CHAPTER 3

A. Fuel Systems

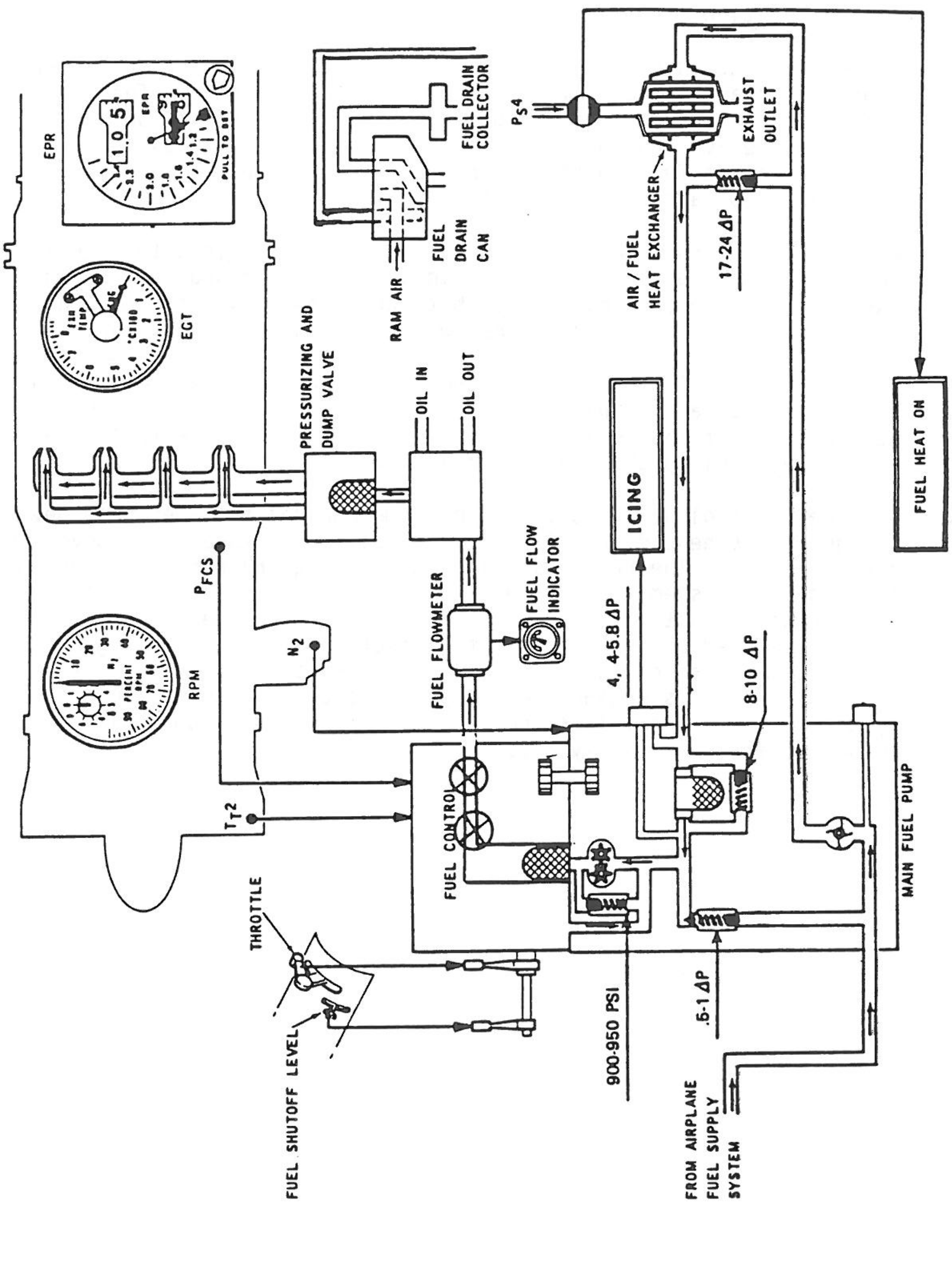
1. General Description

a. The engine fuel distribution and control system of the JT8D engine consists of an engine driven fuel pump and fuel control, fuel deicing system, a fuel pressurizing and dump valve, and a split fuel manifold, delivering fuel to nine individual fuel nozzles. The system delivers fuel to the engine at pressures and flow rates as required to obtain the desired engine thrust output.

b. Fuel supplied from the aircraft fuel boost pumps passes through an engine fuel shutoff valve located on the wing rear spar and along the fuselage to each engine. Lines that carry the fuel from the wing area to the engines are contained within a vented shroud tube.

c. The airplane fuel system enters the first stage of fuel pump, then passes through a fuel heater or heater bypass and filter to the second stage of the fuel pump. The second stage of the fuel pump discharges fuel to the fuel control unit.

d. The fuel control unit (FCU) is a hydromechanical fuel-metering device designed to schedule fuel flow to control engine speed thus governing thrust output. The FCU consists of a metering and computing system. The metering system selects the rate of fuel flow to be suppled to the engine combustion chambers in accordance with the amount of thrust demanded by the pilot, but subject to engine operating limitations as scheduled by the computing system as a result of monitoring various engine operational parameters. The computing system senses and combines the various parameters to control the output of the metering system.



Fuel System Schematic

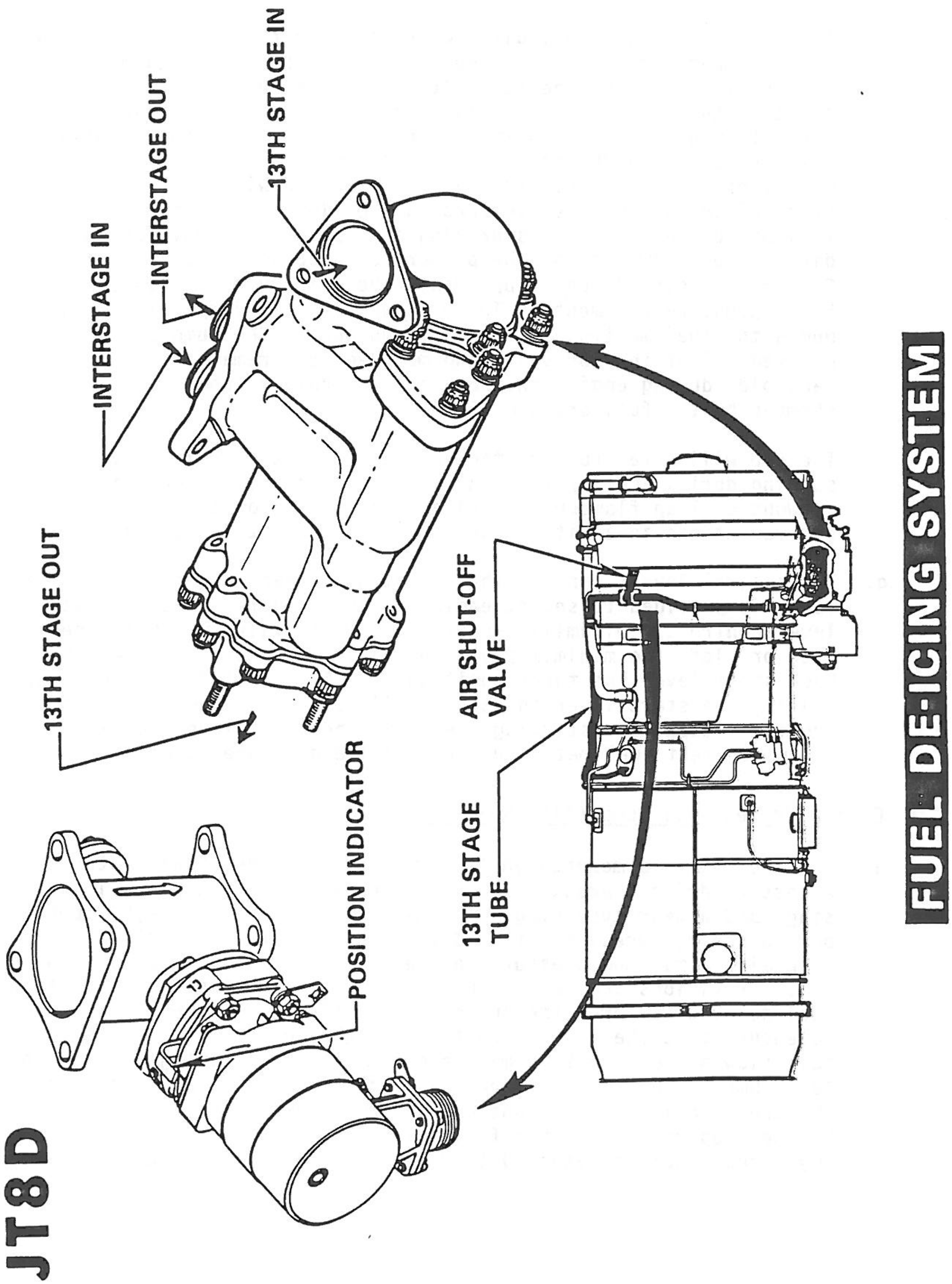
e. Throttle lever position, diffuser case pressure (PS4), compressor inlet temperature (TT2), engine start lever position and N2 rpm are the input signals to the FCU. It will interpret these signals and position the main throttle valve (metering valve) to meter the correct amount of fuel to the engine. Fuel leaving the throttle valve passes through the minimum pressure and shutoff valve at the outlet of the FCU. Metered fuel from the FCU will be suppled to the pressurizing and dump valve through the flowmeter transmitter and fuel oil cooler. The pressurizing and dump valve provides the division of flow between the primary and secondary nozzle orifices. Secondary manifold fuel supplements the primary manifold fuel for high thrust requirements. The pressurizing and dump valve no longer dumps the fuel manifolds at engine shutdown. The dump port has been blanked off at the P&D valve and metered fuel remains in the manifolds during engine shutdown and is drained from the combustion chamber by the fuel drain manifold.

f. The FCU will meter fuel to the engine, to control rpm, prevent surging during acceleration and deceleration and prevent either rich blowout or lean flameout. Fuel delivery is automatically compensated for variations in altitude, and change in fuel temperature.

g. Two control levers control the operation of each engine. A throttle lever is provided to select engine thrust output. An engine start lever controls a windmill bypass and shutoff valve which is used to open or close the minimum pressure and shutoff valve in the FCU. Each start lever has three positions: "OFF" - "START" - and "IDLE". Placing the start lever in "START" allows correct fuel metering and ignition output for starting. Placing the start lever in "IDLE" allows correct fuel metering for normal engine operation.

2. <u>Engine Driven Fuel Pump (ATA 73-11-1)</u>

a. The fuel pump is mounted on the front (right hand side) of the accessory drive gearbox. The pump consists of a centrifugal boost stage and a gear type stage. Normal flow capacity is 14,500 pph at a pump discharge pressure of 1000 psi. A pressure regulating valve maintains a maximum pressure increase across the main stage of 950 psi. Provisions are made at pump interstage for installation of the fuel deicing heater. The interstage porting is located in the pump to ensure that the fuel is routed through the fuel deicing heater. A full flow by-passing type micronic fuel filter is integral with the fuel pump. A bypass valve has been included in the pump to minimize the pressure loss that might occur across the boost stage should it become inoperative. After fuel has been metered by the fuel control, any excess fuel is returned to the main stage inlet of the fuel pump.


JT8D
FUEL DE-ICING SYSTEM
13TH STAGE IN
INTERSTAGE OUT
INTERSTAGE IN
13TH STAGE OUT
AIR SHUT-OFF VALVE
13TH STAGE TUBE
POSITION INDICATOR

3. Engine Fuel Deicing System (ATA 73-14-0)

a. General

(1) Engine fuel deicing system detects the presence of ice in the fuel and provides controlled heating of fuel to melt the ice. Fuel generally contains suspended water droplets when the temperature of the fuel falls below the freezing point of water. These suspended water droplets freeze and form ice. Ice eventually clogs the engine main fuel filter and restricts normal fuel flow to the engine.

(2) The engine fuel deicing system for each engine consists of a fuel deicing heater, fuel deicing air valve, fuel filter pressure switch, fuel icing warning light, and the necessary tubing. The fuel deicing air valve position light illuminates when the valve is fully open. The fuel heater, fuel filter pressure switch, and fuel deicing air valve are mounted on the engine. The fuel deice control switch, valve open light, and fuel icing warning light are on the third crewman's lower panel.

(3) When ice clogs the engine main fuel filter, pressure differential across the filter builds up, the fuel filter pressure switch closes and the fuel icing warning light illuminates. Turning ON the fuel deice control switch permits high pressure compressor air to pass through the fuel deicing heater air tubes and heat the fuel. The warm fuel passes through the fuel filter and melts the ice. When the ice is melted, the fuel filter pressure switch opens and de-energizes the fuel icing warning light, the fuel heat control switch is then turned OFF. The fuel should be heated intermittently.

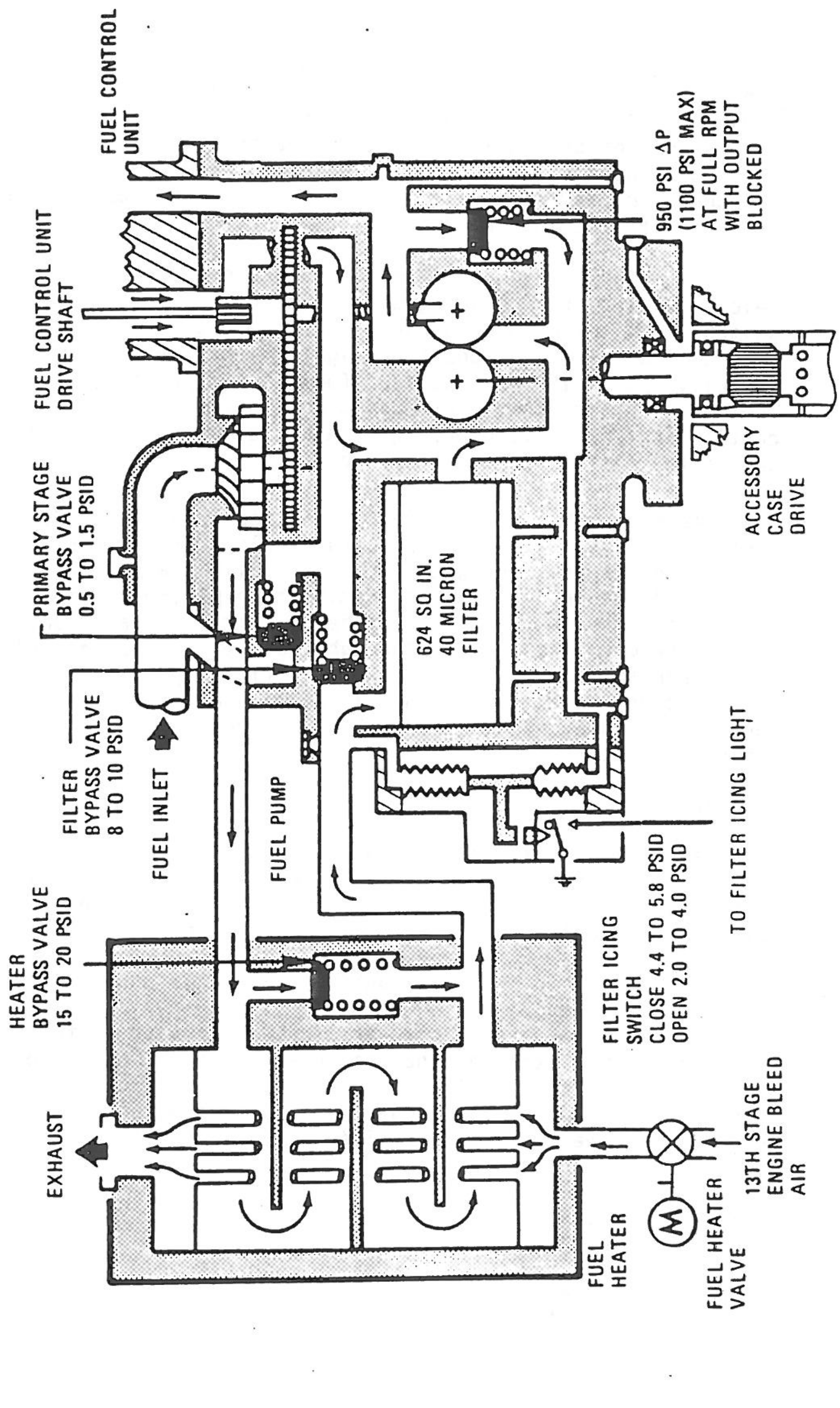
b. Fuel Deicing Heater

(1) The heater is an air-fuel heat exchanger and consists of a housing containing a core composed of air tubes, a series of baffles, and a fuel bypass valve. The heater is mounted on the fuel pump unit between the boost and main stages of the engine-driven fuel pump.

(2) The fuel flowing to the main engine fuel filter passes through the heater at all times. It is heated, only when the fuel deicing air valve is open and permits high pressure compressor (13th stage) bleed air to pass through the heater air tubes. To obtain uniform heating of the fuel, it is baffled around the air tubes. In the event the heater becomes clogged, a bypass valve permits the fuel to bypass the heater and flow directly through the fuel filter to the engine.

c. Fuel Deicing Air Valve

(1) The air valve is used to control the high pressure compressor (13th stage) bleed air flow through the fuel deicing heater. It consists of a butterfly valve and an electrical actuator (motor).



ENGINE FUEL PUMP AND DE-ICING SYSTEM

The air valve is operated by a fuel deice control switch, located on the third crewman's lower panel. There is one air valve for each engine located at the 2 o'clock position slightly forward of the engine mount ring.

d. Fuel Filter Pressure Switch

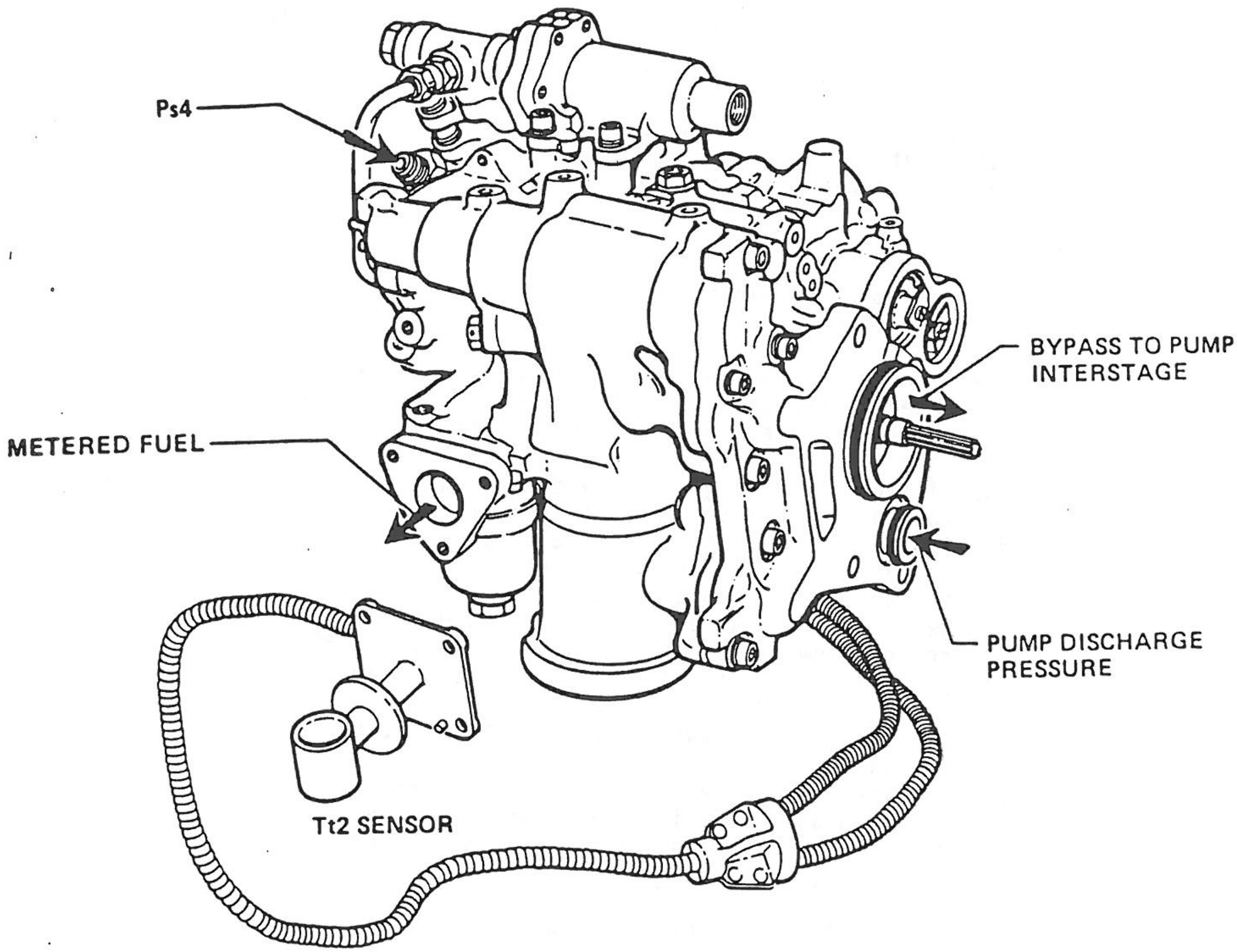
(1) The pressure switch senses the pressure differential across the engine main fuel filter. It is mounted directly on the filter on the engine fuel pump unit. If the engine fuel filter becomes clogged, pressure differential reaches 4.4 to 5.8 psi, the pressure switch closes and illuminates the fuel icing warning light on third crewman's lower panel. When the pressure differential again decreases, the pressure switch opens and the fuel icing warning light goes OFF.

e. Operation

(1) The engine fuel deicing system receives its power from 115 volt as busses through circuit breakers on circuit breaker panel (P6-3).

(2) When ice is present in the fuel it will eventually clog the engine main fuel filter and cause the pressure differential across the filter to increase. When pressure differential reaches 4.4 to 5.8 psi, the fuel filter pressure switch will close and illuminate the fuel icing warning light on third crewman's lower panel. Placing the fuel deice control switch to ON position opens the fuel deicing air valve. High pressure compressor bleed air (13th stage) passes through the valve into the heater air tubes and heats the fuel. To obtain a uniform heating of the fuel, baffles in the heater core direct the fuel around the air tubes in a controlled flow pattern. The heater fuel flows to the fuel filter and gradually melts the ice clogging the filter. When all ice is melted, pressure differential across the filter decreases and the fuel filter pressure switch opens, de-energizing the fuel icing warning light. The hot airflow through the heater is stopped by placing the fuel deice control switch to OFF position. When the fuel deicing air valve is fully open, the valve open light illuminates. The fuel deicing heater should be used intermittently.

(3) If the fuel filter becomes clogged, the fuel icing warning light will remain on, and the filter pressure differential will continue to increase until the filter bypass valve opens. The entire fuel filter system must be cleaned and checked after operating under these conditions. If the fuel deicing heater itself becomes clogged, a bypass valve permits the fuel to bypass the heater and flow directly to the fuel filter to the engine.



FUEL CONTROL

4. Fuel Control Unit (ATA 73-21-0)

a. General Description

(1) The JFC60 fuel control is designed to schedule the fuel flow required by the engine to deliver the designed amount of thrust as dictated by the power lever position and the particular operating conditions of the engine. Two control levers are provided, one, the throttle lever to control the engine during forward or reverse thrust operation and the other, the engine start lever, to effect engine shutdown and starting by closing and opening a fuel shut-off valve.

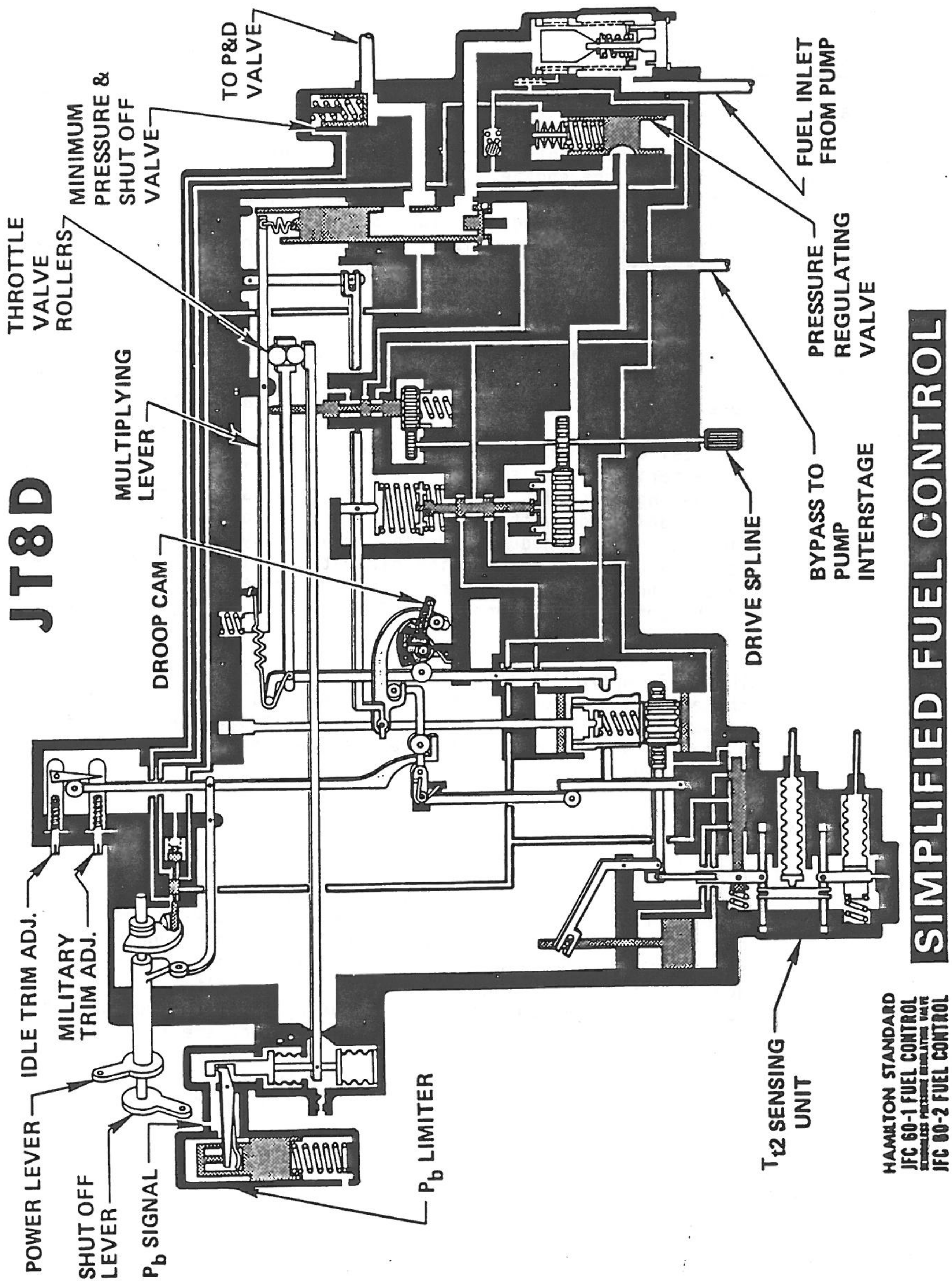
(2) The fuel control accurately governs the engine steady selected speed, regulates acceleration and deceleration fuel flows. The speed governing system is of the proportional or droop type.

(3) The fuel control consists of a metering and a computing section. The metering system selects the rate of fuel flow to be supplied to the engine combustion chambers in accordance with the amount of thrust demanded by the pilot, but subject to engine operating limitations as scheduled by the computing system as a result of its monitoring various engine parameters. The computing system senses and combines the various parameters to control the output of the metering section of the fuel control during all engine operation.

(4) The fuel control is attached directly to the fuel pump by means of three studs secured in the case of the fuel pump. Fuel passes between the fuel pumps and fuel control through two internal cored passages (one for high pressure fuel and one for fuel control return bypass fuel).

b. Metering System

(1) High pressure fuel is supplied to the control inlet from the engine driven fuel pump. This fuel initially encounters the coarse filter which protects the metering system against large particles of fuel contaminants. The fuel then encounters the fine servo supply filter which further protects the computing system against solid contaminants. This filter is self-cleaning due to fuel velocity through the axis of the cylinder toward the metering section is significantly greater than that of the flow through the mesh supplying the servo control valves. Both filters are protected by valves that open to allow the fuel to bypass in the event the screens become clogged to a point where the fuel flow is restricted.



JT8D
SIMPLIFIED FUEL CONTROL
TO P&D VALVE
MINIMUM PRESSURE & SHUT OFF VALVE
THROTTLE VALVE ROLLERS
MULTIPLYING LEVER
DROOP CAM
FUEL INLET FROM PUMP
PRESSURE REGULATING VALVE
BYPASS TO PUMP INTERSTAGE
DRIVE SPLINE
IDLE TRIM ADJ.
MILITARY TRIM ADJ.
POWER LEVER
SHUT OFF LEVER
P_b SIGNAL
P_b LIMITER
T_{t2} SENSING UNIT
HAMILTON STANDARD
JFC 60-1 FUEL CONTROL
JFC 60-2 FUEL CONTROL

(2) The fuel then flows through the metering valve (throttle valve) across which a constant pressure differential is maintained by the pressure regulating valve system. The throttle valve is a window type valve and is positioned by a half-area servo. The movable sleeve (piston) position is controlled by a rotating pilot valve which is displaced from its hydraulic null (steady-state) position by compressor discharge pressure, engine speed, compressor inlet temperature, power lever, or any combination of these parameters. These actuating signals work in conjunction with each other to produce a net torque on the multiplying lever. A balancing torque is created by the throttle valve extension spring load varied with the valve position. As long as the resulting torque is zero, the throttle valve maintains a constant position. However, any change in the signal torque will displace the pilot valve and cause motion of the throttle valve piston until the unbalanced signal torque is balanced by the new throttle valve position and corresponding spring force. By virtue of the constant pressure drop maintained across the throttle valve, fuel flow is proportional to the position of the piston.

(3) The pressure drop across the throttle valve is maintained nominally at 40 psi by the bypass type pressure regulating valve system. All high pressure fuel in excess of that required to maintain the pressure differential is bypassed to pump interstage. The pressure regulating valve system, consisting of a sensor and a pressure regulating valve, is servo controlled. The pressure differential across the throttle valve is compared to a preset valve of the pressure differential. Any deviation from the preset value will displace a rotating pilot valve from its hydraulic null position and cause motion of the pressure regulating valve. The pressure regulating valve will then bypass more or less of the fuel flow, whichever is necessary to maintain the preset pressure differential, and return the sensor to its equilibrium position. The lower end of the pressure regulating valve is subjected to servo supply pressure and the upper end is balanced by a modulated pressure and a spring force. In the event of a failure in the direction of low control discharge pressure, the control will meter at the spring force equivalent pressure and prevent bypassing the total flow back to pump interstage.

(4) Fuel leaving the throttle valve passes through the minimum pressure and shutoff valve on its way to the engine. This valve is designed to shut off the flow of metered fuel to the engine when the pilot moves the shutoff lever to the "OFF" position. When actuated for the shutoff function, high pressure is directed to the spring side of the valve by the action of the windmill bypass and shutoff valve. This pressure closes the valve and allows the spring to keep it in the shutoff position. When the shutoff lever is moved to the "START" position, the high pressure on the spring side of the valve is replaced by pump interstage

pressure and when metered fuel pressure has increased sufficiently to overcome the spring and low pressure fuel force, the valve opens and fuel flow to the engine is initiated. Thereafter, the valve will provide a minimum operating pressure within the fuel control, insuring that adequate pressure is always available for operation of the servos at low flow conditions.

(5) The windmill bypass and shutoff valve, in addition to supplying the high pressure signal for the shutoff function, also provides a windmill bypass feature. This valve is plumbed to a line leading to the spring side of the pressure regulating valve and is positioned by a shutoff lever operated cam so that signals are generated at the desired shutoff lever positions. Movement of the shutoff lever toward the shutoff position displaces the valve, thereby porting the pressure on the spring side of the pressure regulating valve to pump interstage. The pressure regulating valve now operates as a relief valve to handle the full windmilling fuel flow.

c. The Computing System

(1) The computing system positions the throttle valve to control fuel flow during steady state operation, acceleration and deceleration by using the ratio of metered fuel flow to engine compressor discharge pressure (Wf/Ps4) as a control parameter. The positioning of the throttle valve by means of the Wf/Ps4 parameter is accomplished through a multiplying system whereby the Wf/Ps4 signal for acceleration, deceleration or steady state speed control is multiplied by a signal proportional to compressor discharge pressure to provide the required fuel flow.

(2) Compressor discharge pressure is sensed by a motor bellows which is externally exposed to the pressure. The resultant force, caused by the expansion or contraction of this bellows, is opposed by an evacuated bellows of equal size. The net force, which is proportional to absolute compressor discharge pressure, is transmitted through a sensor lever to a set of rollers whose position is proportional to the required Wf/Ps4 ratio. These rollers ride between the sensor lever and a multiplying lever. The force, proportional to compressor discharge pressure, is transmitted through the rollers to the multiplying lever. Any change in the roller position or the compressor discharge pressure signal results in a unbalanced torque which will displace the rotating pilot valve from its hydraulic null position, thereby repositioning the throttle valve. The movement of the throttle valve extends or relaxes a spring which will return the multiplying lever to its equilibrium position when the throttle valve reaches the required fuel flow position. Both the motor and evacuated bellows are located in a chamber vented to ambient

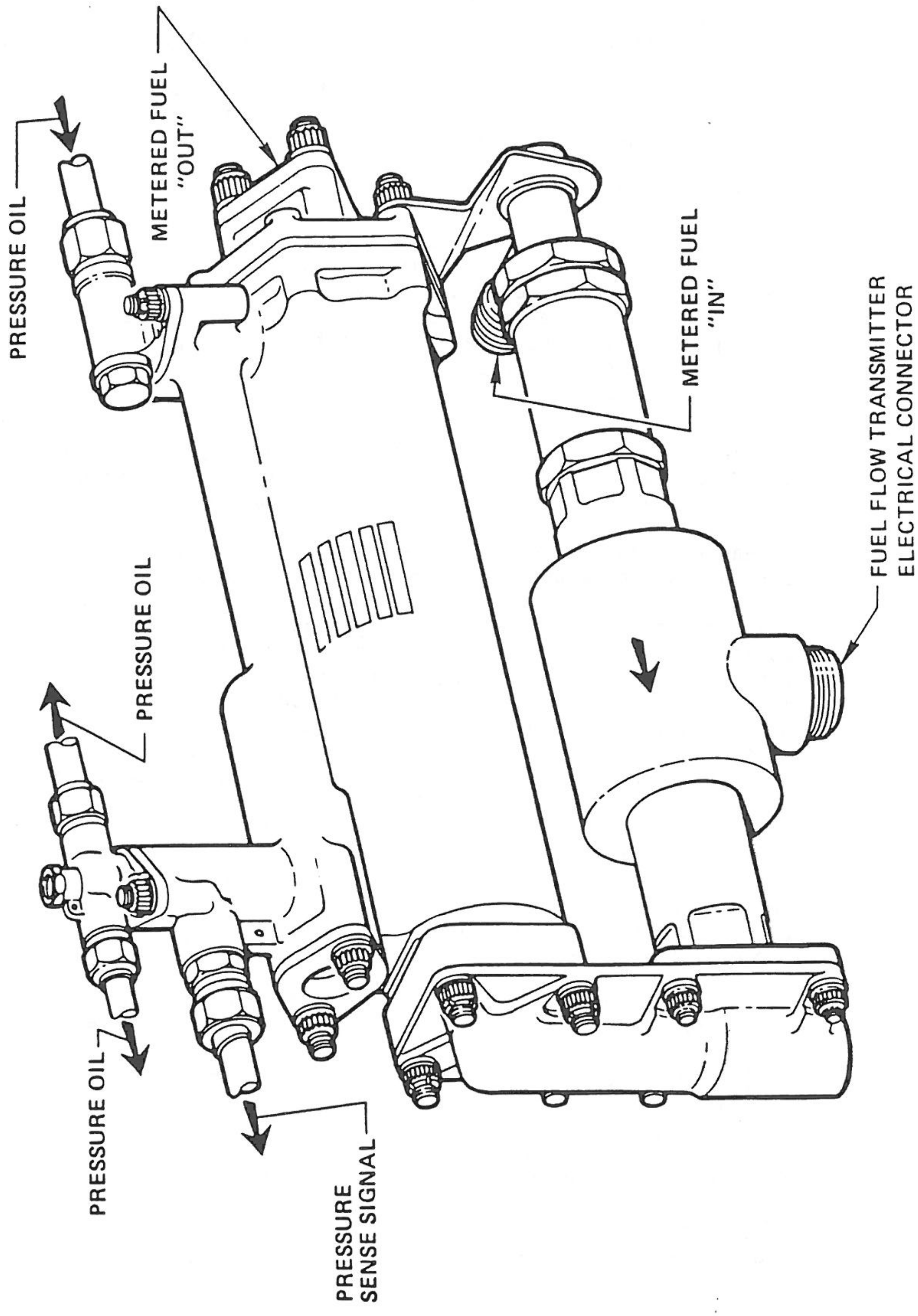
pressure so that in event of an evacuated bellows failure, the fuel flow error is only the difference between the flow required for the absolute pressure reading and that required for a gage pressure reading. The vent line to the bellows chamber contains an orifice which will allow compressor discharge pressure sending should a minor motor bellows failure occur.

(3) The compressor discharge pressure limiting valve is held seated by the action of a spring at Ps4 values below the limiting pressure. Signal pressure to the Ps4 bellows is tapped off between the two valve seats and, below the limiting point, the bellows signal pressure and compressor discharge pressure are equal. When compressor discharge pressure exceeds the limiting valve, the spring force is overcome and the limiter valve opens to bleed off compressor discharge pressure and thereby reduce the bellows signal pressure.

(4) Deceleration control is provided by the constant radius portion of the droop cam and by adjustment of the roller positioning linkage to limit the travel of the rollers toward decreasing fuel flow, thereby effecting a minimum Wf/Ps4 ratio stop. This provides a linear relationship between fuel flow and compressor discharge pressure which results in flame free deceleration.

(5) Acceleration control is provided by adjustment of the roller positioning linkage to effect maximum Wf/Ps4 ratio stop for a particular value of speed and compressor inlet temperature. The maximum Wf/Ps4 ratio at the stop is controlled by a three dimensional (3-D) cam which is translated by a signal proportional to engine speed and rotated by a signal proportional to compressor inlet temperature. The 3-D cam is so contoured as to define a schedule of Wf/Ps4 versus compressor inlet temperature which is used as a limiting value for each speed throughout the transient acceleration range. This combination will permit engine accelerations within the over-temperature and surge limits of the engine. When the acceleration limiting lever is in operation to control the maximum value of the Wf/Ps4 ratio, it overrides the speed setting linkage.

(6) The engine speed signal is transmitted from the engine driven shaft through a gear train to the centrifugal type flyweight governor. This governor controls movement of the speed servo (3-D cam) by displacing a rotating pilot valve from its hydraulic null position. When the speed changes, the flyweight force varies and the pilot valve is displaced causing motion of the speed servo. This motion of the speed servo repositions the pilot valve, through the action of a feedback lever working on a spring, until the speed sensing governor returns to equilibrium at the new speed servo position. The position of the speed servo is, therefore, indicative of actual engine speed.



OIL COOLER AND FUEL FLOW TRANSMITTER

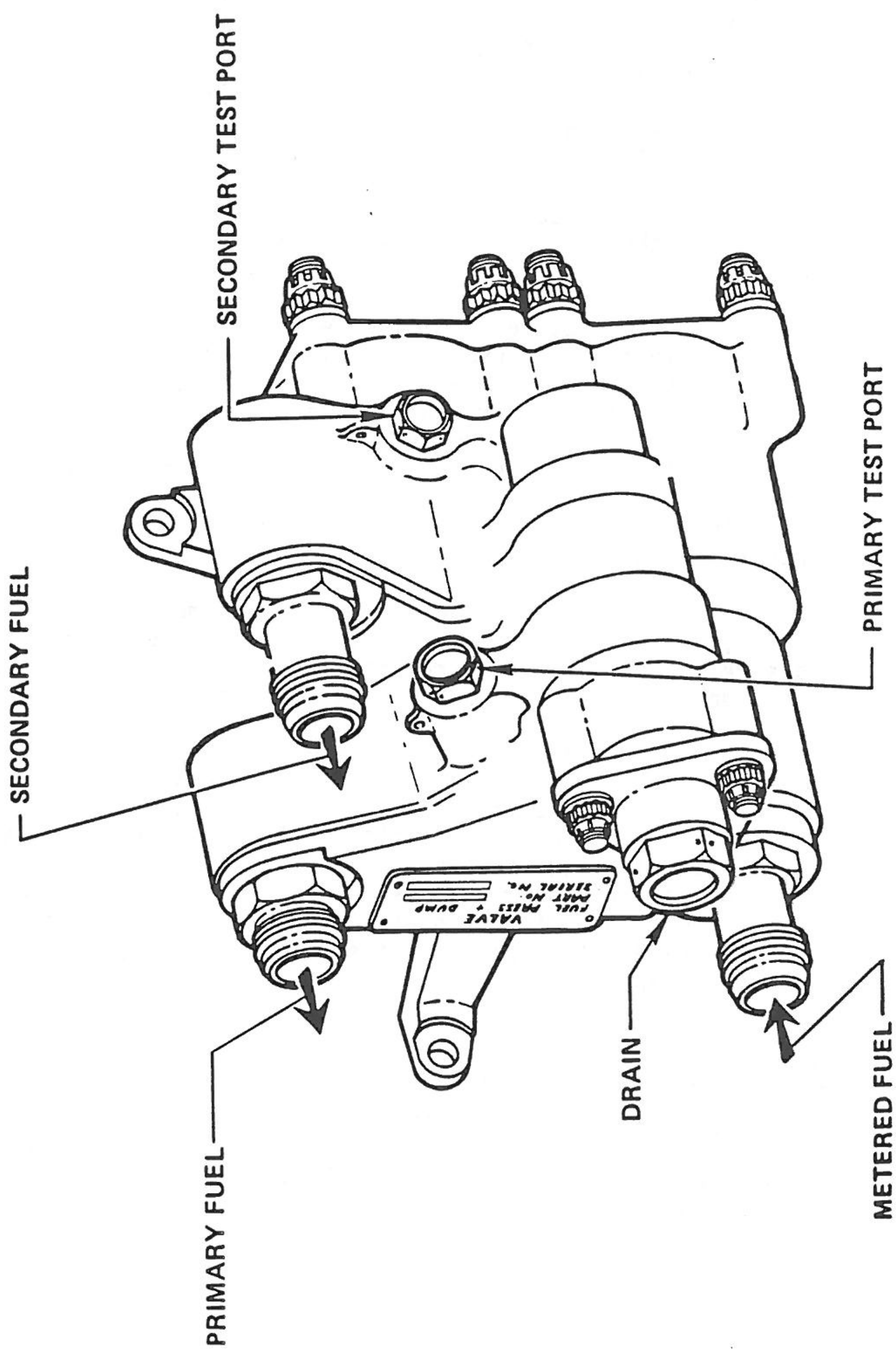
(7) Compressor inlet temperature is sensed by a liquid filler bulb mounted in the compressor inlet and connected to a liquid filled bellows in the control. Changes in inlet air temperature cause corresponding changes in the bellows length. The position output of the motor bellows is biased by a position output of a second, or compensating bellows. The compensating bellows is also liquid filled and is connected to a capillary tube placed adjacent to the line leading from the air inlet bulb to the motor bellows. Pressure changes due to the temperature gradient between the air inlet and the control act on this compensating line as well as the motor bellows supply line. This permits the second bellows to modify the motor bellows output to ensure a correct indication of inlet air temperature. This corrected position output displaces a pilot valve from its hydraulic null (steady-state) position and results in movement of the temperature servo piston. The servo piston is connected through a linkage to a rack which meshes with the spline on the 3-D cam and motion of the piston rotates the cam. As the rack moves to rotate the cam, it also repositions the pilot valve in order to return the valve to the steady-state position. The rotation of the 3-D cam, acting through a linkage, resets the governor droop one.

(8) Engine speed control is accomplished by comparing the actual speed, as indicated by the position of the speed servo, to the desired speed value required for the power selected by the pilot through a power lever positioning speed set cam. The power lever actuates the speed set cam to select a governor droop line. The position of the droop line is biased by compressor inlet temperature. The deviation of desired speed from the actual speed (speed error) causes movement of the speed servo. This movement of the speed servo is transmitted through a lever and results in the repositioning of the droop cam. The rollers in the multiplication system are positioned through the action of the droop cam to be a function of the speed error. The repositioning of the rollers then provides the required steady-state Wf/Ps4 ratio setting.

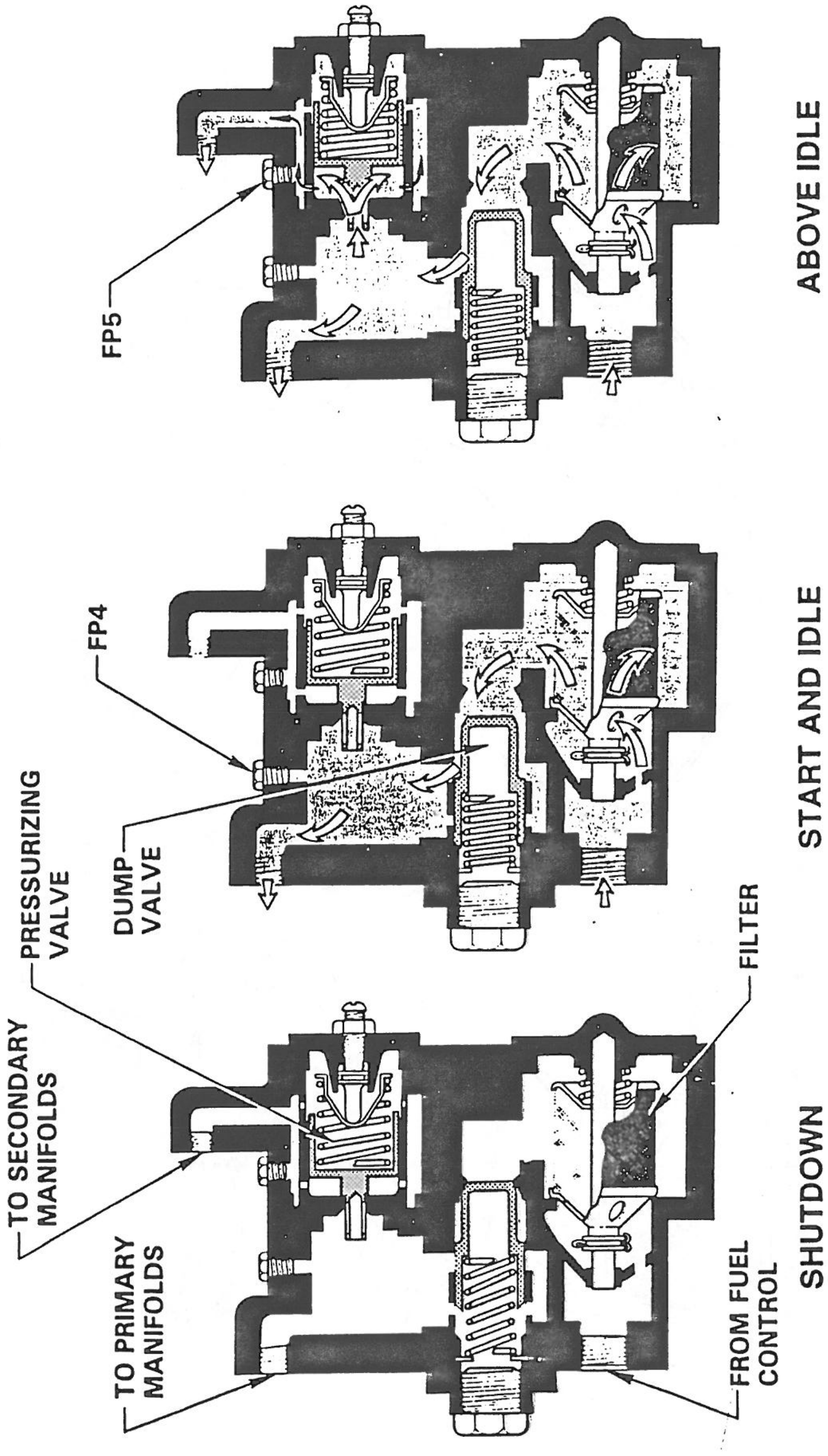
5. Fuel/Oil Cooler (ATA 79-20-1)

a. The fuel flow transmitter is attached to the fuel/oil cooler. Fuel leaving the fuel flow transmitter passes through the fuel/oil cooler and then to the pressurizing and dump valve. For additional information concerning the fuel/oil cooler, see Chapter 4.

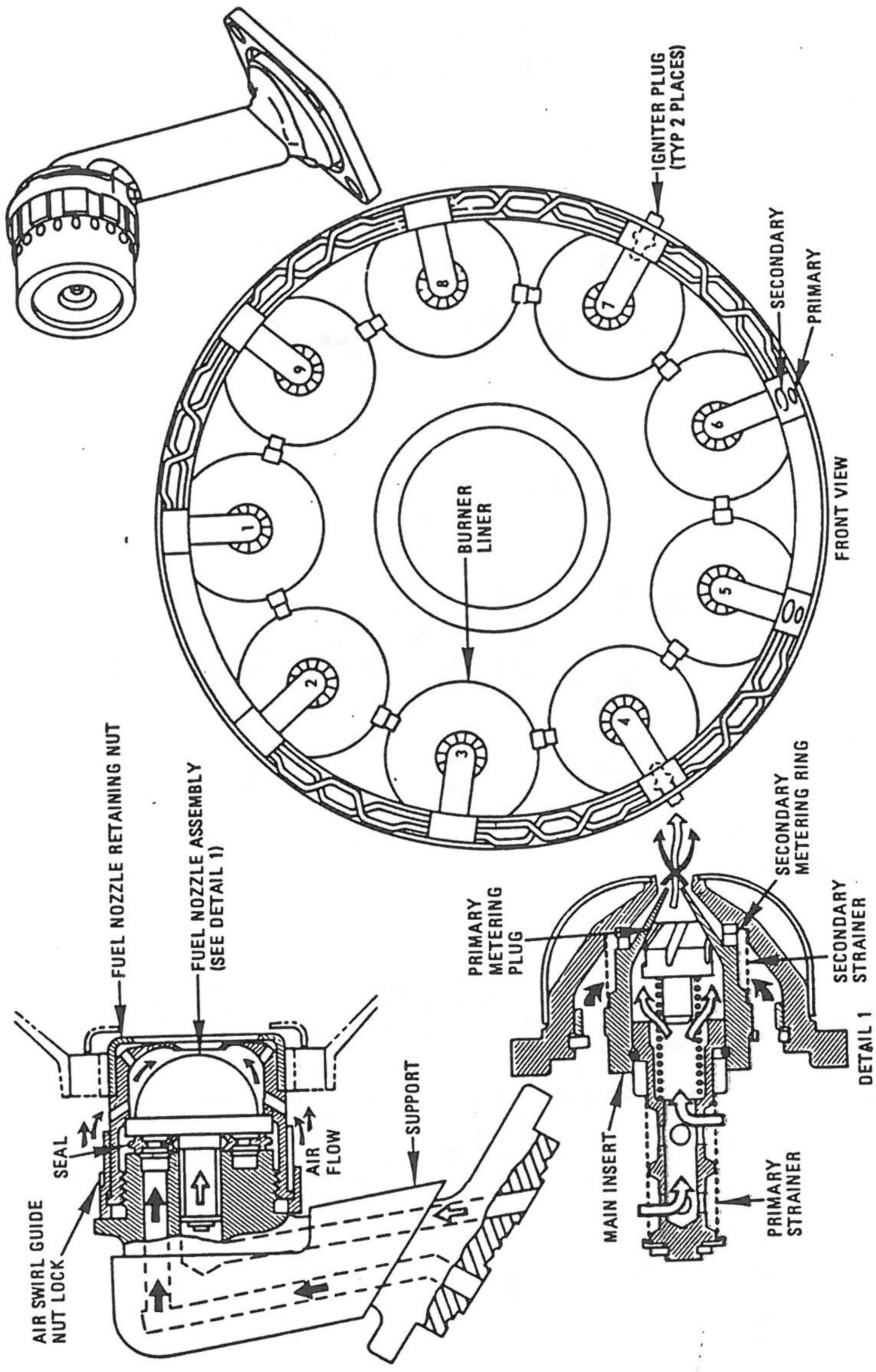
PRESSURIZING AND DUMP VALVE



PRESSURIZING AND DUMP VALVE (OPERATING MODES)



FUEL MANIFOLD AND NOZZLES



6. Pressurizing and Dump Valve (ATA 73-12-1)

a. General Description

(1) The fuel pressurizing and dump valve is located downstream of the fuel control and is connected to the primary and secondary fuel manifolds to which it discharges its fuel. The essential parts of the fuel pressurizing and dump valve include a 200 mesh fuel inlet screen, a dump (manifold drain) valve, which is now plugged and a pressurizing (flow divider) valve.

(2) The fuel pressurizing and dump valve is located on the lower left side of the fan discharge diffuser section outer duct. Locknuts secure the valve to three studs in the duct.

b. Operation

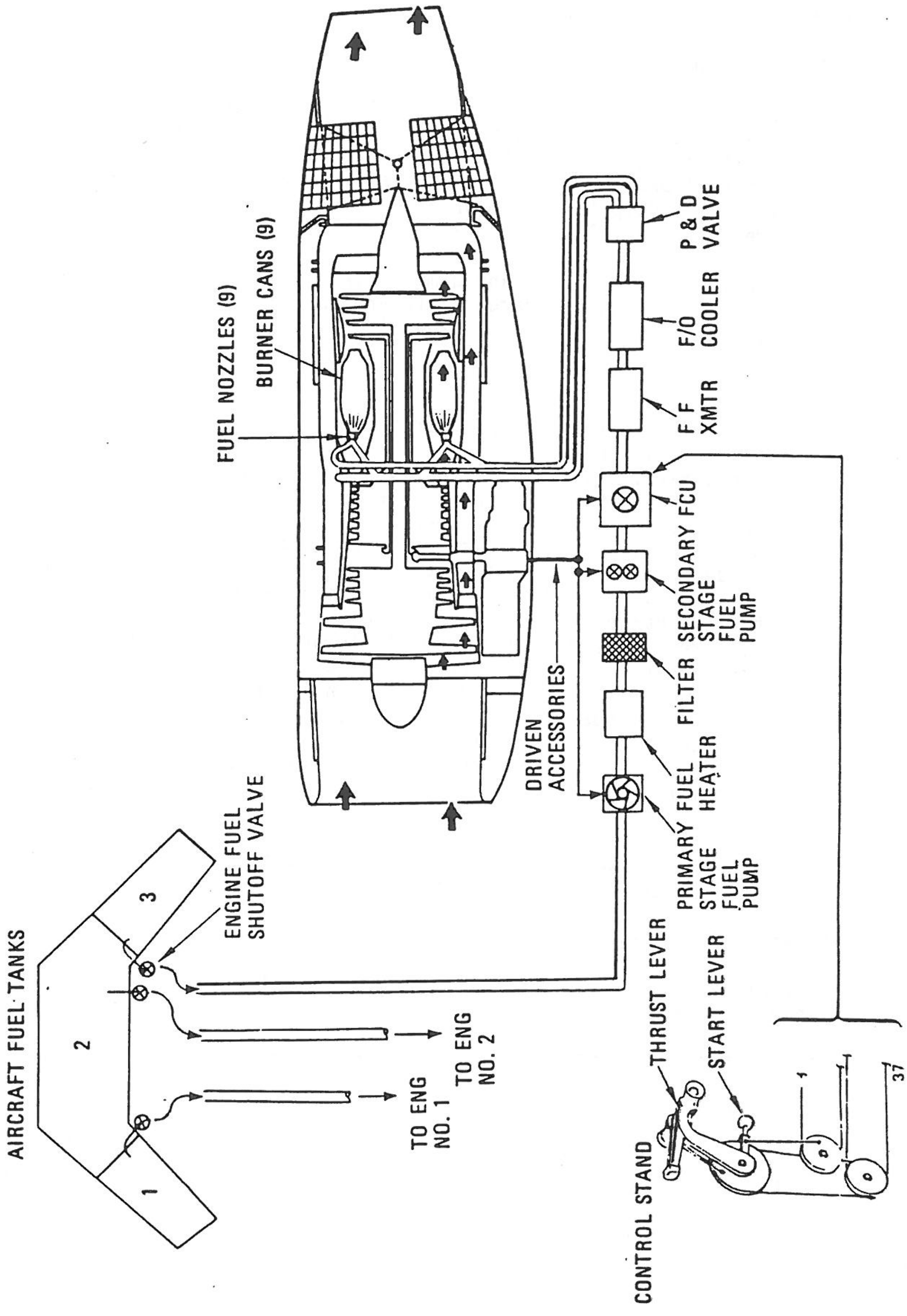
(1) Fuel entering the fuel pressurizing and dump valve is filtered by the 200 mesh fuel inlet screen. The screen unseats at approximately 11.7 psi in the event of clogging, and permits by-pass fuel flow. As the fuel pressure in the strainer chamber increases, spring pressure behind the dump valve is overcome and the valve is forced into the closed position. This movement of the dump valve exposes the port through which fuel then flows to the primary chamber of the pressurizing valve. The entire flow then discharges to the primary manifold. When primary chamber fuel pressure surrounding the pintle of the pressurizing valve becomes sufficient to overcome the force of the valve spring, the valve unseats, and fuel flows into the secondary chamber. Flow from the secondary chamber then discharges to the secondary manifold. The contour of the pintle is designed to divide the primary and secondary flows to give satisfactory nozzle spray characteristics at all fuel flow conditions.

NOTE: The drain port of the P&D Valve has been blanked off for ecology reasons; therefore, the fuel manifolds are not drained on engine shutdown.

7. Fuel Manifold and Nozzles (ATA 73-13-1)

a. The divided fuel flow from the fuel pressurizing valve is delivered through an annular duct to the dual tube manifolds mounted on the diffuser case then enters the nine dual-orifice fuel nozzles. The nozzle support flange of each nozzle is bolted to the diffuser case, with the support extending into the compressor discharge airflow to position the nozzle in each combustion chamber. The nozzles have two concentric orifices. Primary fuel is discharged through the small orifices in the center of the nozzle and provides a wide, well atomized spray that assures prompt ignition of the fuel for starting. Secondary fuel is discharged through the larger orifice that surrounds the inner orifice and provides a narrow but denser spray at higher fuel flows.

ENGINE FUEL SYSTEM FUNCTIONAL DIAGRAM



8. Engine Fuel System Operation

a. The engine fuel flow system delivers fuel to the engine at pressures and flow rates as required to obtain the desired engine thrust output.

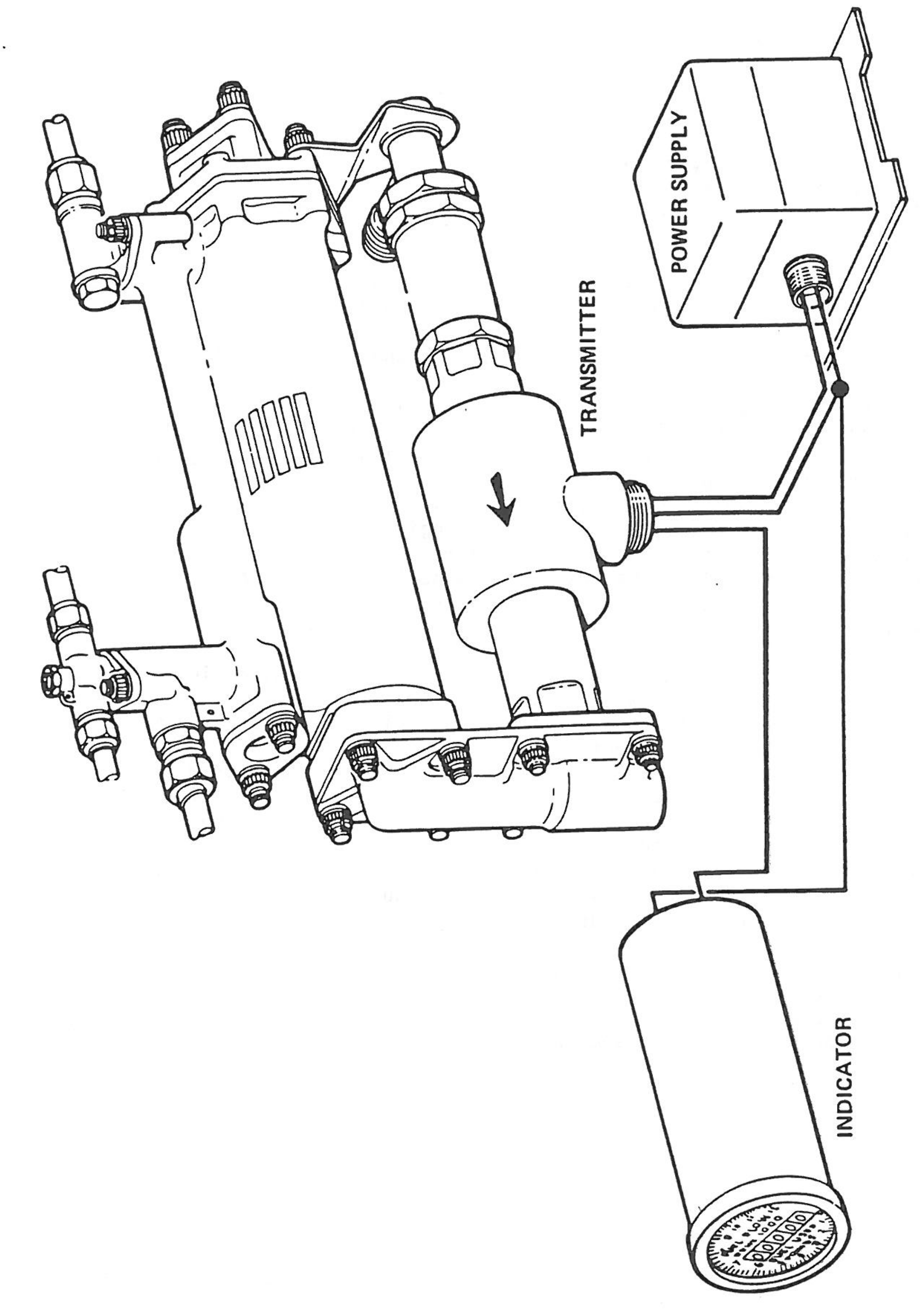
The fuel system may be best described by tracing the passage of the fuel from the inlet to its ultimate discharge through the fuel nozzles in the combustion chambers, as shown in an illustration in this section.

The airplane fuel system supplies fuel at a predetermined pressure to the first stage of the fuel pump, then through a fuel heater or heater bypass and filter to the second stage of the fuel pump. The second stage of the fuel pump discharges fuel to the fuel control unit.

The fuel control unit (FCU) is a hydromechanical fuel metering device designed to schedule fuel flow to control engine speed thus governing thrust output. The FCU consists of a metering and computing system. The metering system selects the rate of fuel flow to be supplied to the engine combustion chambers in accordance with the amount of thrust demanded by the pilot, but subject to engine operating limitations as sheduled by the computing system as a result of monitoring various engine operational parameters. The computing system senses and combines the various parameters to control the output of the metering system.

Thrust lever position, diffuser case pressure, compressor inlet temperature and N2 rpm are the input signals to the FCU. It will interpret these signals and position the main throttle valve (metering valve) to meter the correct amount of fuel to the engine. Fuel leaving the throttle valve passes through the minimum pressure and shutoff valve at the outlet of the FCU. Metered fuel from the FCU will be supplied to the pressurizing and dump valve through flowmeter transmitter and fuel cooled oil cooler. The pressurizing and dump valve provides the division of flow between the primary and secondary nozzle orifices. Secondary manifold fuel supplements the primary manifold fuel for high thrust requirements.

The FCU will meter fuel to the engine, to control rpm, prevent surging during acceleration and deceleration and prevent either rich blowout or lean dieout. Fuel delivery is automatically compensated for variations in altitude, and change in fuel temperature.



FUEL FLOW INDICATING SYSTEM

Two types of control levers are provided: these are the engine thrust levers and engine start levers. The engine start lever controls a windmill bypass and shutoff valve which is used to open or close the minimum pressure and shutoff valve in the FCU. With the engine start lever in the IDLE position, fuel will be delivered to the burners when sufficient pressure is available from the engine fuel pump to hold this valve open. This pressure is available as the engine start lever is moved into the IDLE position during the starting sequence. When the engine has attained idle rpm, forward movement of the engine thrust lever will release fuel flow thus increasing thrust output.

9. FUEL FLOW INDICATING SYSTEM (ATA 73-31-0)

a. General

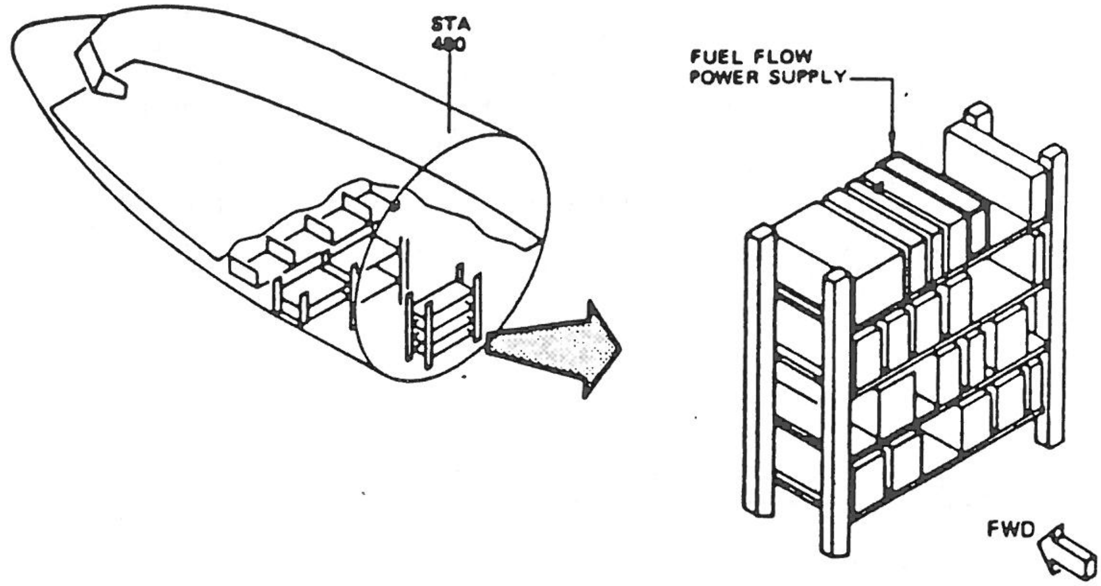
(1) The function of the fuel flow indicating system is to provide a visual indication at the captain's station of the fuel consumption rate in pounds per hour for each individual engine.

(2) This system has three fuel flow transmitters, three fuel flow indicators, and one fuel flow power supply unit. A fuel flow transmitter is located on the forward left side of each engine. All three fuel flow indicators are located on the lower portion of the engine instrument panel. The fuel flow power supply unit is located on the E5-1 equipment rack or behind the SO panel.

(3) When the system is energized, the fuel flow power supply unit supplies constant frequency 3-phase power for driving the three fuel flow transmitters. Each transmitter sense the mass rate of fuel flowing to its respective engine and generates an electrical signal proportional to this flow. The electrical signals are transmitted to the fuel flow indicators which show the fuel being consumed, in pounds per hour, by their respective engines.

(4) Each fuel flow transmitter measures the amount of fuel flowing to its respective engine and provides a corresponding signal to its respective indicator. The indicator uses this signal to provide a visual indication of the rate of fuel flow to the engine.

(5) N218FE thru N223FE has fuel used added to the fuel flow indicator.



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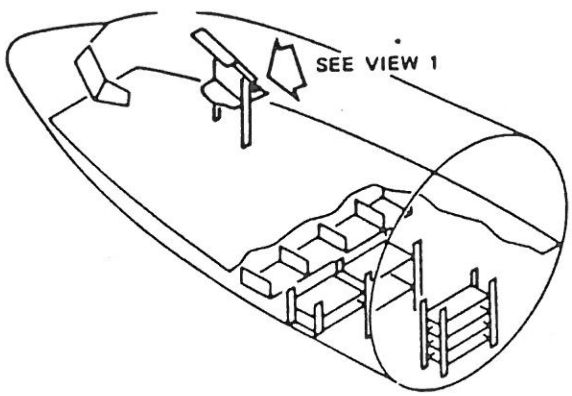
E6 EQUIPMENT RACK

Fuel Flow Power Supply Installation



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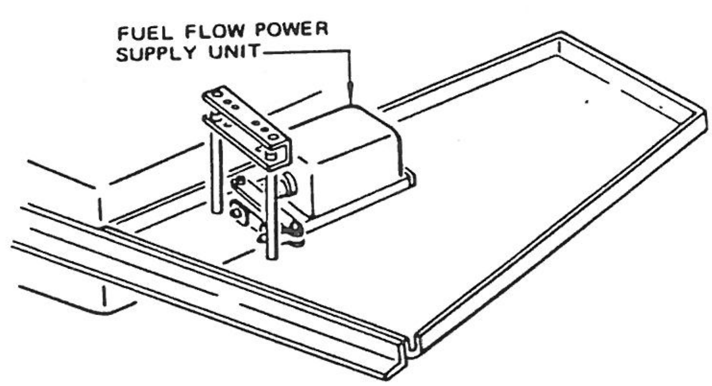


THIRD CREWMAN'S PANEL

b. Fuel Flow Power Supply Unit

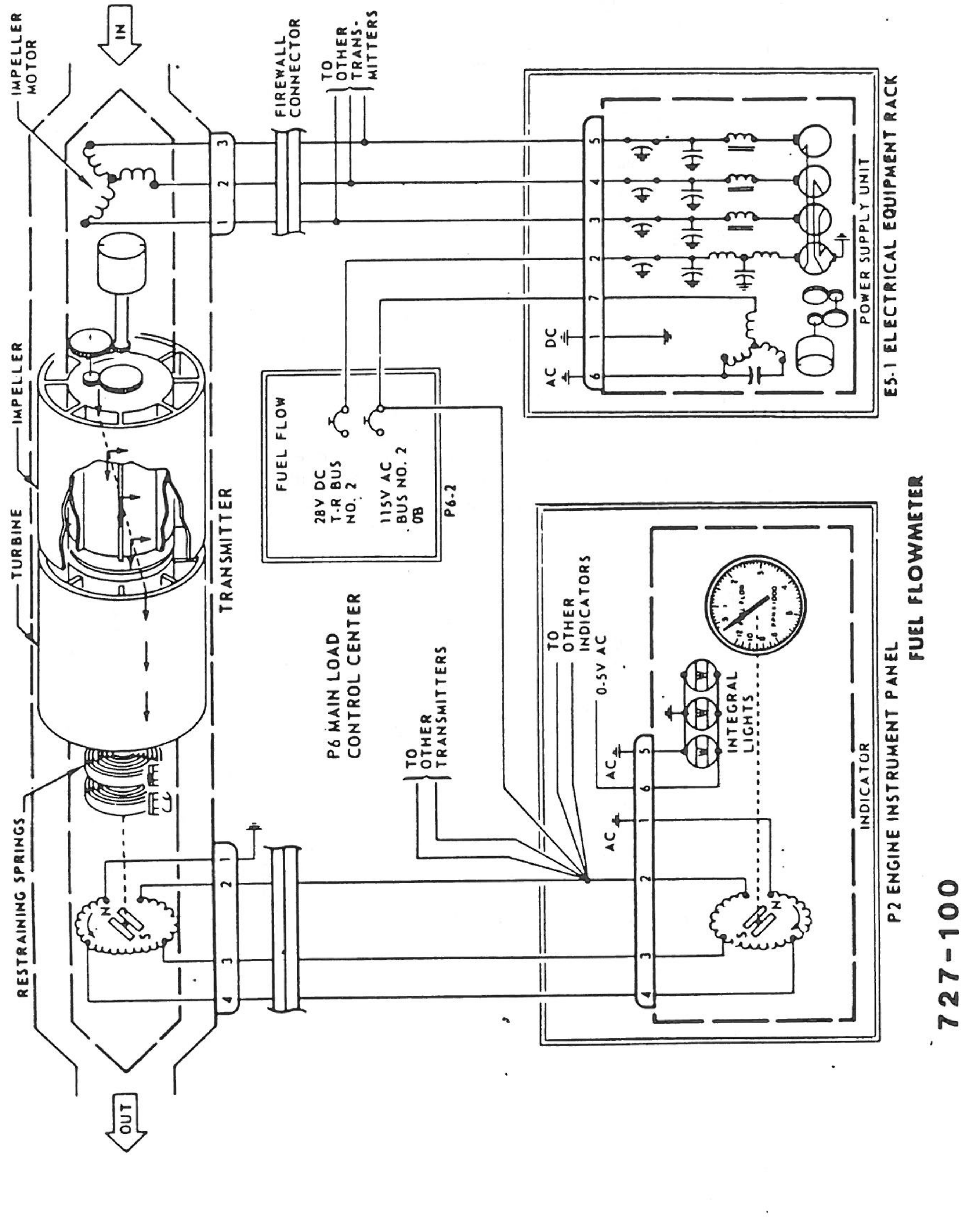
The fuel flow power supply unit furnishes a constant frequency power source for the fuel flow transmitters. The unit consists of a synchronous motor connected to a 3-bar commutator through a reduction gear. When the motor is energized the commutator is driven at a constant speed. As the commutator rotates it chops the dc current to produce a simulated 3-phase, 4-cycle ac current. Filters are installed in the unit to ensure that the output is free of radio noise.

c. Fuel Flow Transmitter

(1) The fuel flow transmitter consists of a housing containing two identical cylinders placed end to end so that the axes of the cylinders coincide. The upstream cylinder is the impeller and the downstream cylinder is the turbine. The housing fits closely to the outer diameter of both the impeller and the turbine. Around the periphery of the circular cross section of the cylinders, at a fixed radius from the center, are a number of equally spaced holes which are accurately parallel to the axes of the cylinders. Upstream of the impeller is the impeller motor. Downstream of the turbine, a second harmonic transmitter is attached to the turbine with two sets of springs of different torque gradients used to restrain it. This permits a two-slope scale on the indicator allowing greater sensitivity at low flow rate.

NOTE: To prevent dry operation damage and to prolong the life of the transmitter, it is recommended that the "FUEL FLOW" Circuit breakers be pulled (open) whenever the engine fuel feed line is drained or the airplane is out of service for maintenance.

(2) The impeller motor drives the impeller at a constant angular velocity, thus as the fuel passes through the impeller it is given a velocity at right angles to the direction of flow. This angular velocity constitutes a change in the momentum of the fuel directly proportional to the mass of fuel flow. As the fuel passes through the turbine, the angular component of the momentum is removed, this imparts to the turbine a torque directly proportional to the mass rate of fuel flow. This torque rotates the impeller against calibrated springs and positions the magnet in the second harmonic transmitter to a position corresponding to the fuel flow.



FUEL FLOWMETER

727-100

d. Fuel Flow Indicator

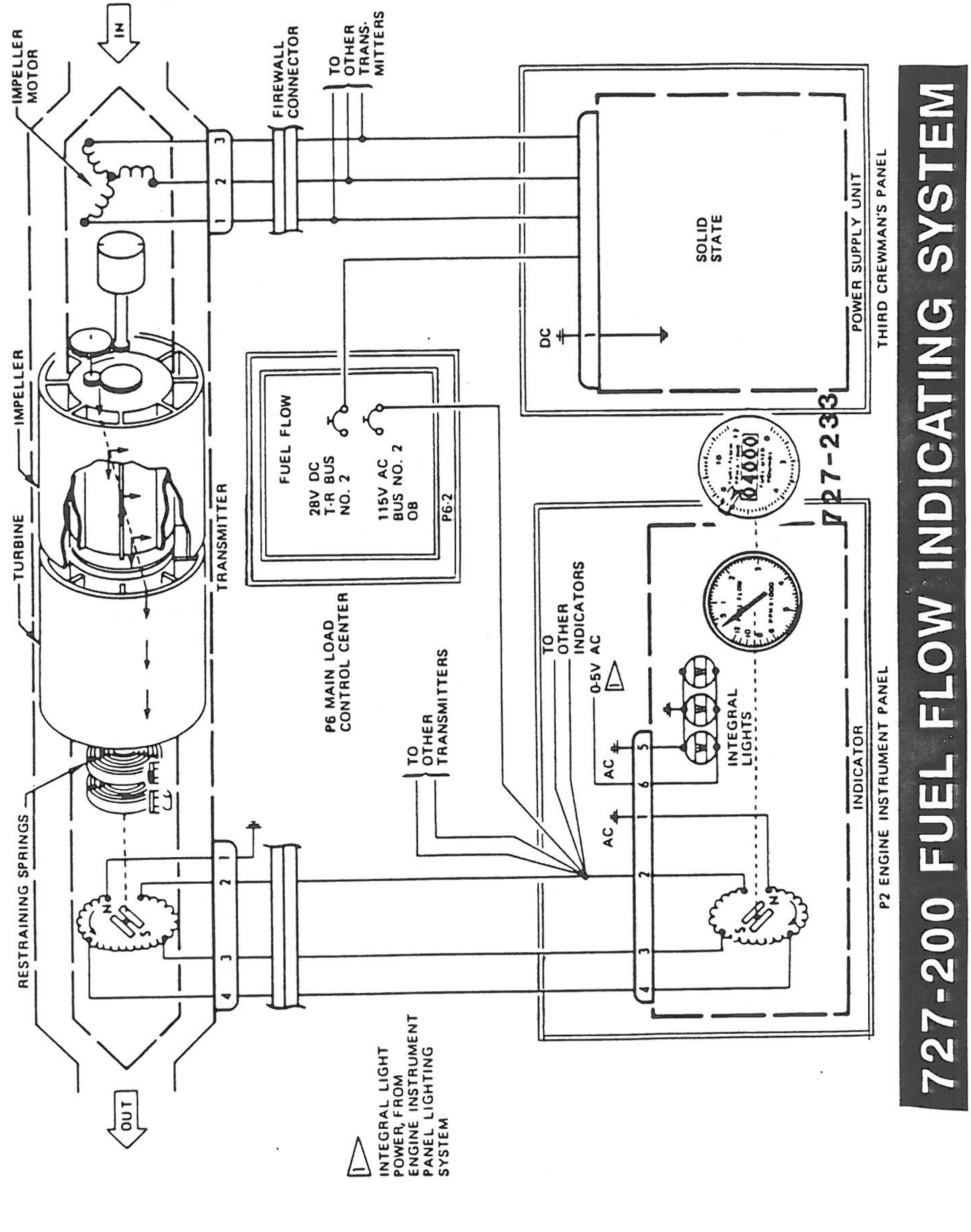
(1) The indicator provides high accuracy fuel flow indications in the 500 pph to 6000 pph range, and coarser indications from 6000 to 12,000 pph. The dial face is graduated with 100 pph marks up to 6000 pph and from 6000 pph to 12,000 pph the graduation marks are 500 pph apart. The indicator is hermetically sealed.

(2) N218FE thru N223FE has a fuel used indicator added to the indicator, a reset button is on the second officer's panel. The unit consists of a coil and core similar to the transmitter pickoff operating on a permanent magnet rotor. This is a type of synchro-transmitter using a permanent magnet rotor operating on a saturation principle. It requires no leads to the rotor. A pointer is attached to the rotor. As the second harmonic principle of remote indication is used the permanent magnet rotor assumes a position parallel to the rotor in the transmitter to provide fuel flow indication.

e. Operation

(1) The fuel flow indicating system electrically transmits the signal from each transmitter to its respective indicator. This signal is a measurement of mechanical torque in terms of angular deflection directly proportional to the fuel mass rate of flow through the transmitter.

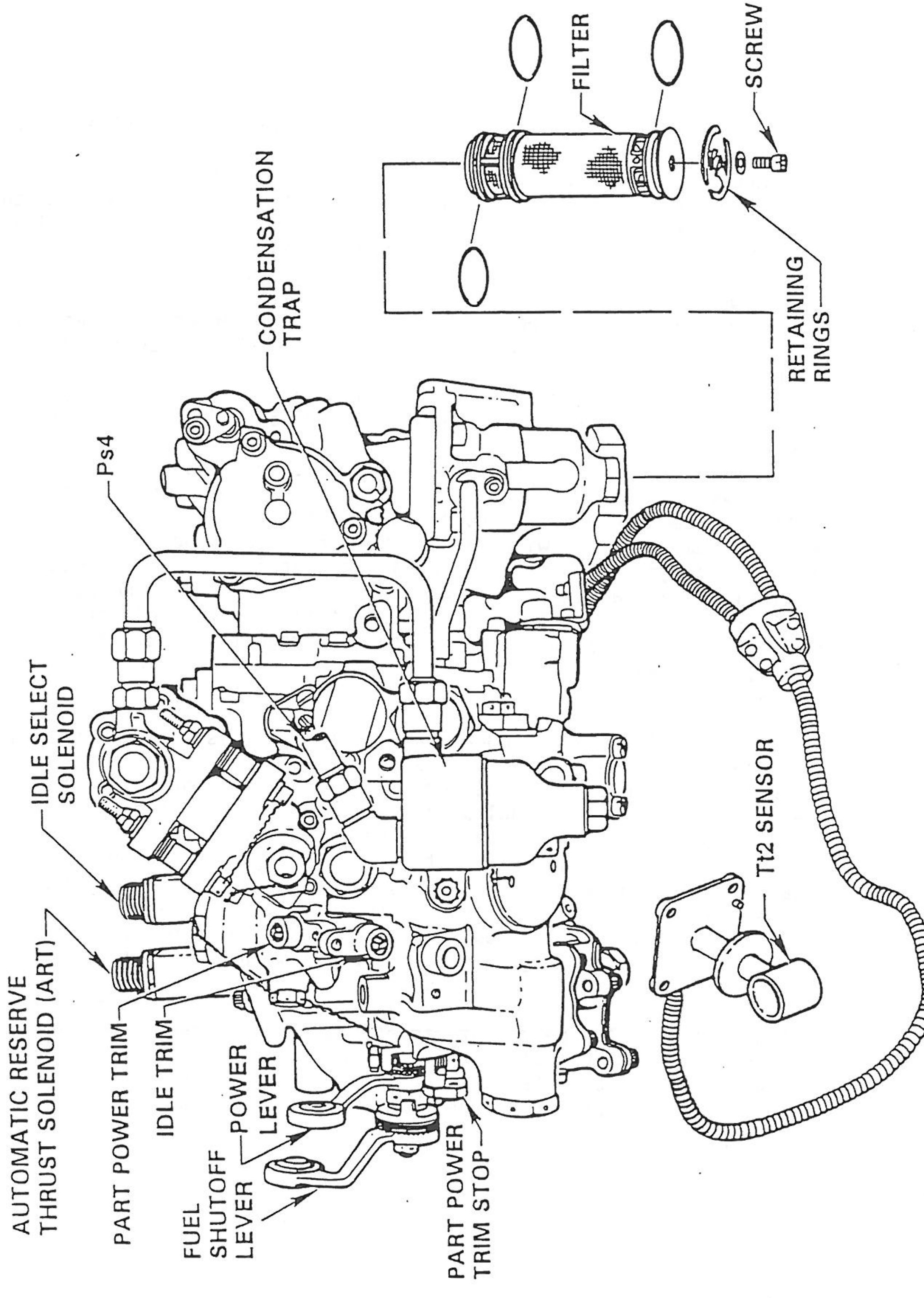
(2) Closing the FUEL FLOW, 28V DC circuit braker on circuit breaker panel P6-2 makes the system operative and supplies power to the fuel flow power supply unit. The solid state power supply unit provides a simulated 3-phase 4 cycle electric output that drives the transmitter impeller motor at 240 rpm. The frequency is maintained constant within o.3%. Fuel from the fuel control unit passes through the holes in the impeller then through the holes in the turbine, leaves the transmitter and enters the fuel oil cooler. The fuel on passing through the impeller, is given a velocity at right angles to the direction of flow because the impeller is rotated at a constant angular velocity of approximately 60 rpm by the transmitter impeller motor through a reduction drive. This angular velocity constitutes a change in momentum of the fuel which is directly proportional to the mass of fuel flowing. The angular momentum of the fuel is removed while passing through the turbine resulting in a torque directly proportional to the mass rate of flow. Restraining springs on the downstream turbine oppose this torque causing a deflection of the turbine proportional to the flow rate. Since the magnet, in the second harmonic transmitter, is directly coupled to the turbine it is also deflected an amount proportional to the flow rate.



727-200 FUEL FLOW INDICATING SYSTEM
IN
OUT
IMPELLER MOTOR
IMPELLER
TURBINE
RESTRAINING SPRINGS
TRANSMITTER
FIREWALL CONNECTOR
TO OTHER TRANS-MITTERS
SOLID STATE
DC
POWER SUPPLY UNIT
THIRD CREWMAN'S PANEL
FUEL FLOW
28V DC T-R BUS NO. 2
115V AC BUS NO. 2 OB
P6-2
P6 MAIN LOAD CONTROL CENTER
TO OTHER TRANSMITTERS
TO OTHER INDICATORS
0-5V AC
AC
INTEGRAL LIGHTS
INDICATOR
P2 ENGINE INSTRUMENT PANEL
727-233
INTEGRAL LIGHT POWER, FROM ENGINE INSTRUMENT PANEL LIGHTING SYSTEM

(3) A voltage can be induced in a conductor by a magnetic field only if there is a relative motion between the conductor and the flux lines of the magnetic field. Since the permanent magnet rotor in the transmitter is stationary for constant fuel flow, an artificial means of causing relative motion between the rotor flux and stator windings must be employed. Relative motion is produced by forcing a 115V, 400 cycle ac excitation current through the stator windings, the magnitude of this ac current is sufficient at its peaks to completely saturate the stator core. The core is therefore unsaturated when current flow is zero. As the excitation current builds up to its peak it expels the permanent magnet rotor flux from the core, conversely the permanent magnet flux enters the core as the excitation current decreases to zero. This alternate expelling and accepting of the permanent magnet flux creates a relative motion between the stator windings and flux field, thus inducing a second harmonic voltage of 800 cycles in each segment of the windings. The magnitude of the voltage in each segment is dependant upon the position of the permanent magnet rotor with respect to the stator windings. Since the stator windings of the transmitter and the indicator are connected in parallel, identical current flows must appear in corresponding portions of the twp stators. The current flow in the indicator windings must therefore, cause a resultant magnetic flux field, exactly parallel to that in the transmitter, to appear in the indicator.

(4) The magnetic flux field induced in the indicator is alternating and will therefore provide 2 positions, 180° apart, for the permanent magnet rotor. To provide the correct position for the rotor the flux field is made unidirectional by applying a 400 cycle ac current to the stator windings in the indicator. The applied current causes an increase in the flux density in the core during both the positive and negative halves of the excitation cycle. Phase relation between the excitation current and the second harmonic current is such that the indicator flux density is low during the positive halves of the second harmonic current, and high during the negative halves. This cancels out the negative portion of the second harmonic current leaving a flux of a positive value to create an effective dc field across the indicator core. The permanent magnet rotor of the indicator will align itself with this field. In this manner the rotor of the indicator will assume the same angular position as the rotor in the transmitter, thus providing the remote position of fuel flow.



FUEL CONTROL - FRONT VIEW

Fuel Control

Approach Idle (Ref. Figure 1)

(a) The fuel control incorporates a two position idle selection solenoid whose function is to select high engine idle rpm during approach.

(b) The approach idle control system which is fitted to No. 1 and No. 3 engines consists of a nosegear position switch, a nose gear indication relay, ground and air sensing safety relay, two 5 second time delay relays, a 3 second time delay relay, a latched relay, an illuminated reset relay, and an engine fuel control idle solenoid.

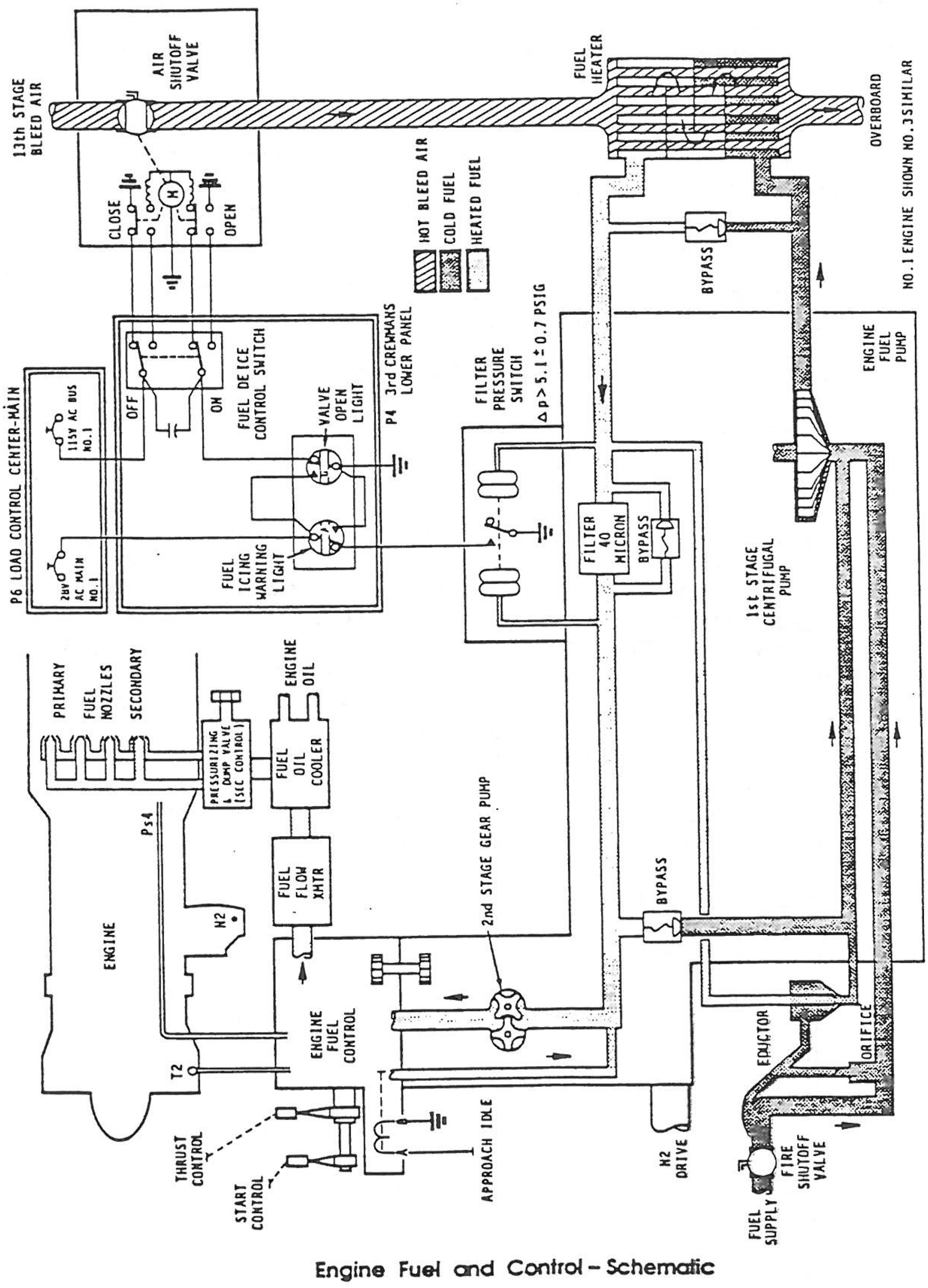
(c) The idle solenoid selects ground/descent (low) idle when electrical power is applied and approach (high) idle when power is removed.

(d) During normal flight, the contacts of both safety relays are open and the contacts of both the nosegear position switch and the nosegear indication relay are closed. As a result, both the 5 second time delay relays and consequently the engine idle solenoids are in the energized (low idle) condition. When the landing gear is lowered, the contacts of the nosegear position switch and the nosegear indication relay open, the two 5 second delay relays become de–energized and the engine idle solenoids change to the de–energized (high idle) condition. At touchdown, the contacts of the air and ground sensing relays close and energize the 5 second delay relays. After 5 seconds the time delay relay contacts close and the idle solenoids revert to the low idle condition. This 5 second high idle facility provides rapid engine acceleration capability in the event of an aborted landing.

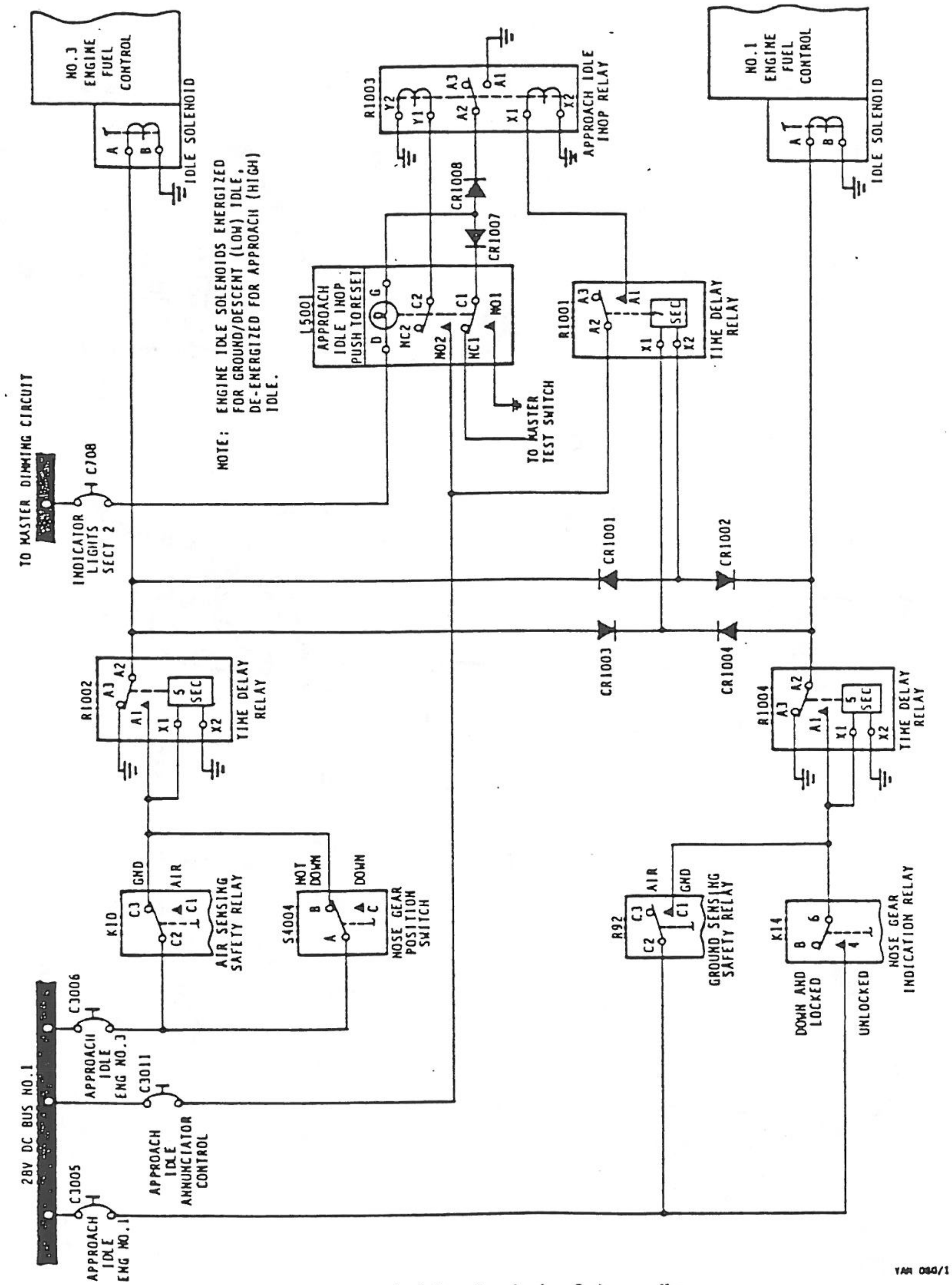
(e) The approach idle inop light is located on the P2 engine instrument panel. The light operation is based on the difference of electrical inputs to the two engine idle solenoids as sensed by diode network CR1001 thru CR1004. If a fault condition exists where one system is grounded and the other is energized, the 3 second delay relay is energized. After 3 seconds the relay contacts close, energizing the approach idle inop relay whose closed contacts illuminate the approach idle inop light. The light remains illuminated until the fault is rectified and the reset switch is closed, latching the relay in the fault–free position.

(8) Deceleration Bleed Override

(a) The fuel control incorporates a bleed override circuit which is designed to open the bleed valves when the engine is on a rapid deceleration schedule. A reduced fuel flow associated with a rapid decelerating thrust lever movement results in a lower bleed override fuel signal. This fuel signal is carried through external plumbing to a bleed valve control which interrupts the flow of actuating air to the bleed valves from the pressure ratio bleed control. When the override fuel signal is low because of rapid deceleration scheduling, the bleed valve control cuts the bleed valves off from their actuating air pressure and allows them to open. When the rapid deceleration phase is terminated, an increased fuel signal pressure to the bleed valve control opens the air valve in the control and allows pressure from the pressure ratio bleed control to close the bleed valves.



Engine Fuel and Control – Schematic



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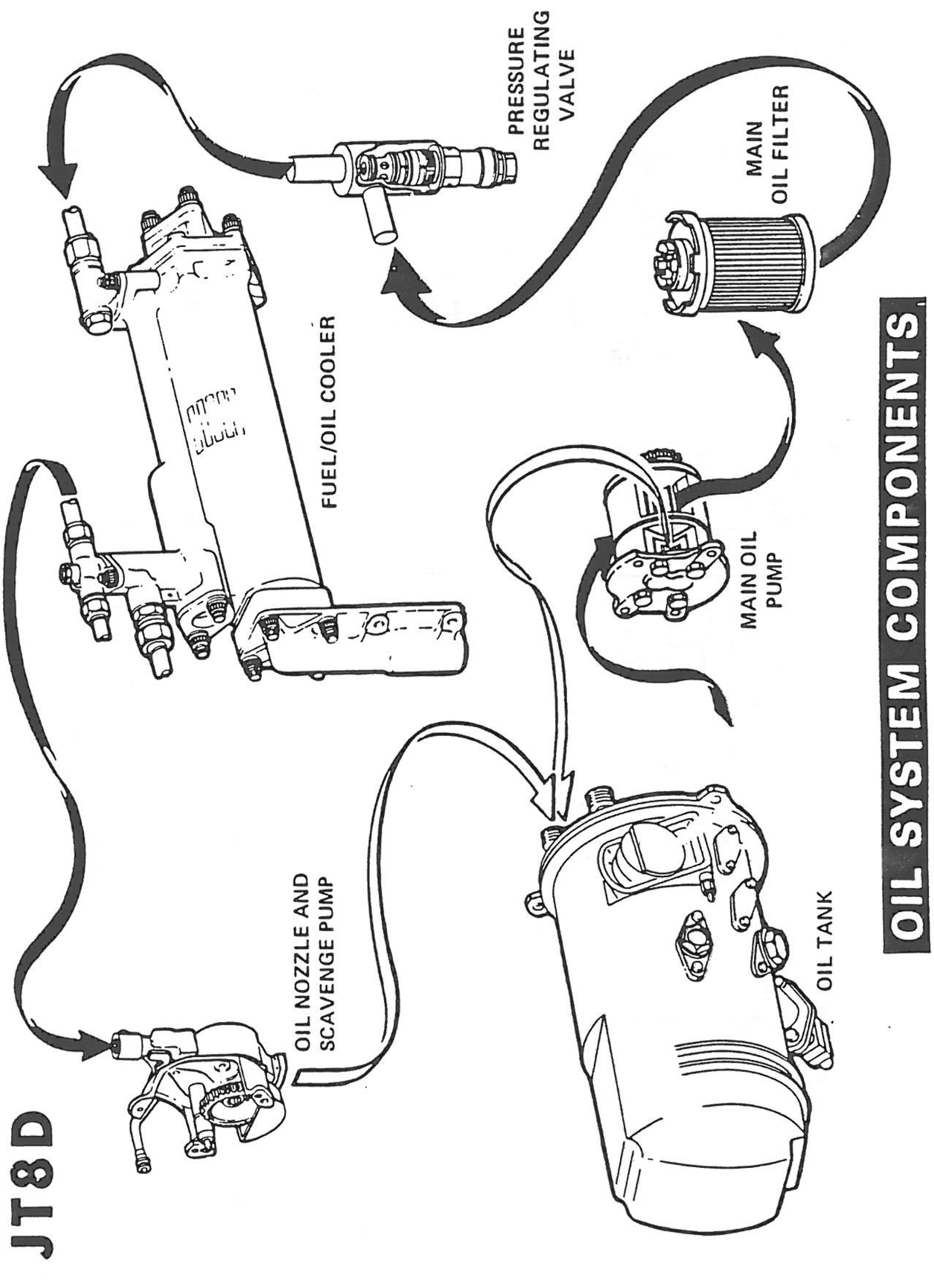
Approach Idle Control – Schematic

Figure 1


JT8D
OIL SYSTEM COMPONENTS
PRESSURE REGULATING VALVE
MAIN OIL FILTER
FUEL/OIL COOLER
MAIN OIL PUMP
OIL NOZZLE AND SCAVENGE PUMP
OIL TANK