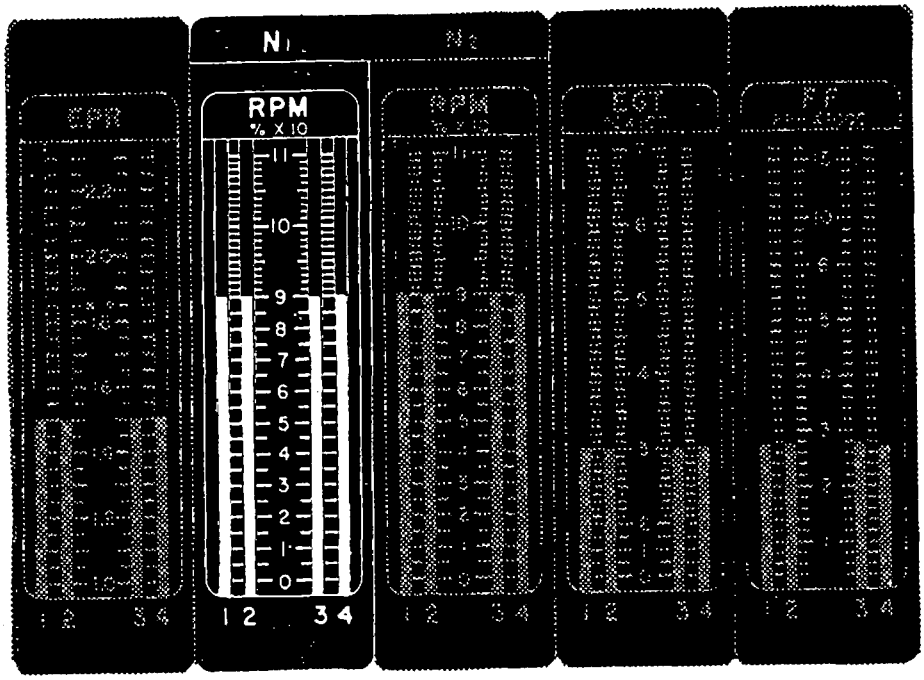
The instrument converter receives 115 VOLT, 400 CYCLE, SINGLE PHASE power from the ESSENTIAL AC Bus #2 through:

(✓) Circuit breakers

( ) Fuses

(X) Circuit breakers

Yes, the instrument converter is protected by circuit breakers, one for each of the engine's 4 functions. Consider it group protection.



The N-1 indicator reflects the speed of the LOW PRESSURE COMPRESSOR in %. The tach transmitter, located on the nose section of each engine, sends the signal to the instrument converter which amplifies and sends the signal to the N-1 VSEIs. Remember, one FUSE for each engine N-1 RPM indicating system is located on the instrument converter for a total of four fuses.

Can we say that each engine N-1 RPM VSEI system is protected by a fuse on the converter?

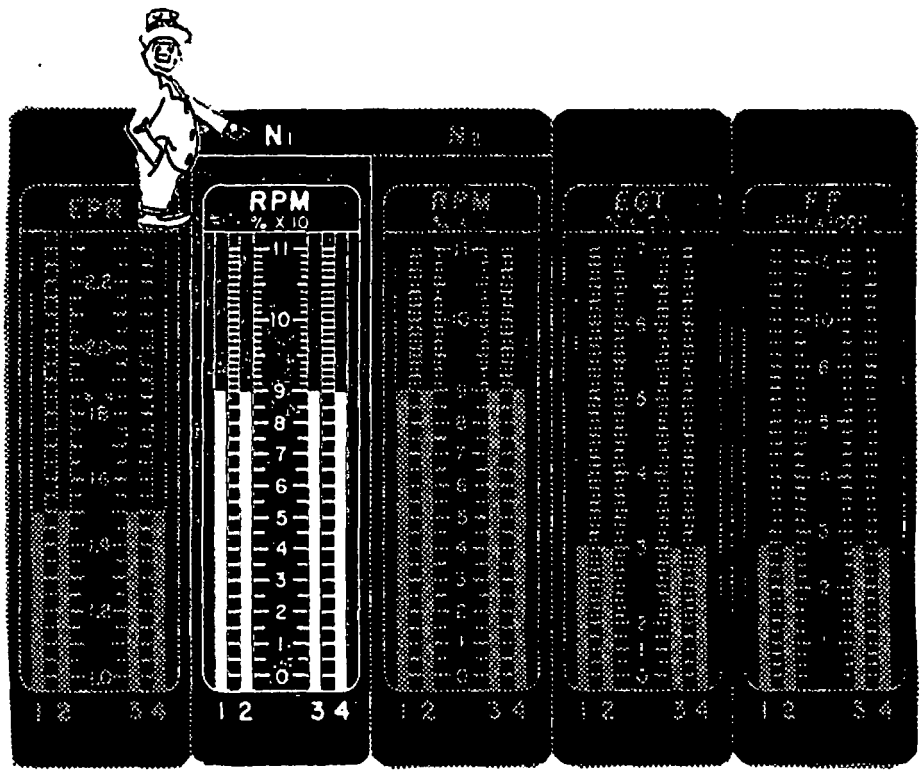
(✓) Yes

( ) No

(X) Yes

Sure we can. Each N-1 VSEI system is protected by a fuse on the instrument converter.

As stated before, the N-1 RPM VSEIs display the N-1 low speed compressor speed in %. The VSEI is calibrated from 0% to 110%. The range from 0% to 90% is in 5% increments, from 90% to 110% in 1% increments.



The above N-1 VSEI indicates most nearly

( ) 84%

(✓) 90%

( ) 87 RPM

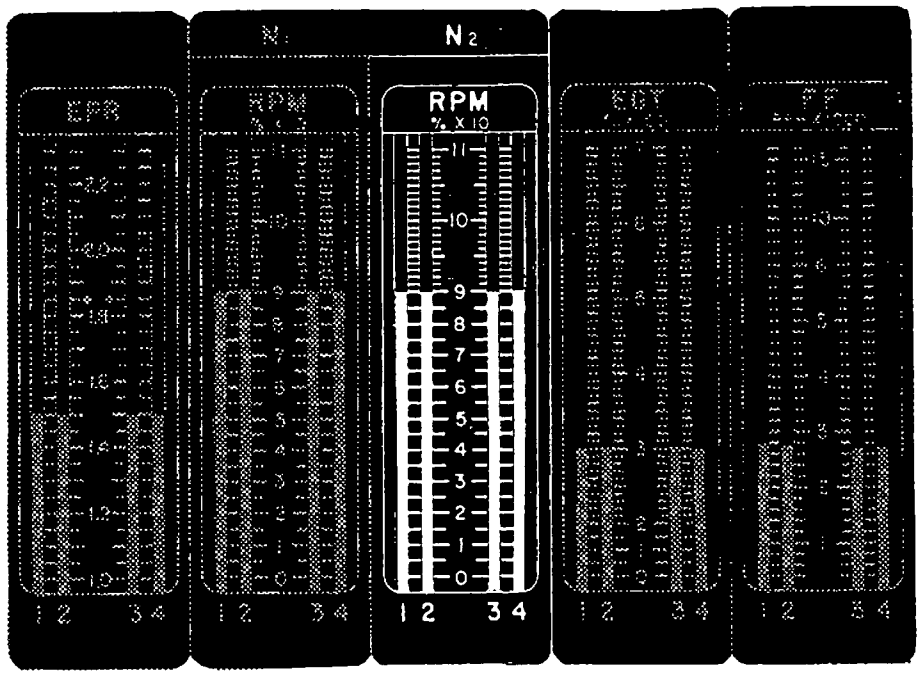
(X) 90%

Yes, you are correct.

Now we must move on to the N-2 RPM indicating system.

The N-2 RPM VSEIs display the speed in % of the HIGH SPEED COMPRESSOR. A tach transmitter located on the engine accessory section of each engine sends a signal to the instrument converter which, in turn, amplifies the signal to the VSEIs.

Sound familiar? It is; with the exception of the high speed compressor indication and the location of the tach transmitter, this system is identical to the N-1 RPM system.



The N-2 VSEI indicates the speed of the

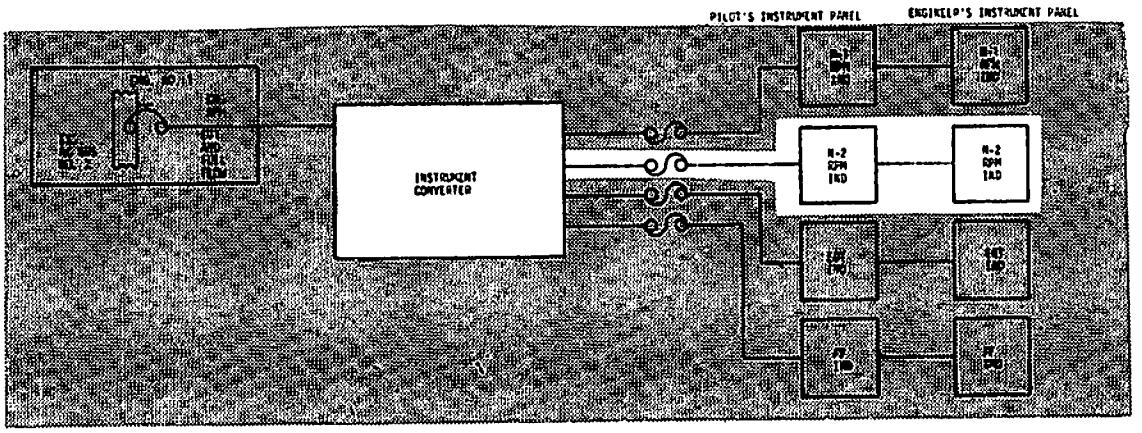
(✓) high speed compressor

( ) low speed compressor

(X) high speed compressor

Yes, N-2 indicates the speed of the high speed compressor in %.

The N-2 tach transmitter is located on the accessory section of each engine. This transmitter signal is sent to the INSTRUMENT CONVERTER which amplifies it to the VSEIs. A fuse for each engine is located on the instrument converter to protect the N-2 VSEIs.



ENG RPM, EGT AND FUEL FLOW INDICATING SYSTEM

CIRCUIT FOR NO. 1 ENG
OTHER ENGINE CIRCUITS
SIMILAR

A tach mounted on the accessory section of the engine sends a signal to the /_____ _____.

( ) N-2 VSEIs

(✓) instrument converter

(X) instrument converter

Right, the signal must be amplified at the instrument converter to be sent to the VSEIs.

The electrical power, circuit breakers and calibration for N-2 RPM are the same as for N-1 RPM.

We can say then that the N-2 RPM system is identical to the N-1 except for the high speed compressor indication and transmitter location.

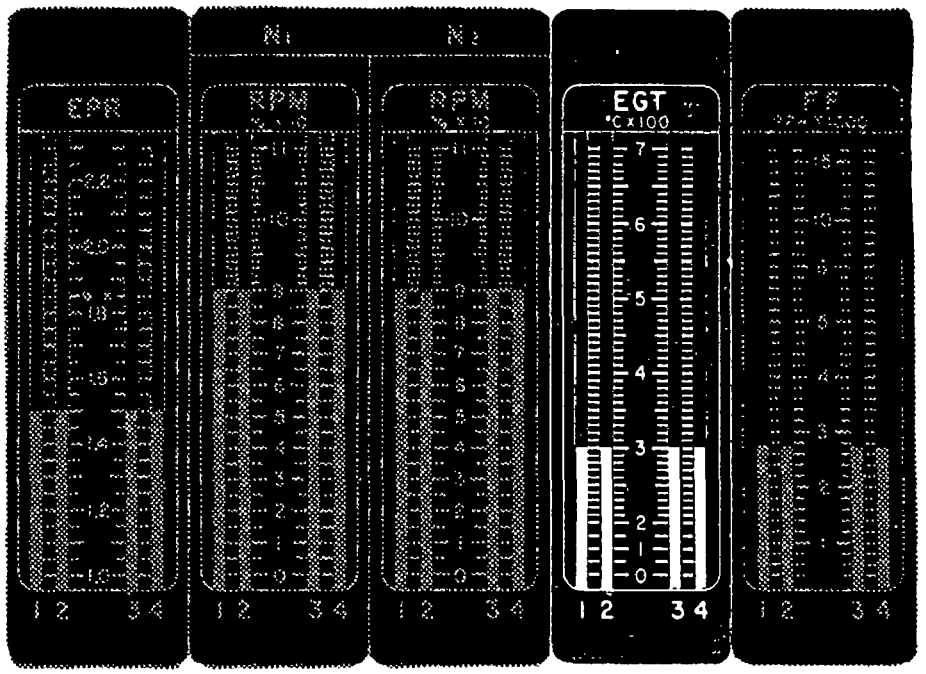
(✓) True

( ) False

(X) True

It is identical except for the high speed compressor indication and tach transmitter location.

The EGT VSEIs indicate the exhaust gas temp of the engine. This temp is sensed at the exhaust of the engine by 6 temp PROBES and the signal sent to the instrument converter.



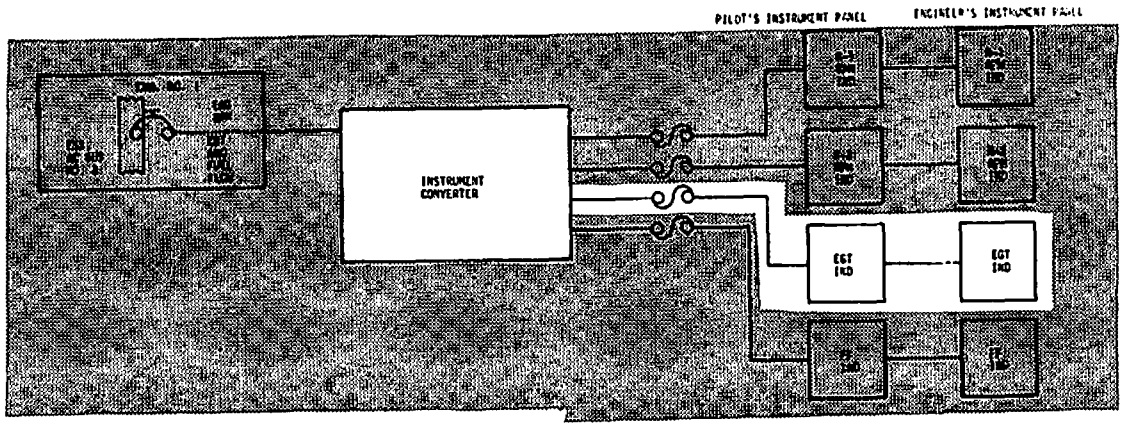
EGT is sensed at the engine exhaust by six temp_____.

(✓ probes

( ) transmitters

(X) probes

The EGT probe signal is received at the instrument converter which amplifies it and sends it to the VSEIs. A FUSE is located on the instrument converter for EACH ENGINE EGT VSEI system.



ENG RPM, EGT AND FUEL FLOW INDICATING SYSTEM

CIRCUIT FOR NO. 1 ENG
OTHER ENGINE CIRCUITS
SIMILAR

Located on the instrument converter are _____fuses to protect all the EGT VSEIs.

( ) 1

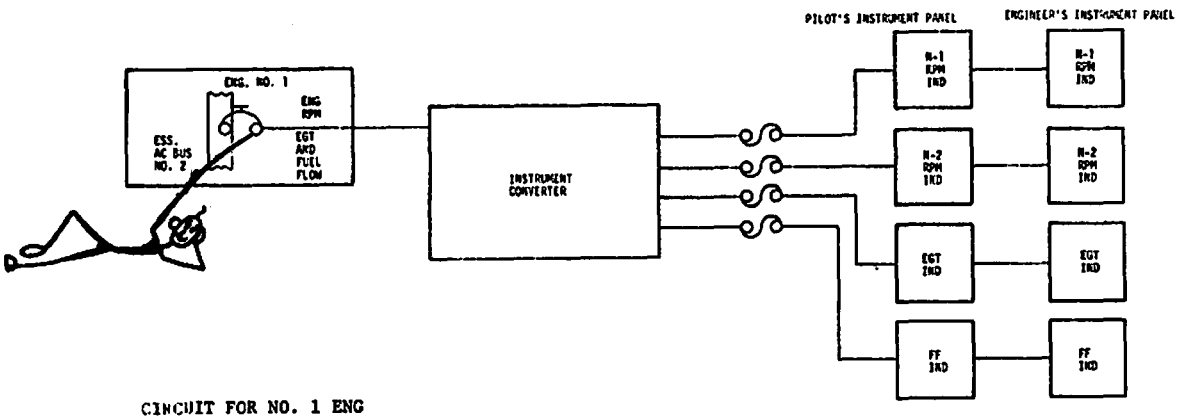
(✓) 4

( ) 8

(X) 4

Right, there is a fuse for each engine EGT signal to the VSEIs.

The electrical power, 115 VOLT, 400 CYCLE, SINGLE PHASE, for the EGT system is obtained from the ESSENTIAL #2 AC BUS through an individual circuit breaker for each engine. This circuit breaker is labeled ENG EGT - RPM - FUEL FLOW. This is provided for each engine.



CIRCUIT FOR NO. 1 ENG
OTHER ENGINE CIRCUITS
SIMILAR

ENG RPM, EGT AND FUEL
FLOW INDICATING SYSTEM

The electrical power for the EGT system is obtained from the_____ AC bus.

(✓) Essential AC #2

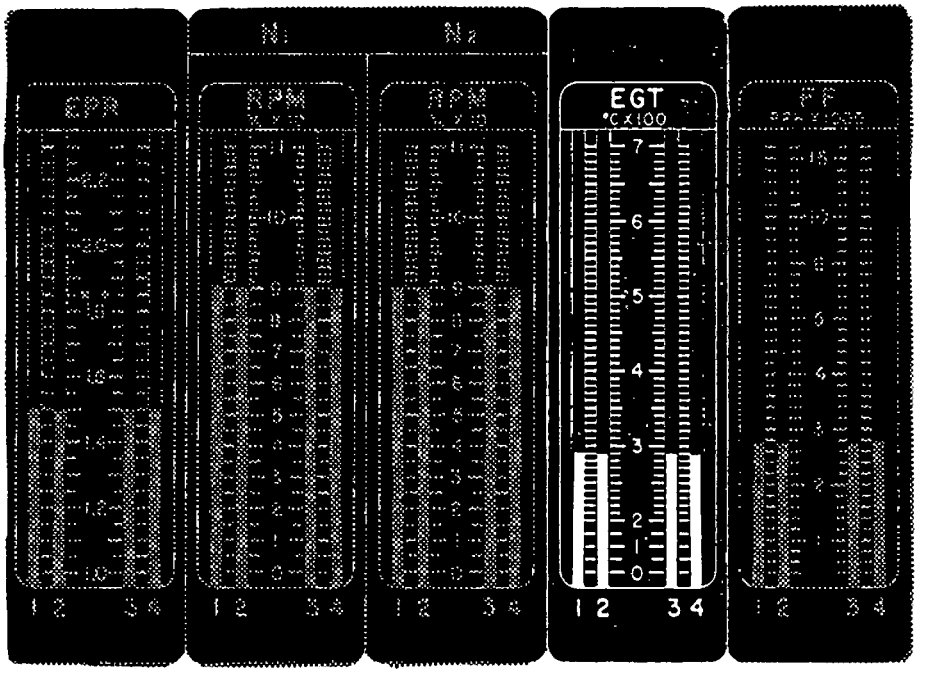
( ) Isolated

( ) Main

(X) Essential AC #2

You bet. Power is taken from the ESSENTIAL AC NO. 2 BUS through a circuit breaker for each engine.

The EGT indicator is calibrated from 0° to 700° C, from 0° to 200° in 50° increments, 200° to 700° in 10° increments.



The above EGT VSEIs indicate

( ) 290° F

(✓) 290° C

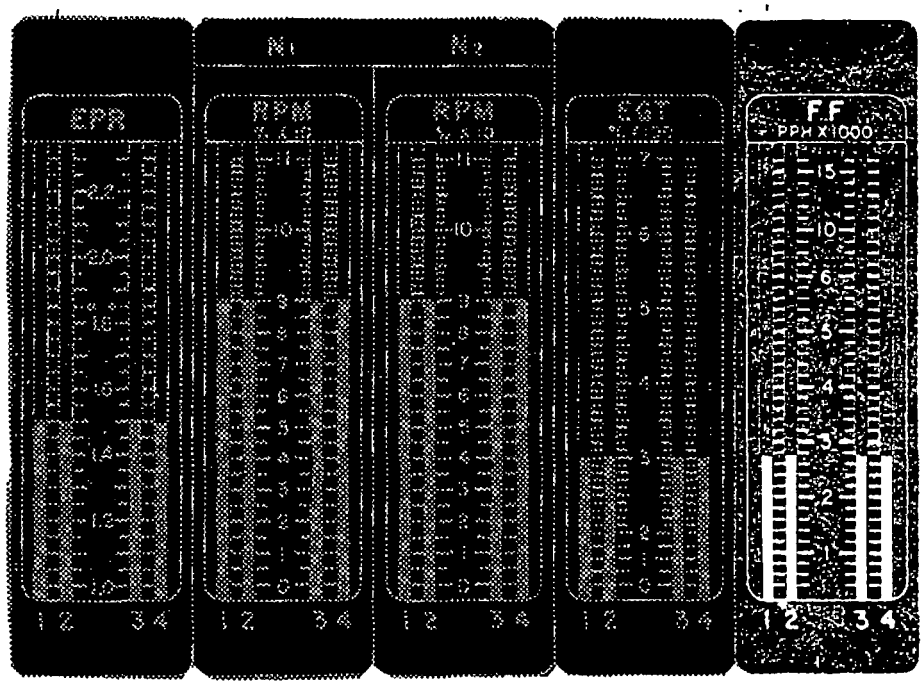
( ) 280° C

(X) 290°C

Good. You're able to read the indicator and know its calibrated in °C.

Now to cover the last of the VSEIs.

The Fuel Flow VSEI is a measurement of fuel flow in POUNDS PER HOUR that the engine is consuming.



The fuel flow VSEI shows the amount of fuel the engine is using in _____per hour.

( ) gallons

(✓) pounds

(X) pounds

Pounds is correct.

Each fuel flow transmitter is located on the right side of each engine. It measures the amount of fuel flow and sends a signal to the INSTRUMENT CONVERTER.

The fuel flow transmitter measures fuel flow and sends the signal to the _____ _____.

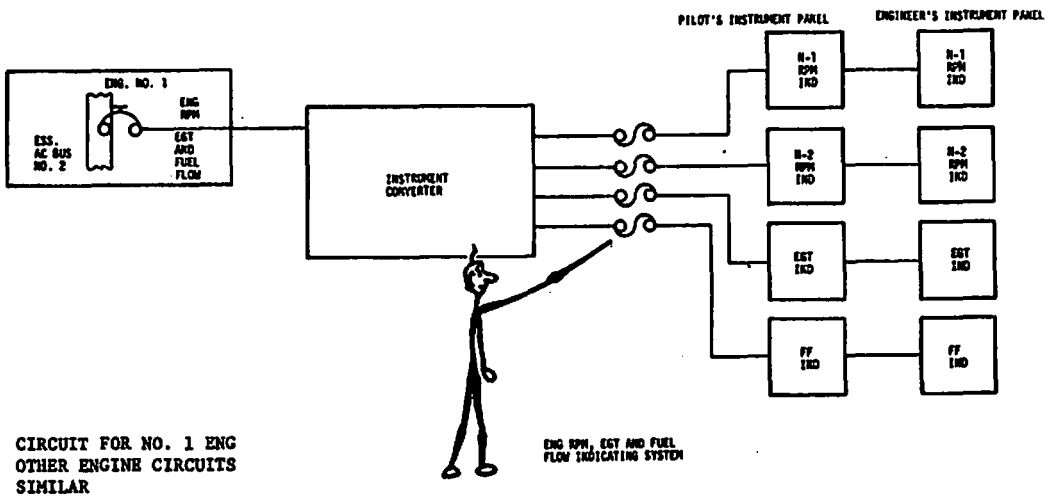
( ) FF VSEI

(✓) instrument converter

(X) instrument converter

You are right.

The fuel flow signal is received by the instrument converter, amplified and sent to the fuel flow VSEIs. A fuse is installed on the instrument converter for each engine fuel flow signal to the VSEIs.



CIRCUIT FOR NO. 1 ENG
OTHER ENGINE CIRCUITS
SIMILAR

Each engine fuel flow signal is sent to the instrument converter, amplified and sent to the VSEIs. A fuse on the instrument converter protects each engine's fuel flow VSEIs.

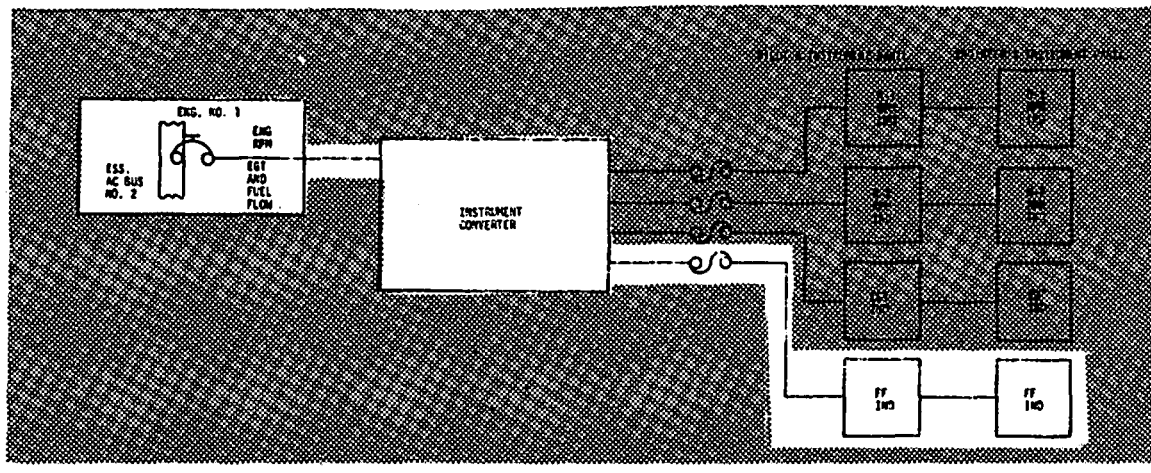
(✓) True

( ) False

(X) True

The electrical power is the same as the other VSEIs (with the exception of the EPR, which, you will recall, is powered through the isolated AC bus).

115 VOLT, 400 CYCLE, SINGLE PHASE power is taken from the ESSENTIAL AC BUS NO. 2 through a circuit breaker for each engine. These circuit breakers are labeled ENG EGT, RPM, and Fuel Flow.



CIRCUIT FOR NO. 1 ENG
OTHER ENGINE CIRCUITS
SIMILAR

ENG RPM, EGT AND FUEL
FLOW INDICATING SYSTEM

AC power is obtained for the FUEL FLOW VSEIs form the ESSENTIAL AC BUS NO. 2.

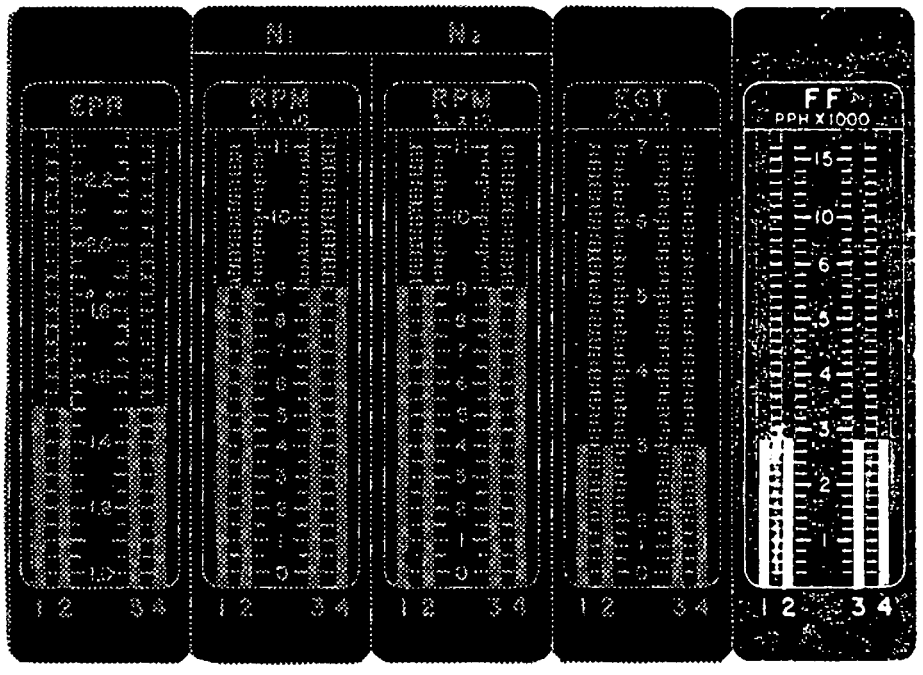
(✓) True

( ) False

(X) True

Essential AC Bus AC NO. 2 is the power source.

The fuel flow VSEIs are calibrated in POUNDS PER HOUR from 0 to 16000 PPH. 0 PPH to 6000 PPH is in 200 PPH increments, 6000 to 16000 PPH in 1000 PPH increments.



The total fuel flow indication above is most nearly_____for all 4 engines.

(C) 2,800 PPH

(A) 11,200 PPH

( ) 11,200 PPM

(X) 11,200 PPH

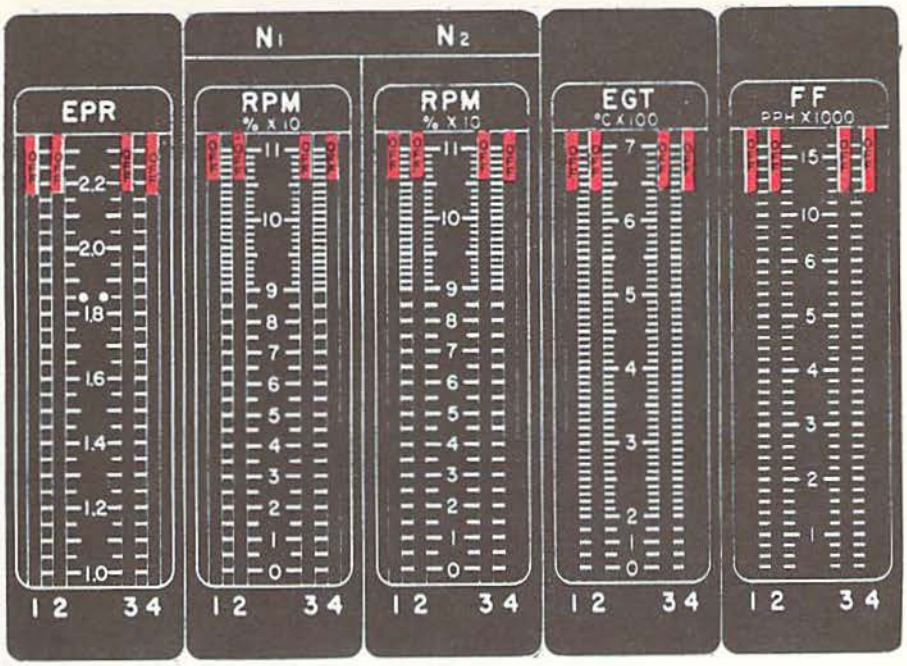
You're right. The total fuel flow for all the engines is 2,800 x 4 = 11,200 PPH.

Now for a quick review.

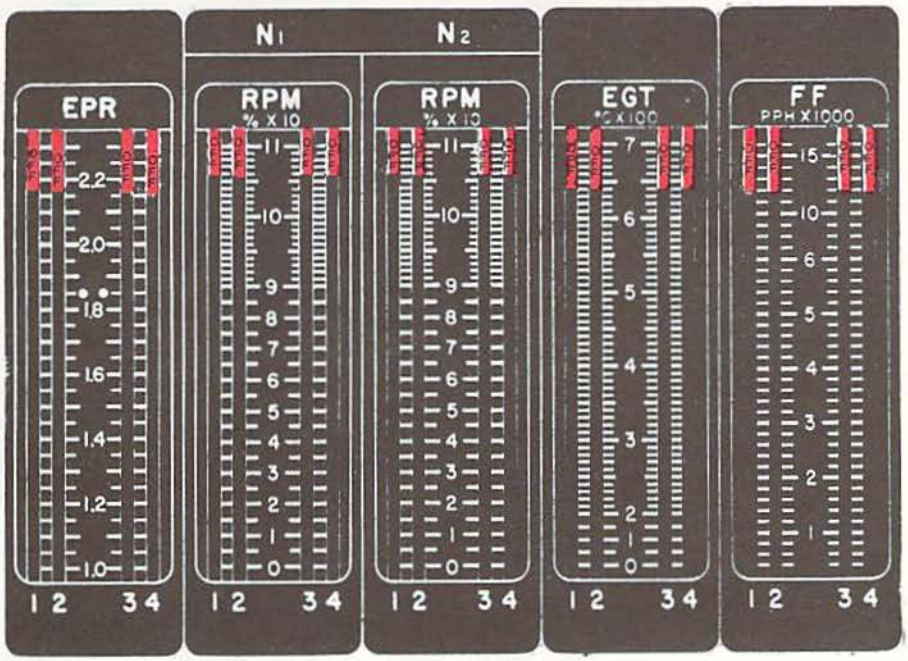
1. The VSEIs are the EPR, N-1 RPM, N-2 RPM, EGT, and FF indicators.
2. The VSEIs are grouped in two places; at the pilot's center instrument panel and the other at the engineer's panel.
3. Each VSEI in each group is a four channel taped instrument, indicating all engine readings for that function.
4. Each VSEI channel is electrically and mechanically isolated from each other.
5. Each group of VSEIs, at the pilot's and engineer's positions, display readings from the same transmitting systems.
6. The EPR system displays the engine pressure ratio of the engine. The transmitter is a servo loop located in each engine pylon. 115 volt, 400 cycle, single phase Power is obtained from the ISOLATED AC BUS through a circuit breaker for each engine.
7. The RPM, EGT, and FF VSEIs receive power from the ESSENTIAL AC #2 BUS. One circuit breaker protects all the functions for each engine.
8. The RPM, EGT, and FF transmitter signals are sent to a instrument converter, amplified, and sent to the VSEIs.
9. Sixteen fuses are located on the instrument converter to protect the N-1 RPM, N-2 RPM, EGT and Fuel Flow VSEIs.

The remainder of this program will consist of views of the VSEIs at both the pilot's and engineer's positions. Some are normal and others abnormal. Study each page, determine the malfunction and probable trouble-shooting possibilities. The answer is at the top of the following page.

PILOT'S VSEIs



ENGINEER'S VSEIs



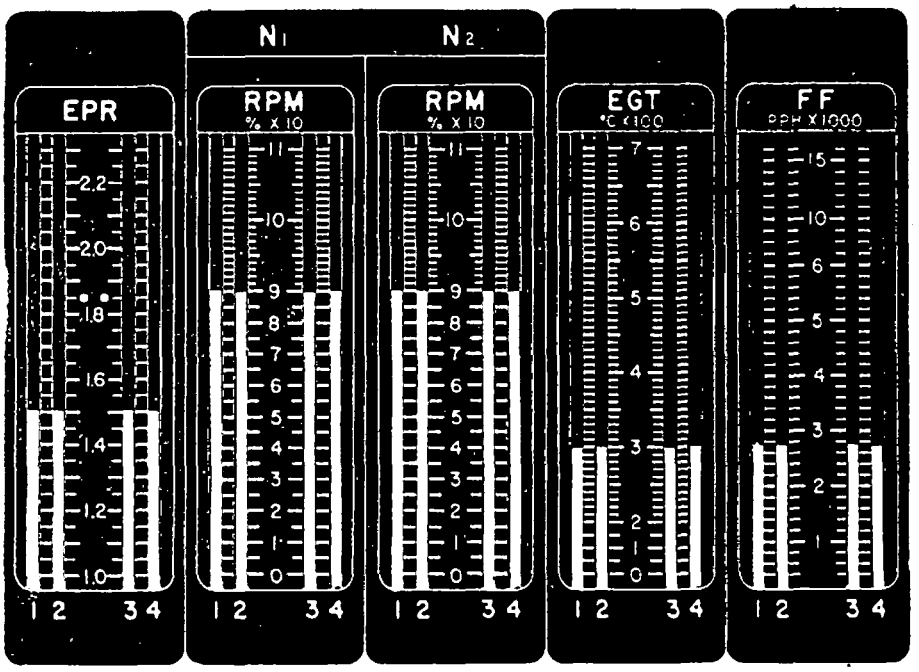
Malfunction - _____

Probable cause - _____

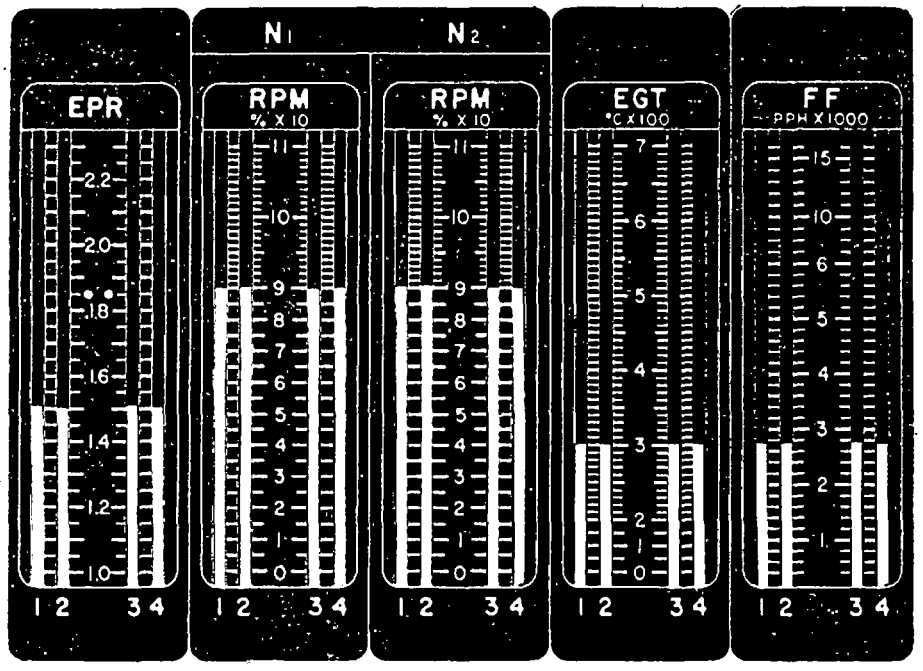
Malfunction - Loss of power to all instruments.

Probable cause - Normal indication, power not applied to aircraft.

PILOT'S VSEIs



ENGINEER'S VSEIs



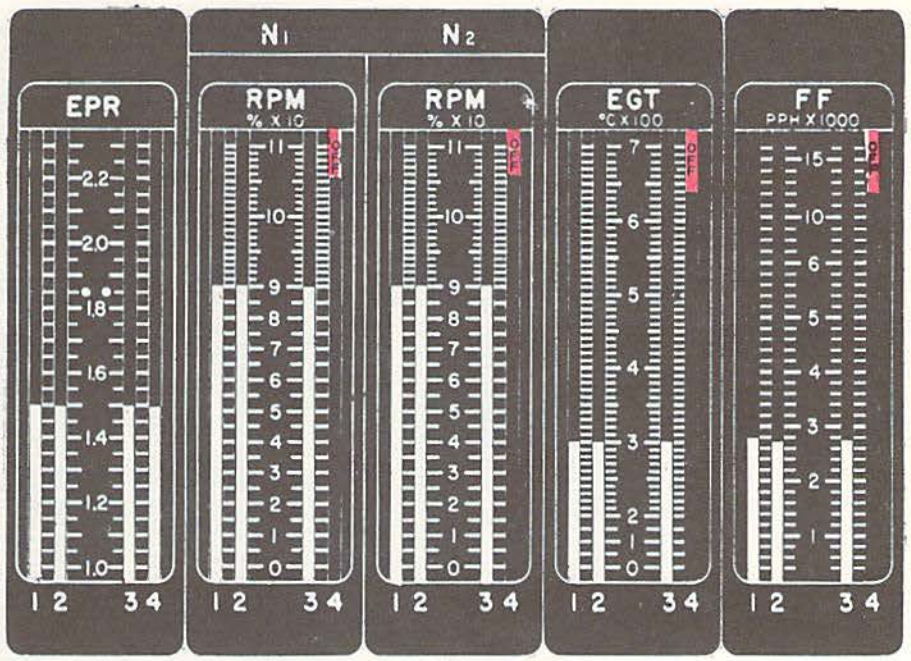
Malfunction - NORMAL

Probable cause - _____

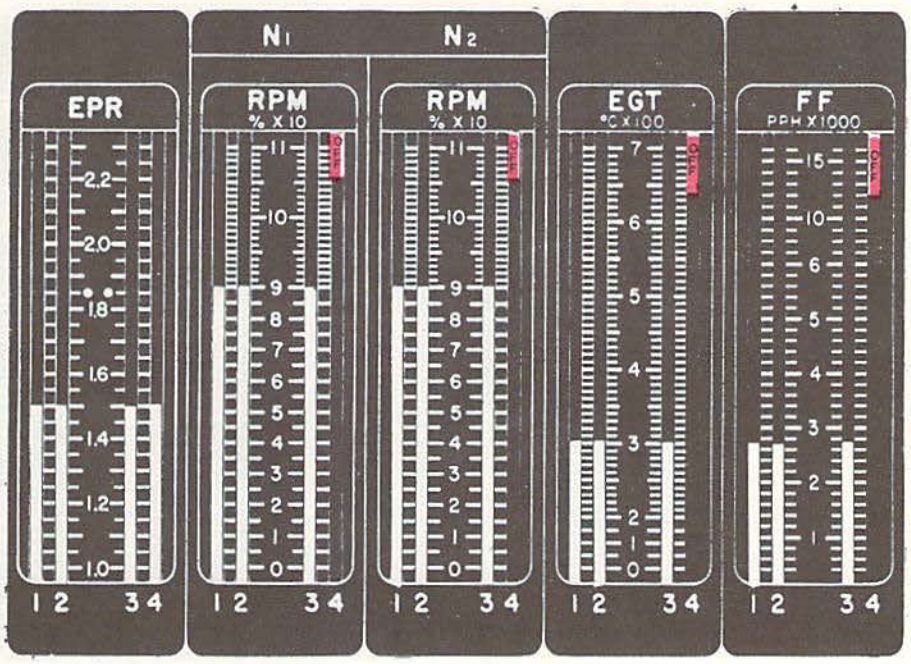
Malfunction - None; this is a normal engine's running indication.

Probable cause - None.

PILOT'S VSEIs



ENGINEER'S VSEIs



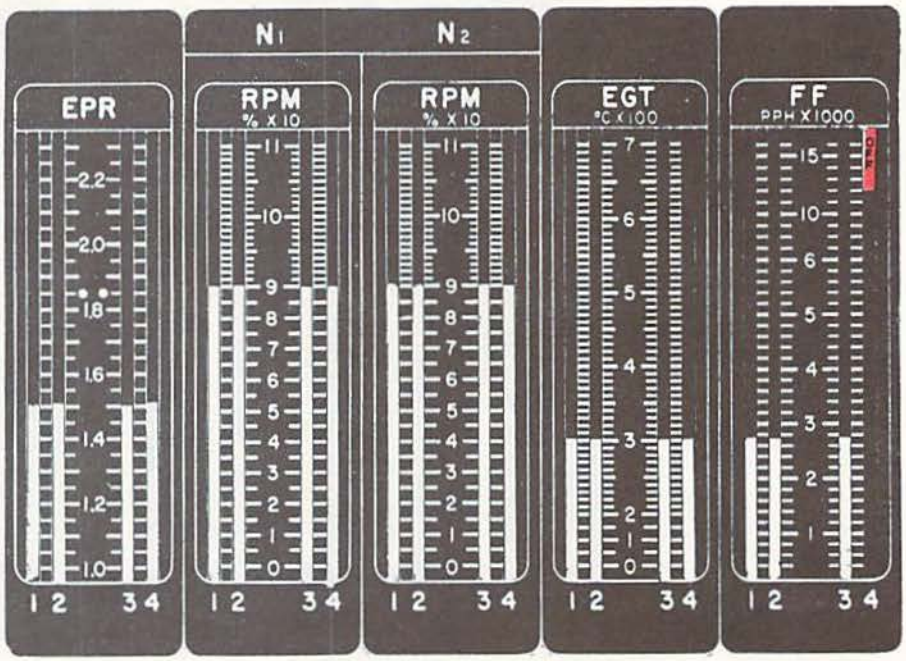
Malfunction - Fuses Blown Ins Cony

Probable cause - _____

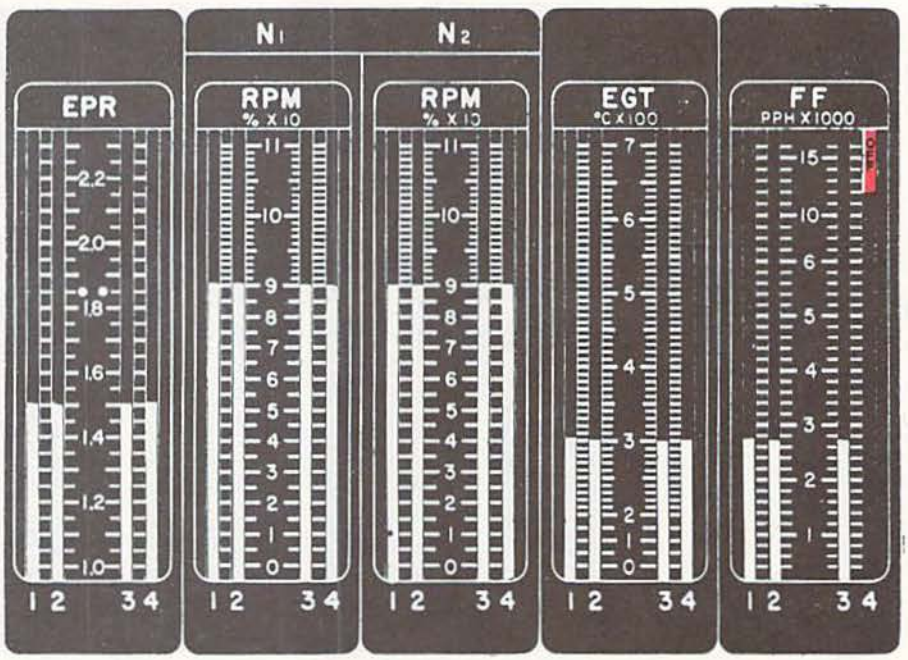
Malfunction - Power loss to all #4 engine VSEI's, except for the EPR indicator.

Probable cause - #4 engine RPM, EGT and FF circuit breaker open on the Essential AC Bus #2

PILOT'S VSEIs



ENGINEER'S VSEIs



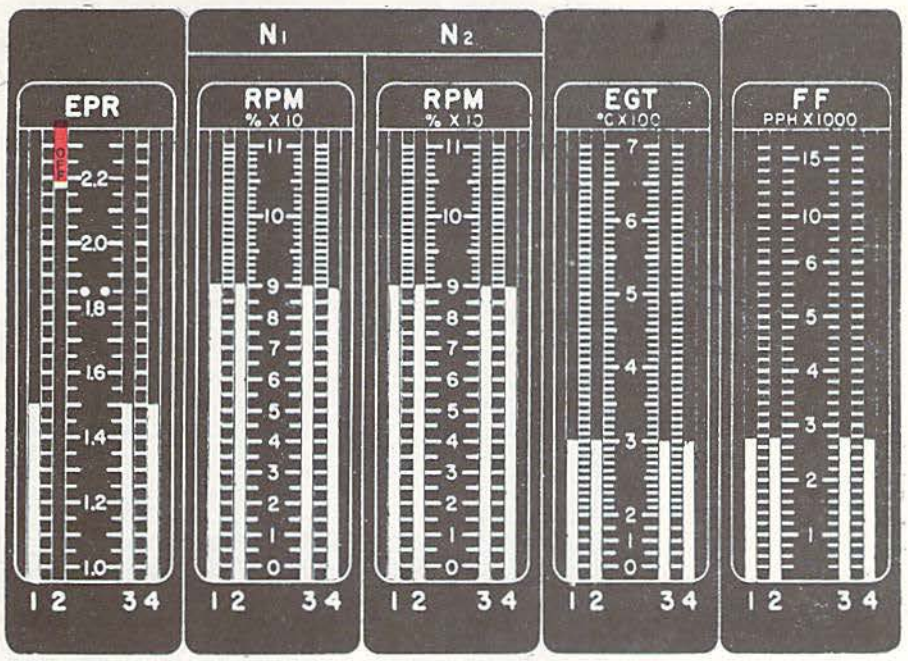
Malfunction - PUSH OUT

Probable cause - _____

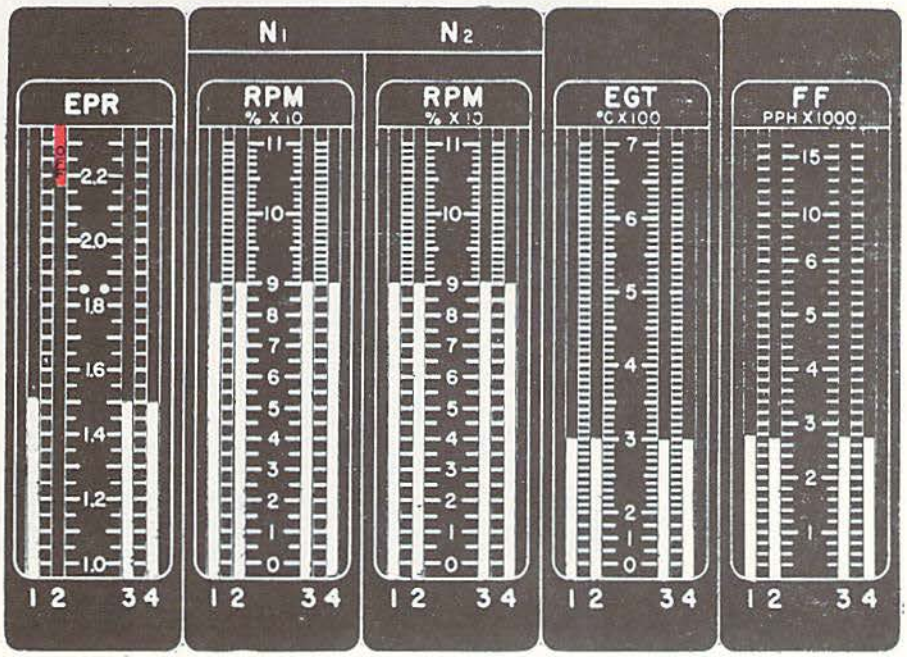
Malfunction - Power loss to both pilot's and engineer's #4 Fuel Flow indicator.

Probable cause - #4 engine fuel flow fuse open on the instrument converter.

PILOT'S VSEIs



ENGINEER'S VSEIs



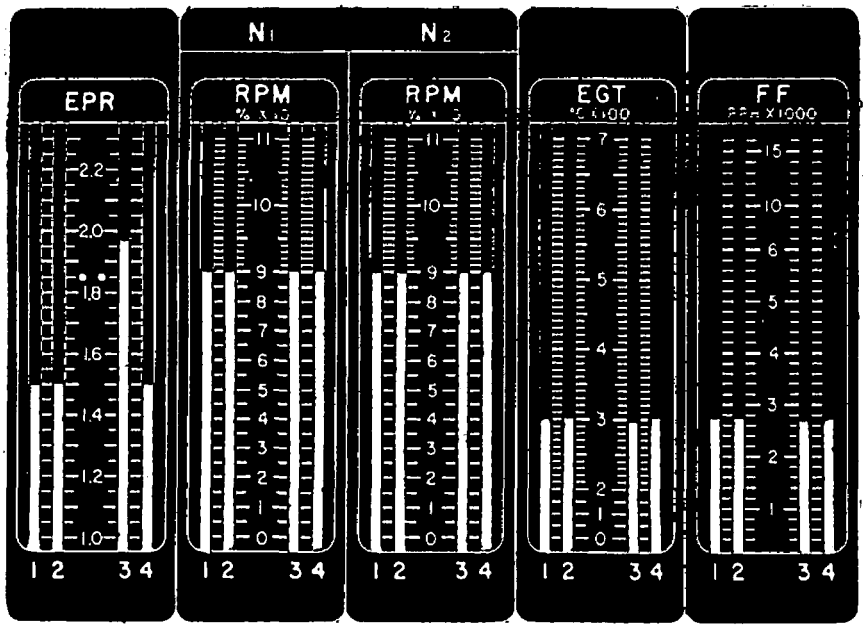
Malfunction - XMTTER

Probable cause - _____

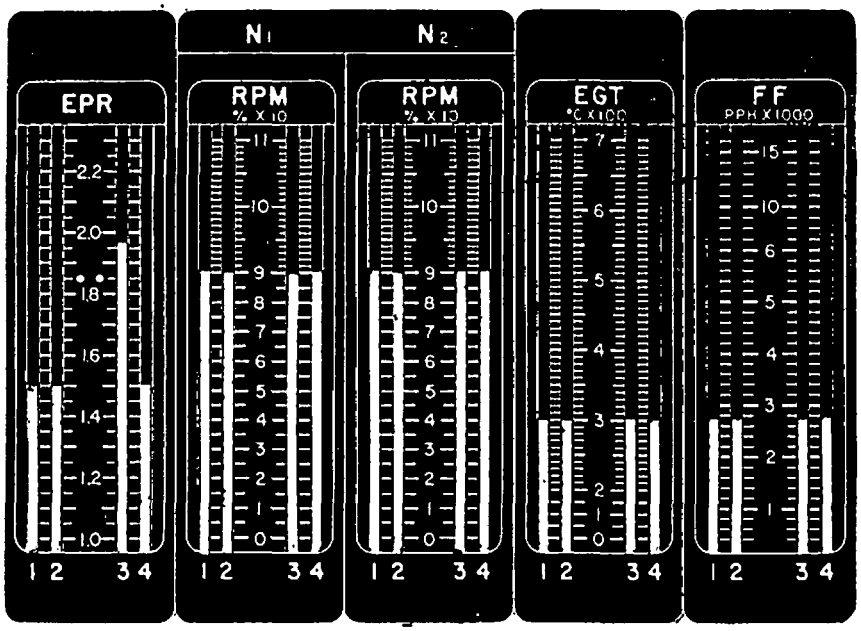
Malfunction - Power loss to both pilot's and engineer's #2 EPR indicator.

Probable cause - #2 engine EPR circuit breaker open on the Isolated AC Bus.

PILOT'S VSEIs



ENGINEER'S VSEIs



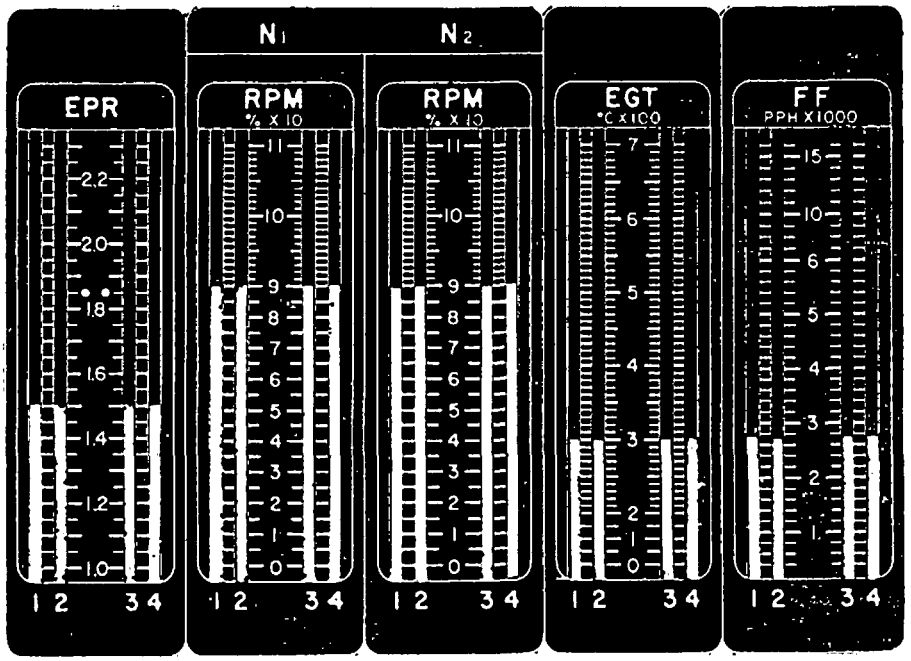
Malfunction - Ice

Probable cause - _____

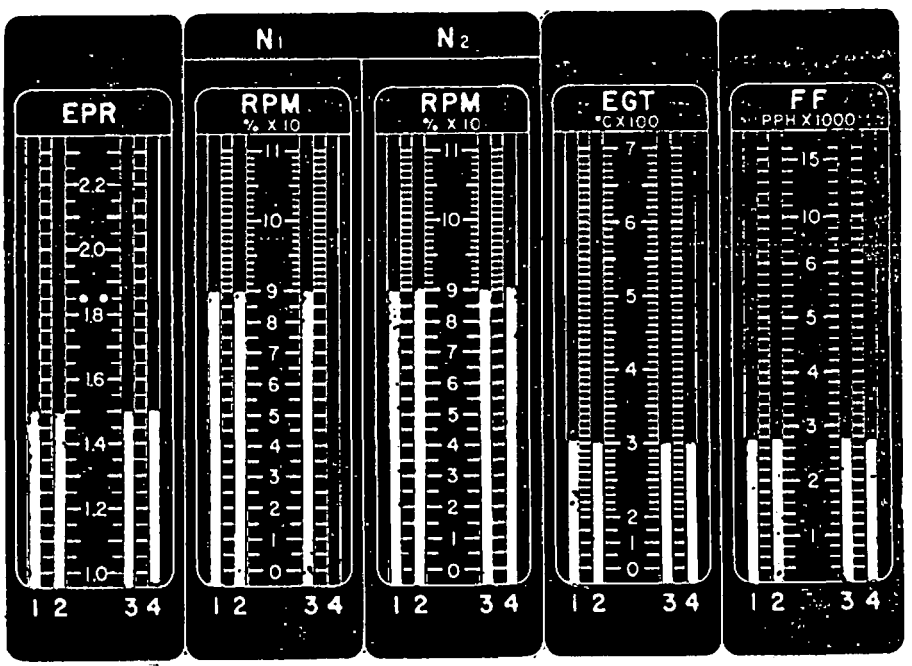
Malfunction - Gradual increasing higher than normal #3 engine EPR indication at both pilot's and engineer's position.

Probable cause - An iced #3 engine EPR inlet probe.

PILOT'S VSEIs



ENGINEER'S VSEIs



Malfunction - Normal

Probable cause - _____

Malfunction - No reading on the engineer's engine #4 N-1 RPM VSEI.

Probable cause - Mechanical failure of engineer's #4 N-1 RPM VSEI.

From the previous illustrations the following can be noted:

When the "OFF" portion appears on both the pilot's and engineer's like VSEIs, it indicates electrical power loss common to both. A possible cause is an open fuse or circuit breaker.

If a VSEI is not indicating a reading at either the pilot's or engineer's position and the same tape at the opposite position is normal, it is indicative of a mechanical failure of the effected instrument.

When the same VSEI tape at the pilot's and engineer's position does not indicate a reading and the "OFF" portion of the tape is not in view, it is indicative of a possible transmitter failure.

When the EPR VSEI at the pilot's and engineer's positions progressively increases, it is indicative of an icing EPR probe.

This concludes this program of the Vertical Scale Engine Instruments.

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