United States Army Aviation Logistics School
Fort Eustis, Virginia

APRIL 1994

THIS DOCUMENT HAS BEEN REVIEWED FOR OPSEC CONSIDERATIONS

STUDENT HANDOUT

AUXILIARY POWER UNIT (APU)

071-624-04

The proponent for this SH is USAALS

TERMINAL LEARNING OBJECTIVE:

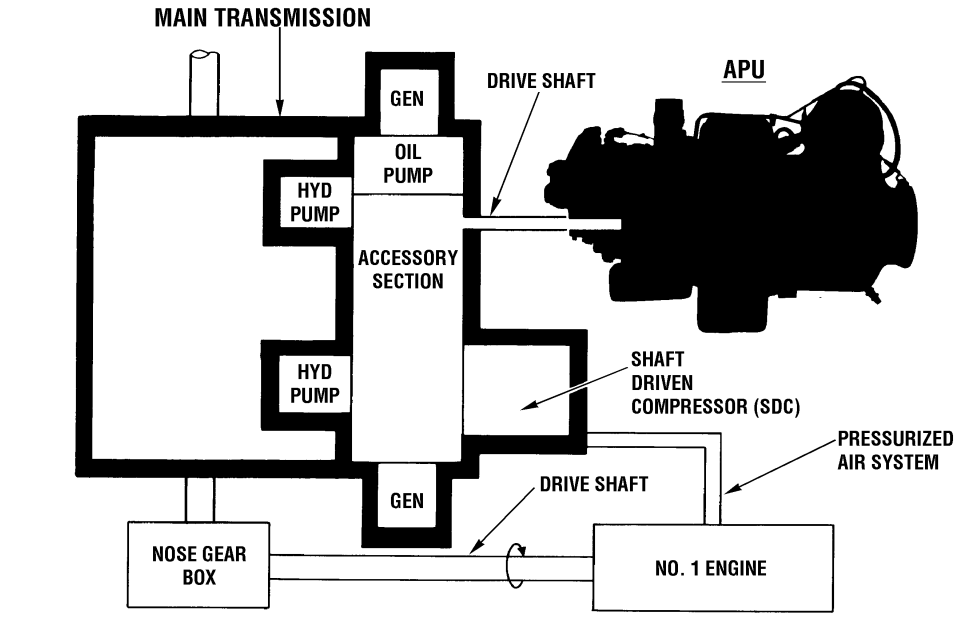
At the completion of this lesson you will:

ACTION:	Analyze auxiliary power unit malfunctions.
CONDITIONS:	Given TM 1-1520-238-T and TM 55-1520-238-23 series manuals.
STANDARDS:	Determine by selecting from a list, the corrective actions for abnormal conditions of the AH-64A's auxiliary power unit in accordance with TM 1-1520-238-T and TM 55-1520-238-23 series manuals, with a minimum of 70% accuracy.
SAFETY REQUIREMENTS:	In addition to the specific safety requirements of this lesson plan, aviation shop and flight line safety standards established in the applicable manuals will be reinforced.

WARNING

To prevent accidental APU start, the APU circuit breaker in the aft avionics bay and the APU HOLD circuit breaker on the pilot overhead circuit breaker panel shall be out when battery or external power is connected to the helicopter and unqualified personnel are in or around the pilot's crew compartment.

APU DRIVEN ACCESSORIES



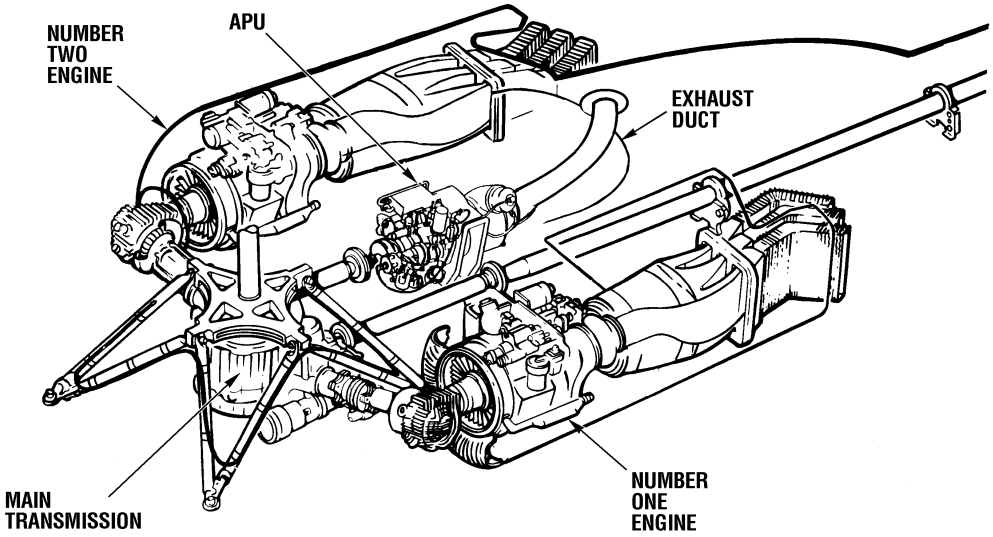
NOTES

A. Auxiliary power unit

1. The auxiliary power unit (APU) drives the accessory section of the main transmission. This provides electrical power, hydraulic power, and pressurized air to the helicopter when the engines are not running.

2. Provides the AH-64A with a self-supporting means in a field environment by eliminating the need for external pneumatic, hydraulic, and electrical power.

APU LOCATION



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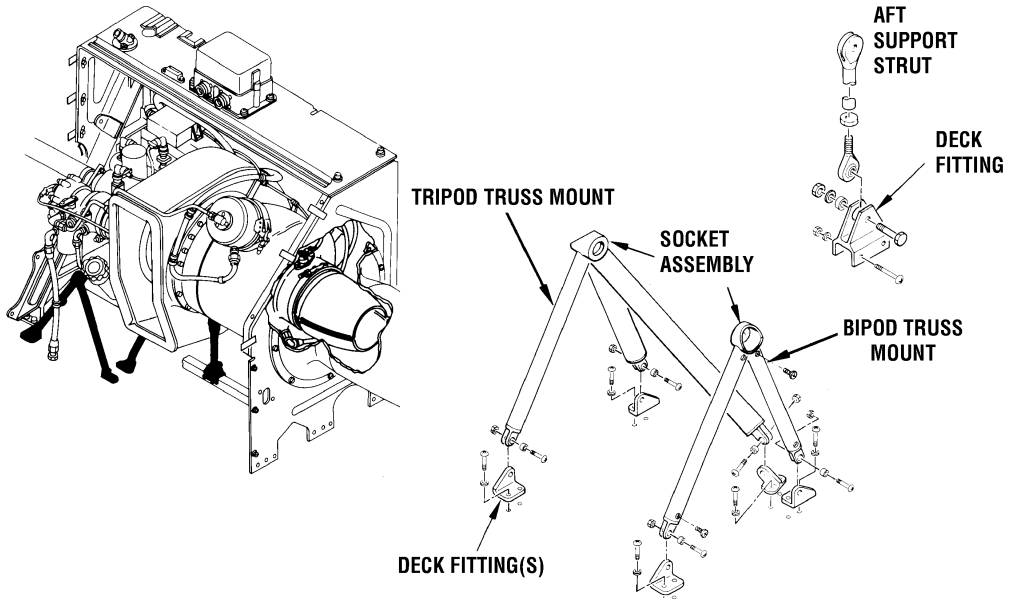
NOTES

3. The APU is located on the right side of the aft equipment bay, aft of the main rotor support structure.

C

APU MOUNTS



NOTES

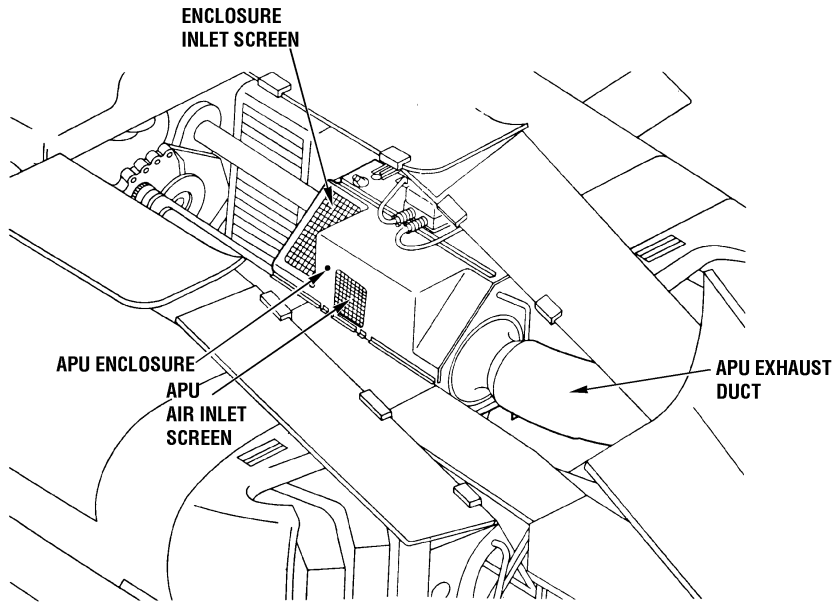
4. Mounts are used to attach the APU to the equipment bay deck and are the sole supports for the APU. Mount components are:

   a. Bipod truss mount

   b. Tripod truss mount

   c. Aft support strut

APU ENCLOSURE



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NOTES

5. APU enclosure

   a. A five-piece Kevlar enclosure fits over the APU, forming a compartment.

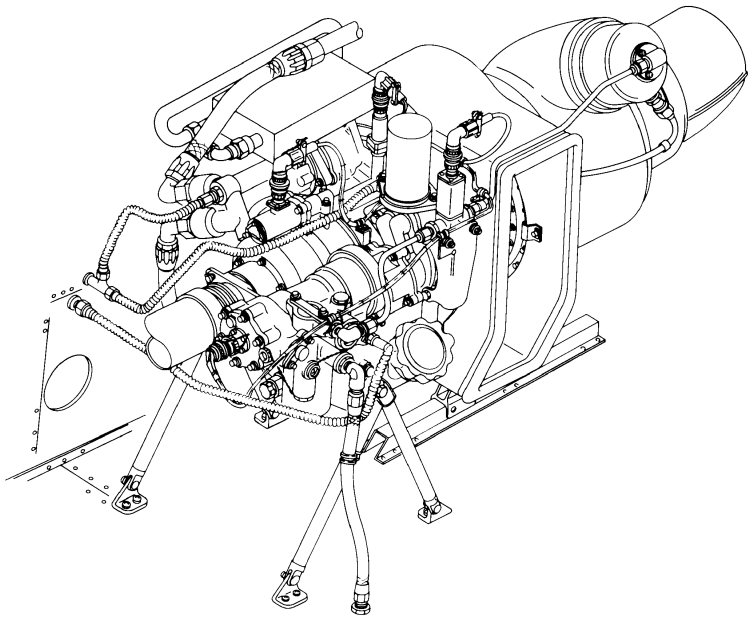
   b. The forward portion of the upper center panel contains a wire mesh inlet screen. The inlet screen allows cooling air to be drawn across the APU. This is made possible by the ejector effect of the APU exhaust.

   c. The upper center and lower center panels contain an APU air inlet wire mesh screen. This screen allows ambient air to be ingested for combustion.

   d. The enclosure is secured using machine screws, turn-lock fasteners, and velcro strip fasteners.

C

APU GTCP36-55 (H) MODEL



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NOTES

6. APU GTCP36-55 (H) model

   a. Self-contained, fully-automatic, constant speed, gas turbine engine requiring only DC power, fuel, and input signals from the helicopter for operation.

   b. Single-shaft, gas turbine engine, employing a single-stage centrifugal compressor, and a single-stage radial inflow turbine.

   c. The accessory gearbox section is mounted to the front of the APU.

   d. An integral system of electro-mechanical controls provide control of APU starts, acceleration, operation, and shutdown.

APU PARAMETERS

1) WEIGHT (DRY)	100 POUNDS
2) SHAFT POWER OUTPUT	125 SHAFT HORSEPOWER
3) APU SPEEDS:	
a) TURBINE ROTOR	59,566 RPM
b) PTO CLUTCH	CCW 8216 RPM
4) ELECTRICAL SYSTEM VOLTAGE	14 TO 30 VDC
5) LUBRICATION SYSTEM:	
a) LUBRICATION SPECIFICATION	(SAME AS MAIN ENGINES) MIL-L-23699 OR MIL-L-7808
b) SUMP CAPACITY	2 U.S. QUARTS
6) FUEL SYSTEM:	(SAME AS MAIN ENGINES)
a) FUEL SPECIFICATION	GRADES JP4, JP5, AND JP8
b) FUEL CONSUMPTION:	135 POUNDS PER HOUR
7) START MOTOR HYDRAULIC FLUID	MIL-H-83282 OR MIL-H-5606

8) AUTOMATIC SHUTDOWN FEATURES:	
a) OVERSPEED	107 PERCENT (63,736 RPM)
b) OVERCURRENT:	
(1) FUEL SHUTOFF VALVE SOLENOID	1.2 + 0.5 AMP
(2) IGNITION UNIT	4.0 + 0.5 AMP
(3) PTO CLUTCH SOLENOID	1.0 + 0.5 AMP
(4) START VALVE SOLENOID	1.0 + 0.5 AMP
c) LOW OIL PRESSURE	75 PSIG MIN
d) OVER TEMPERATURE	
(1) 1785° AT 60 PERCENT APU SPEED	
(2) 1325° AT 100 PERCENT APU SPEED	
e) LOSS OF TEMPERATURE SIGNAL FROM THERMOCOUPLE	
f) LOSS OF SPEED SENSOR SIGNAL FROM MONOPOLE	
9) OPERATING RANGE	-65° TO 135°F SEA LEVEL TO 15K FEET

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NOTES

7. APU parameters

   a. Manufacturer: Garrett Auxiliary Power Division, Allied Signal Aerospace Company

   b. Model: GTCP36-55(H)

   c. Type of engine: Gas turbine

   d. Weight (dry): 100 pounds

   e. Shaft power output: 125 shaft horsepower

   f. Engine speeds:

      (1) Turbine rotor (nominal full load governed) 59,566 rpm

      (2) Power takeoff (PTO) clutch: 8216 rpm

   g. Electrical system: 14 to 30 VDC

   h. Lubrication system:

      (1) MIL-L-23699 or MIL-L-7808

      (2) Sump capacity: Approximately 2.0 U.S. quarts

   i. Fuel system:

      (1) Fuel grades: JP4, JP5, and JP8

      (2) Fuel consumption: 135 pounds per hour

   j. Automatic shutdown features:

      (1) Overspeed: 107% (63,736 rpm)

      (2) Overcurrent

         (a) Fuel shutoff valve solenoid: 1.2 +0.5 amp

         (b) Ignition unit: 4.0 +0.5 amp

         (c) PTO clutch solenoid: 1.0 +0.5 amp

         (d) Start valve solenoid: 1.0 +0.5 amp

      (3) Low oil pressure: 75 psi min (for 5 seconds above 95%)

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b) FUEL CONSUMPTION:	135 POUNDS PER HOUR
7) START MOTOR HYDRAULIC FLUID	MIL-H-83282 OR MIL-H-5606

8) AUTOMATIC SHUTDOWN FEATURES:	
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b) OVERCURRENT:	
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f) LOSS OF SPEED SENSOR SIGNAL FROM MONOPOLE	
9) OPERATING RANGE	-65° TO 135°F SEA LEVEL TO 15K FEET

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NOTES

(4) Over-temperature:

(a) Over-temperature: 1785EF (+974EC) at 60 % APU speed

(b) Over-temperature: 1325EF (+719EC) at 100 % APU speed

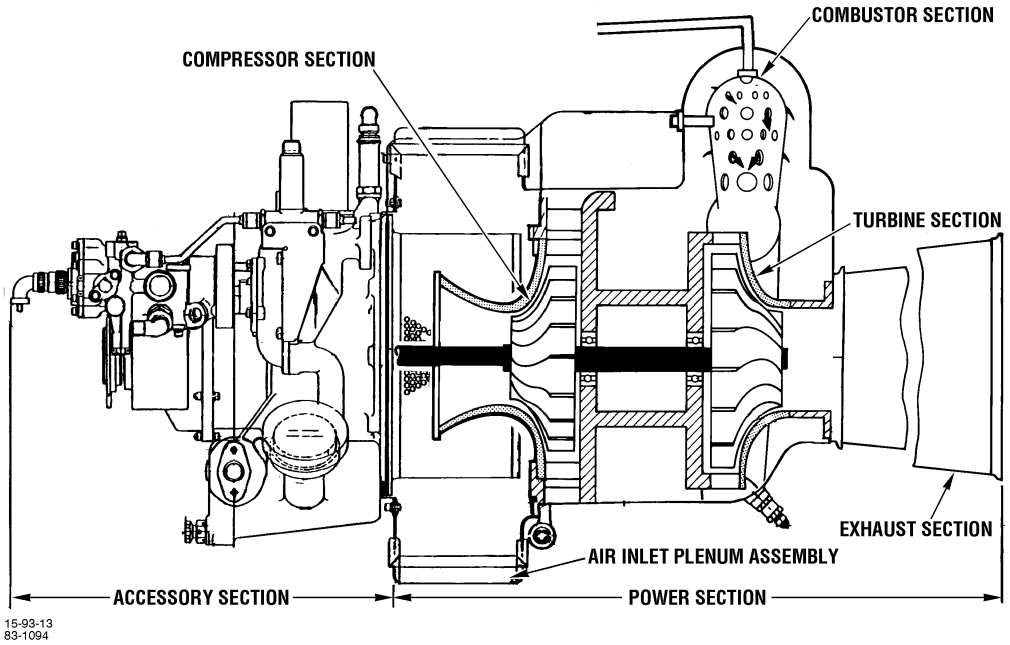
(5) Loss of temperature signal from thermocouple

(6) Loss of speed sensor signal from monopole

k. Operating range: -65EF to 135EF (-54EC to +57EC), sea level to 15,000 feet

l. Start motor hydraulic fluid: MIL-H-83282 or MIL-H-5606

APU POWER SECTION COMPONENTS



NOTES

A. The APU is divided into two major sections; the power section and the accessory gearbox section.

B. APU power section

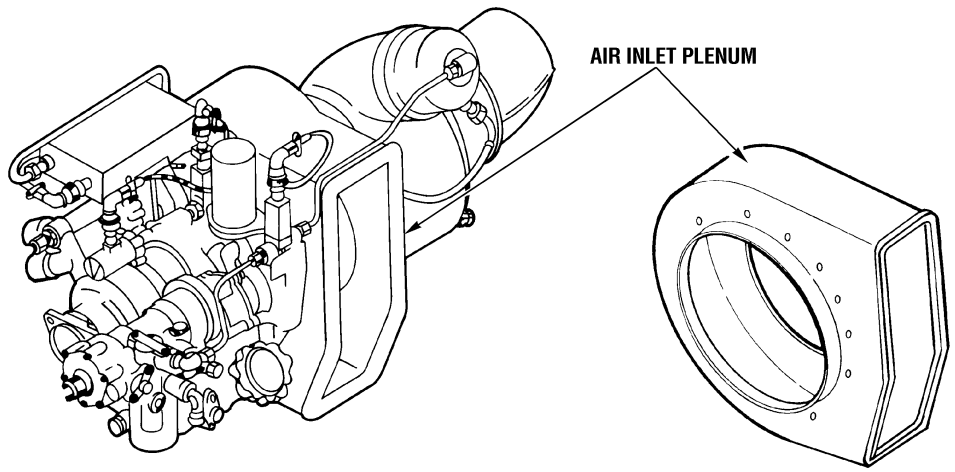
1. Provides drive for the accessory section.

2. Located behind the accessory section of the APU.

3. The APU power section consists of the air inlet plenum assembly, compressor section, turbine plenum assembly, torus assembly, combustor section, turbine section, and exhaust section.

C

APU AIR INLET PLENUM



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NOTES

a. Air inlet plenum assembly

(1) Directs inlet airflow to the compressor section.

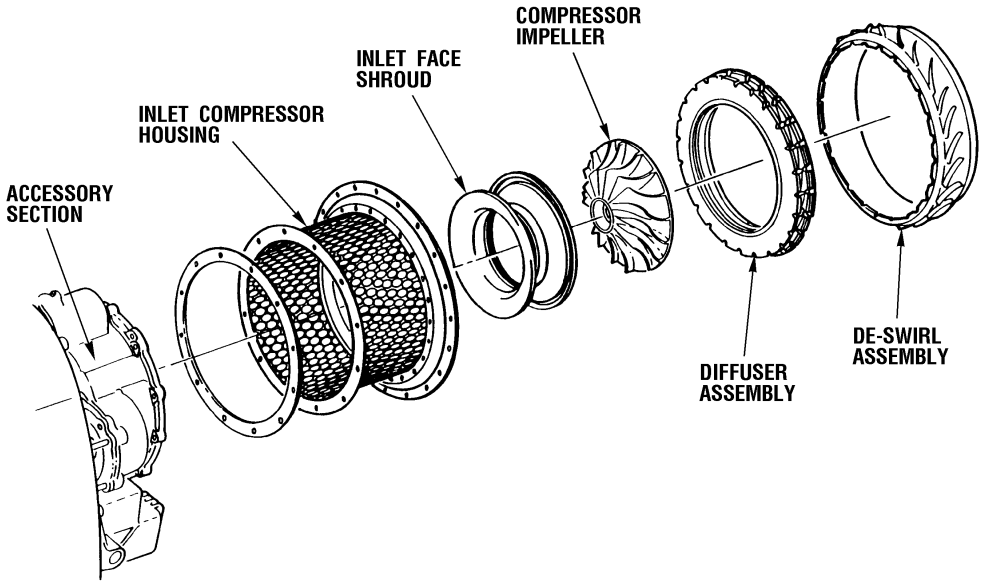
(2) Isolates the APU intake airflow from the APU enclosure cooling airflow.

(3) Installed around the inlet housing and bolted to the turbine plenum on the aft end, and to the accessory gearbox on the forward end.

(4) One-piece, lightweight, fiberglass construction.

(5) Does not require gaskets or clamps.

APU COMPRESSOR SECTION



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b. Compressor section

(1) Draws in a large volume of ambient air and reduces it to a small volume. The compression of the air raises the pressure and temperature yielding pneumatic energy.

(2) Forces compressed air through the combustor and turbine.

(3) Attached to the rear of the accessory gearbox case.

(4) The major components of the compressor section are the inlet compressor housing, inlet face shroud, compressor impeller, diffuser assembly, and de-swirl assembly.

(a) Inlet compressor housing

1) Allows the inlet plenum air to enter the compressor section. Helps prevent foreign object damage. Provides interfacing of the accessory section and the turbine plenum/torus assembly.

2) Mounted between the accessory gear case and turbine plenum and is covered by the air inlet plenum.

3) Made of lightweight aluminum alloy with several air inlet holes. The holes help prevent the entrance of foreign objects of dimensions equal to, or greater than, a 0.250-inch sphere.

(b) Inlet face shroud

1) Guides the inlet air toward the hub of the compressor impeller and provides containment for the impeller.

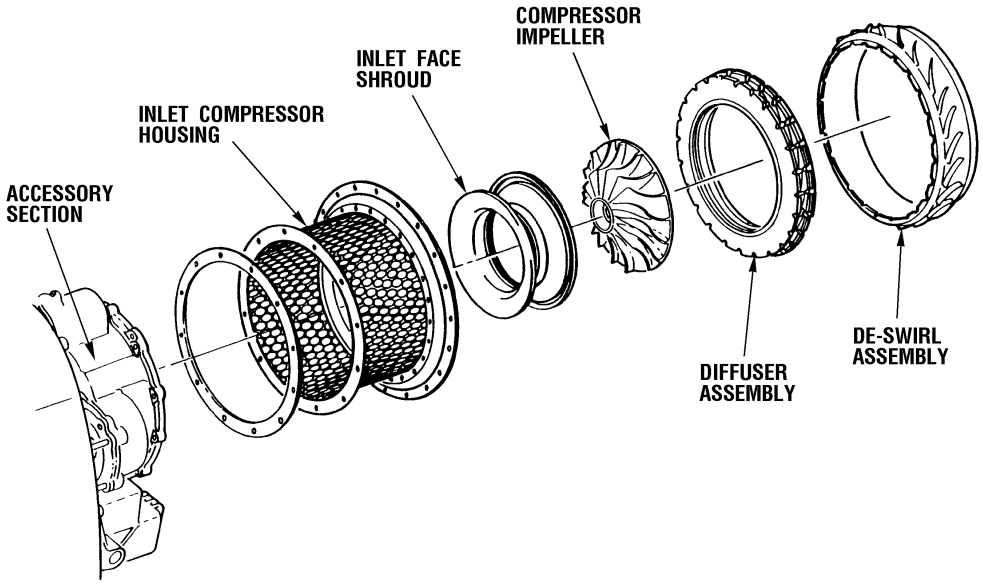
2) Mounted to the diffuser assembly. Fits over the contoured face of the compressor impeller.

(c) Compressor impeller

1) Draws in a large volume of air and accelerates it radially outward to a very high velocity. It then feeds this air to the diffuser assembly.

2) Mounted on the sun gear shaft in the inlet compressor housing.

APU COMPRESSOR SECTION



NOTES

3) This is a single-stage centrifugal impeller, cast of corrosion-resistant steel, and is extremely tolerant to foreign object damage.

(d) Diffuser assembly

1) Converts the high velocity air from the impeller to lower velocity and higher static pressure (compression).

2) Surrounds the compressor impeller.

3) This is a circular assembly shaped with divergent ducts cast of corrosion-resistant steel.

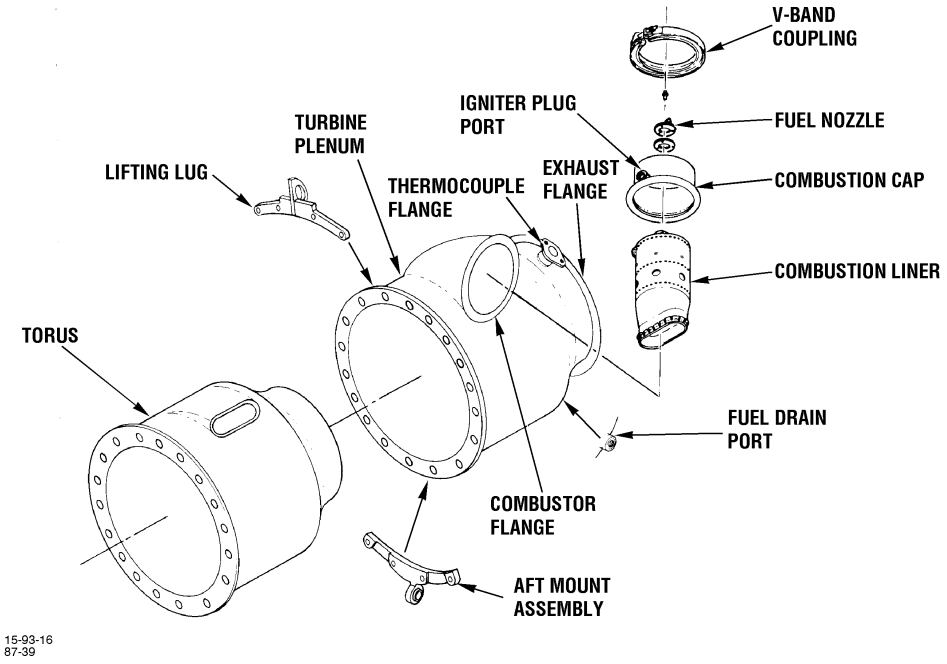
(e) De-swirl assembly

1) Stops rotation of the airflow from the diffuser and directs it into the turbine plenum/torus assembly.

2) Installed between the diffuser and the turbine plenum/torus assembly.

3) A circular assembly with straightening vanes cast out of aluminum alloy.

APU TURBINE PLENUM/TORUS ASSEMBLY AND COMBUSTION SECTION



NOTES

c. Turbine plenum assembly

(1) Serves as a receiver for the de-swirled compressor discharge air.

(2) Provides an enclosure for the combustion liner and torus assembly.

(3) Serves as a cooling encasement for the hot turbine.

(4) Installed directly behind the deswirl assembly, attached to the aft portion of the inlet housing.

(5) Constructed of corrosion resistant steel.

(6) A hole and flange are provided for mounting the combustion liner.

(7) Contains a fuel drain port, exhaust flange, and a thermocouple flange.

(8) Contains air under pressure.

(9) An aluminum alloy lifting lug assembly is attached to the mounting flange at the 12 o'clock position.

(10) An aluminum alloy mount assembly is attached to the mounting flange at the 6 o'clock position. It contains a self aligning bearing.

d. Torus assembly

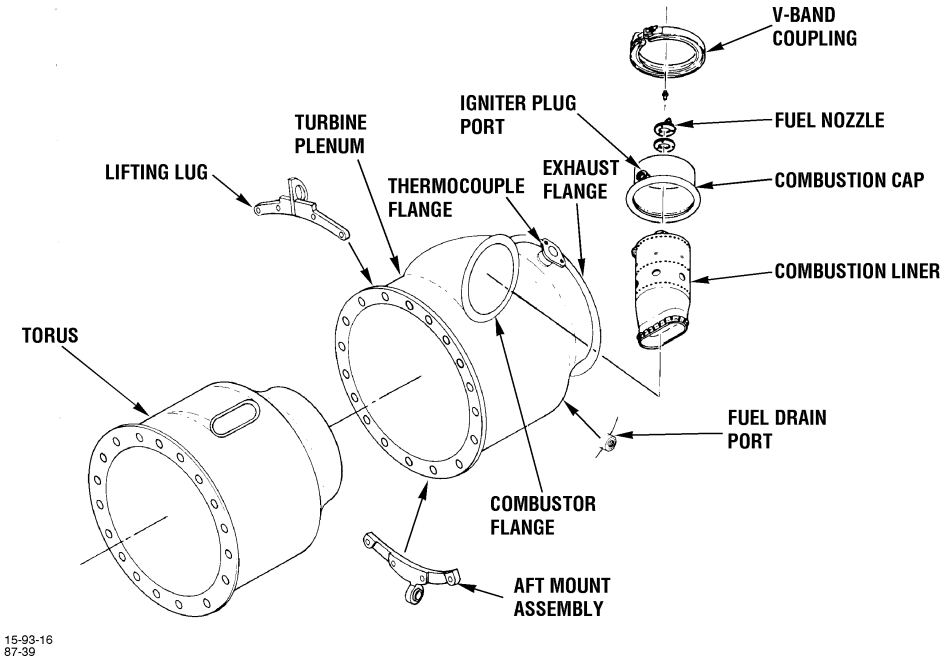
(1) Collects the hot combustion gases and directs them to the turbine nozzles.

(2) Installed into the turbine plenum assembly and attached to the aft portion of the compressor housing.

(3) A doughnut shaped air duct constructed of hastealloy forging. (Hastealloy is a nickel base alloy having approximately 53% nickel. Nickel alloys possess high strength volume. Nickel also forms a protective oxide coating on its surface much like aluminum. Because of the tendency to form such a protective film, nickel alloys are superior wherever oxidizing conditions at high temperatures are to be encountered).

(4) A hole and flange assembly allows the discharge end of the combustor to mate with the torus.

APU TURBINE PLENUM/TORUS ASSEMBLY AND COMBUSTION SECTION



NOTES

e. Combustor section

(1) Provides an area for uniting the compressor discharge air, atomized fuel, and spark so combustion can take place.

(2) Major components of the combustor section are the combustion cap and combustion liner.

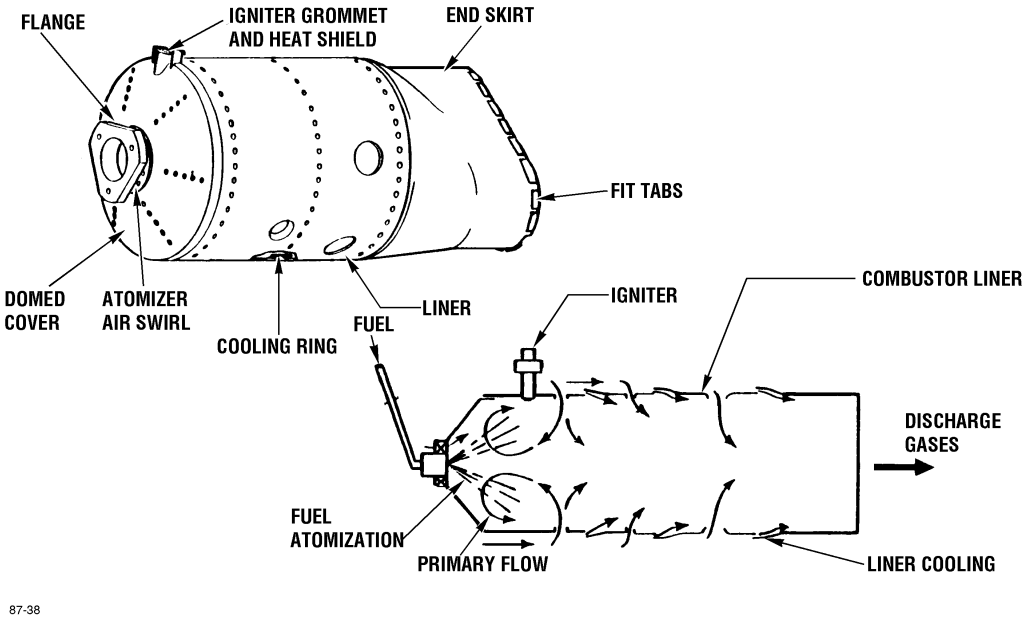
(a) Combustion cap

1) Provides mounting for the fuel nozzle, igniter plug, and the combustion liner.

2) Secured to the turbine plenum combustor flange with a V-band coupling.

3) Made of corrosion resistant steel.

APU COMBUSTOR LINER



NOTES

(b) Combustion liner

1) Forms an air passage between the plenum and torus.

2) Forms the combustion chamber.

3) The liner is secured to the combustion cap by bolts which pass through the fuel nozzle and mount to the flange of the liner.

4) Fit tabs, at the base of the end skirt insert into the torus assembly.

5) Singular cannular type, constructed of hastealloy.

6) Holes of varying diameter exist in the liner and are specially designed to perform several functions:

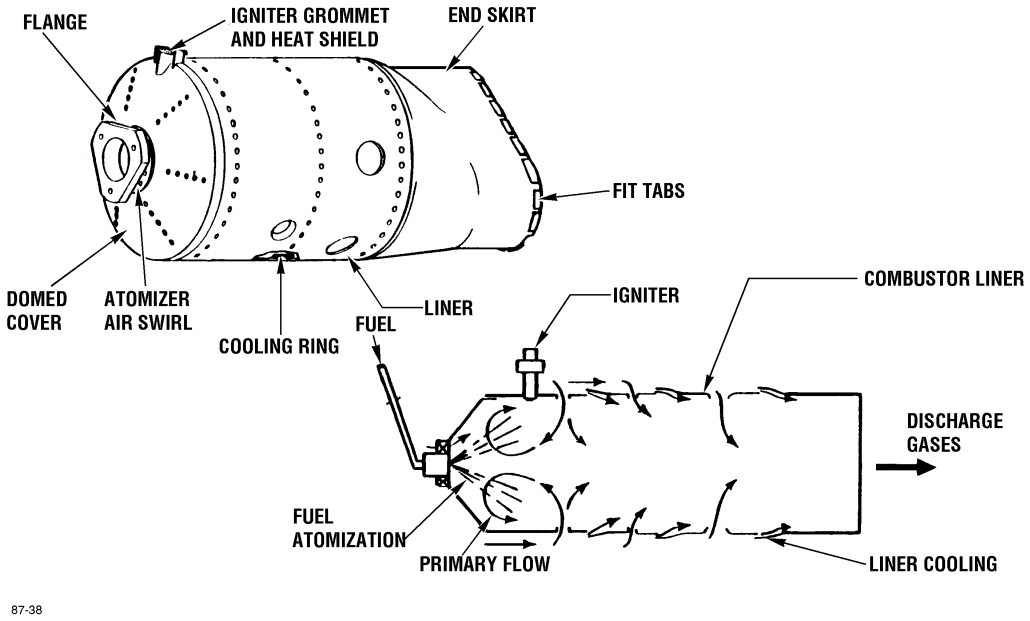
a) Holes in the flange allow air to flow through the air passages within the atomizer assembly. This ensures proper atomization. This same airflow passes through swirl vanes and prevents carbon buildup on the face of the nozzle. It also forms a blanket of air around the fuel spray cone, maintaining the proper spray pattern, and preventing direct contact with the walls of the liner, which could result in hot spots.

b) Holes in the dome cover allow air to flow adjacent to the liner dome. Secondary air flows through the cooling rings and also precludes hot spots.

c) A small series of holes around the periphery of the liner provide a cooling airflow at the combustor walls.

d) A large series of holes around the periphery of the liner provide additional cooling air, which dilutes and shapes the burning gases before they reach the turbine section. This reduction in gas temperature prevents APU over-temperature.

APU COMBUSTOR LINER

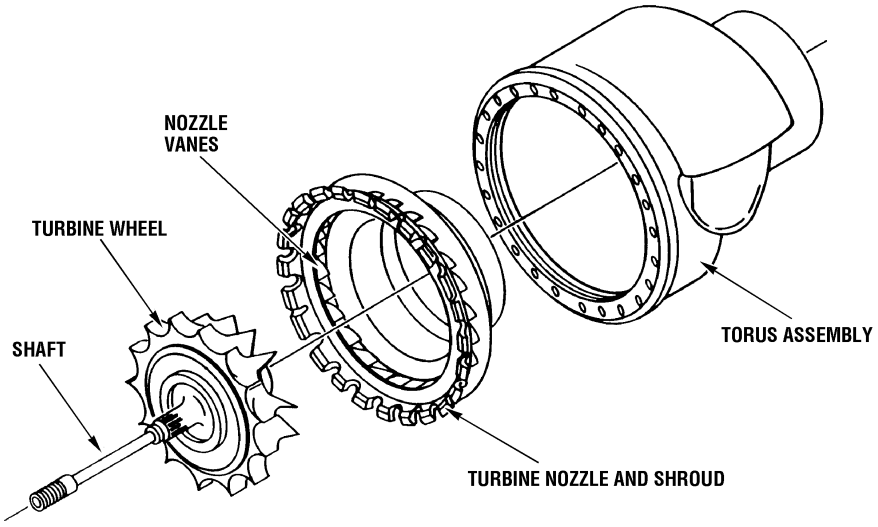


NOTES

7) The proper proportions of air are controlled by the spacing and sizing of the holes in the liner.

8) Much of the compressor discharge air (70 to 75%) is used to cool the high temperature combustion gases to the point where by they can be safely applied to the turbine nozzle and turbine wheel. Therefore, only a small portion (25 to 30%) of the compressor air supplies the oxygen used in combustion.

APU TURBINE SECTION



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NOTES

f. Turbine section

(1) Converts heat energy supplied from the combustor section into mechanical energy to drive the compressor and accessories.

(2) Located inside the torus.

(3) The turbine section consists of the turbine nozzle and shroud, and the turbine wheel.

(a) Turbine nozzle and shroud

1) The turbine nozzle accelerates and directs the combustion gases so they strike the turbine wheel blades at the angle most efficient for converting the pneumatic power into shaft horsepower.

2) The shroud contains and controls the airflow as it passes across the turbine wheel.

3) Mounted inside the torus assembly and the inlet compressor housing flange.

4) A one piece design.

5) A stationary disk with several fixed nozzle vanes which are shaped and sized to form a convergent duct.

6) Due to the convergent shape of the vanes, the air increases in velocity and decreases in air pressure, exactly the opposite of the diffuser.

(b) Turbine wheel

1) Transforms the high temperature expanding gases into shaft horsepower to drive the compressor and accessory section.

2) Aft of the turbine nozzle inside the torus assembly.

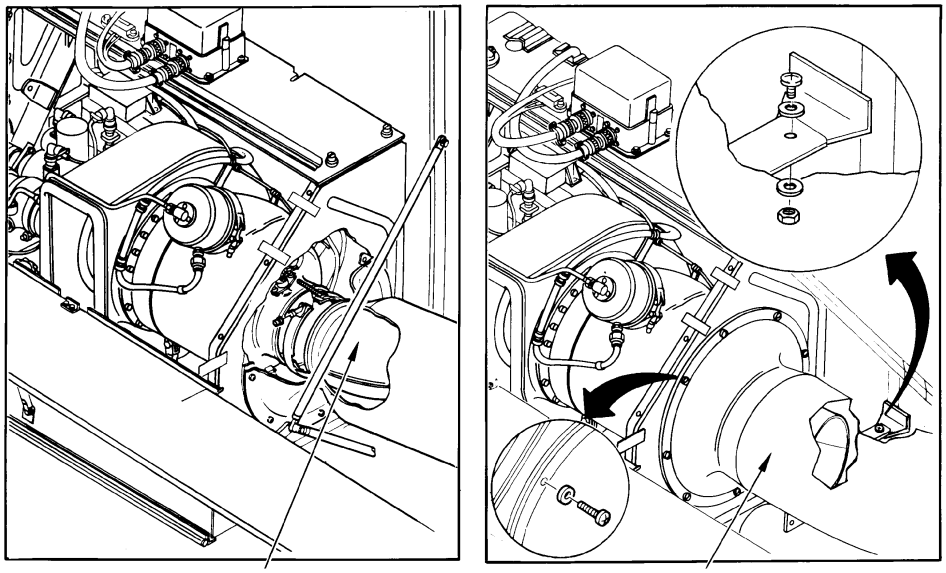
3) A radial inflow type constructed of cast nickel base alloy.

4) The shaft (tie bolt) and wheel assembly are one piece.

5) It is similar in appearance to the compressor impeller, but made of stronger material to withstand higher temperatures.

C

APU EXHAUST NOZZLE AND DUCT



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NOTES

g. Exhaust section

(1) Directs the expended gases from the turbine section into the exhaust duct.

(2) Creates cooling airflow across the APU.

(3) Located aft of the turbine section.

(4) Exhaust section components consist of the exhaust nozzle and exhaust duct.

(a) Exhaust nozzle

1) Directs the exhaust gases from the turbine section into the exhaust duct.

2) Attached to the turbine plenum via a V-band coupling.

3) Cone shaped, corrosion resistant steel duct.

4) As the high pressure gases are expelled from the exhaust nozzle, a low pressure area is created around the intake of the exhaust duct. The resulting low pressure area draws ambient air around the APU to be mixed with the high pressure gases. This airflow helps cool the APU and reduces the temperature of the exhaust plume.

(b) Exhaust duct

1) Allows mixing of ambient air and hot exhaust gas.

2) Creates airflow through the APU enclosure for cooling of APU external components.

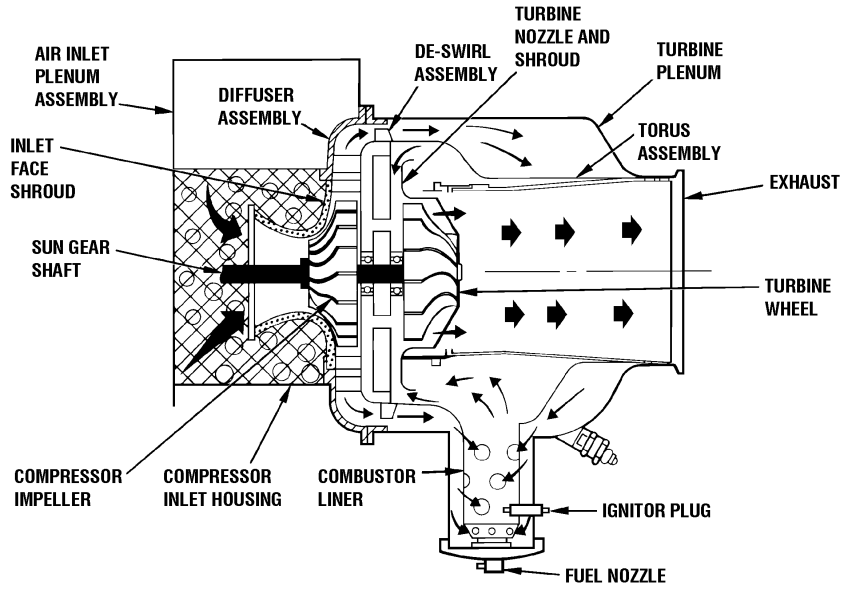
3) Attached to the aft panel of the APU enclosure and an airframe support bracket. (Right-hand side.)

4) Bell shaped at the APU enclosure attachment point, transitioning into a tubular shaped duct.

5) Constructed of stainless steel.

6) Covered with "low-Q" insulation which prevents heat transfer. (Low-Q insulation is a flexible heavy aluminum, sandwiching a wire mesh screen).

APU AIR FLOW



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NOTES

h. APU air flow

(1) Air is drawn through a wire mesh screen attached to the APU enclosure.

(2) The air inlet plenum directs ambient air to the inlet compressor housing.

(3) Holes in the inlet compressor housing preclude FOD from entering the compressor section. The inlet air is then guided toward the hub of the compressor impeller by the inlet face shroud.

(4) As the compressor impeller rotates, air is drawn into the impeller blades near the center where the blades are curved.

(5) The centrifugal action of the impeller causes the airflow to accelerate and leave the blades outward toward the rim of the compressor impeller.

(6) The accelerated airflow is ejected at a high velocity into the diffuser assembly.

(7) The diffuser assembly reduces airflow velocity and increases pressure.

(8) Following compression by the impeller and the diffuser, the air is directed through the de-swirl assembly. The vanes on the outer periphery of the de-swirl assembly straighten the air, thereby relieving the swirl component, which developed as the air passed through the diffuser. The air is then routed aft into the turbine plenum/torus assembly.

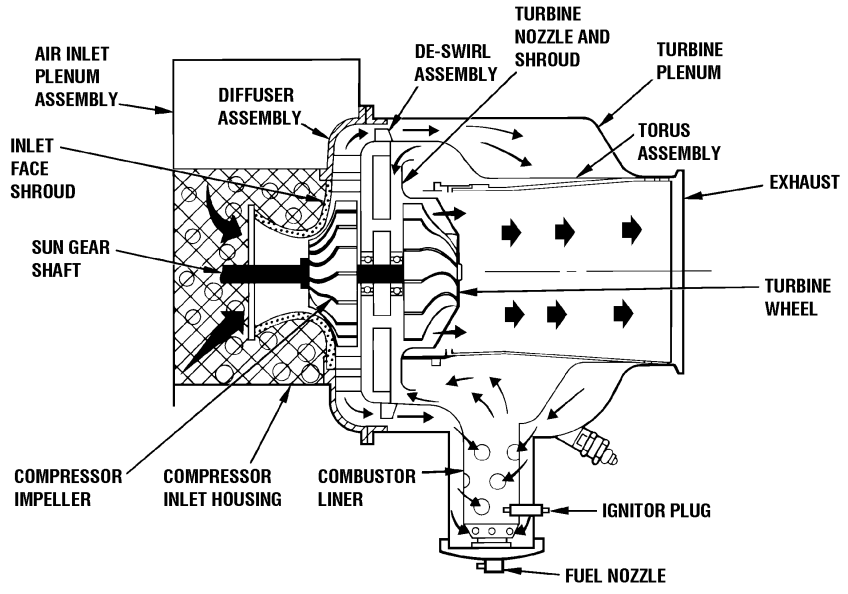
(9) As the compressed air is directed through the plenum/torus assembly, it will provide cooling for the torus and enter the singular cannular combustor liner through specially designed holes of varying diameters.

(10) Fuel is injected in the form of a finely atomized spray into the center of the combustion liner by the fuel nozzle. The fuel/air mixture is ignited by a series of sparks created by the igniter.

(11) The torus assembly mates with the discharge end of the combustor liner. The torus also envelopes the turbine nozzle and shroud. The hot combustion gases flow through the torus to the turbine nozzle.

(12) The turbine nozzle will redirect the hot expanding gases at the most efficient angle to drive the turbine wheel.

APU AIR FLOW



NOTES

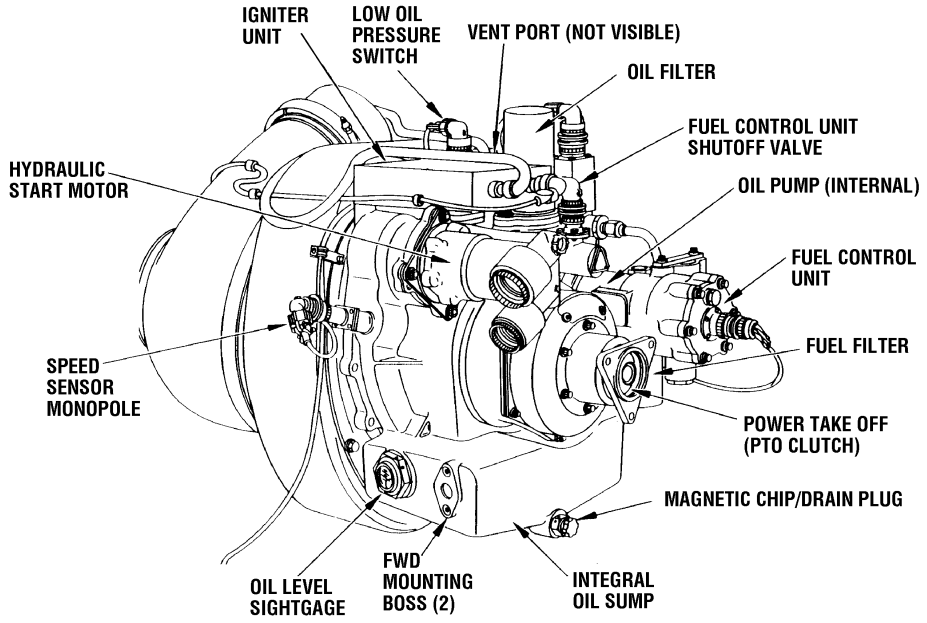
(13) The turbine converts the thermal and kinetic energy into shaft horse power.

(14) The shaft power is used to turn the compressor and the reduction gears. The gears drive the accessory section components and provide the power output.

(15) The exhaust gases will be directed into the exhaust nozzle, which is clamped to the turbine plenum/torus assembly and from there directed into the exhaust duct.

(16) The exhaust duct, bolted to the aft panel of the APU enclosure, will direct the exhaust gases out of the right side of the helicopter fuselage.

APU ACCESSORY GEARBOX AND MOUNTED COMPONENTS



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NOTES

C. Accessory gearbox section

1. Converts the high speed of the turbine wheel (59,566 rpm) to the required speed to drive the power takeoff clutch output and accessories.

2. Provides a means for starting the APU.

3. Mounted to the front of the power section.

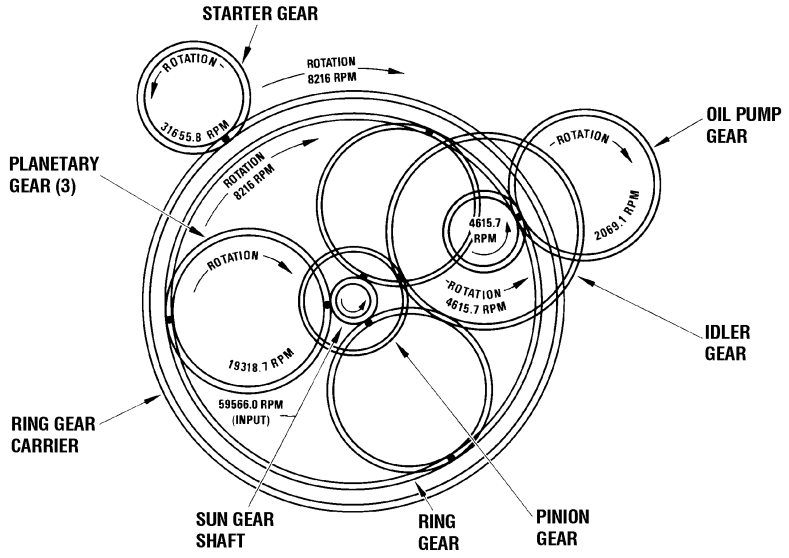
4. Provides mounting for the low oil pressure (LOP) switch, oil filter, fuel control unit shutoff valve, oil pump (mounted internally), fuel control unit, fuel filter (mounted to fuel control), power takeoff (PTO) clutch, magnetic chip/drain plug, forward mounting boss (2), oil level sight gage, speed sensor monopole, hydraulic start motor, and igniter unit.

5. The lower portion forms the integral oil sump.

6. A vent port is located at the top of the accessory gearbox. It permits air/oil separation and prevents excessive pressure buildup.

7. Several oil cooling fins, which provide maximum heat dissipation, are located at the aft end of the accessory gearbox. The cooling fins are visible through the air inlet.

GEAR TRAIN SCHEMATIC



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85-559

NOTES

8. APU gear train

a. Start Sequence

(1) The hydraulic start motor drives the starter gear which rotates the ring gear carrier.

(2) As the ring gear carrier rotates, it turns the ring gear that drives the planetary gears.

(3) The planetary gears drive the sun gear shaft which starts the impeller rotating.

b. Normal operation

(1) Three planetary gears are driven by the sun gear shaft.

(a) Sun gear shaft output is 59,566 rpm.

(b) Planetary gears rotate at 19,318.7 rpm.

(2) An internal ring gear is driven by the planetary gears (8216 rpm).

(3) The ring gear drives:

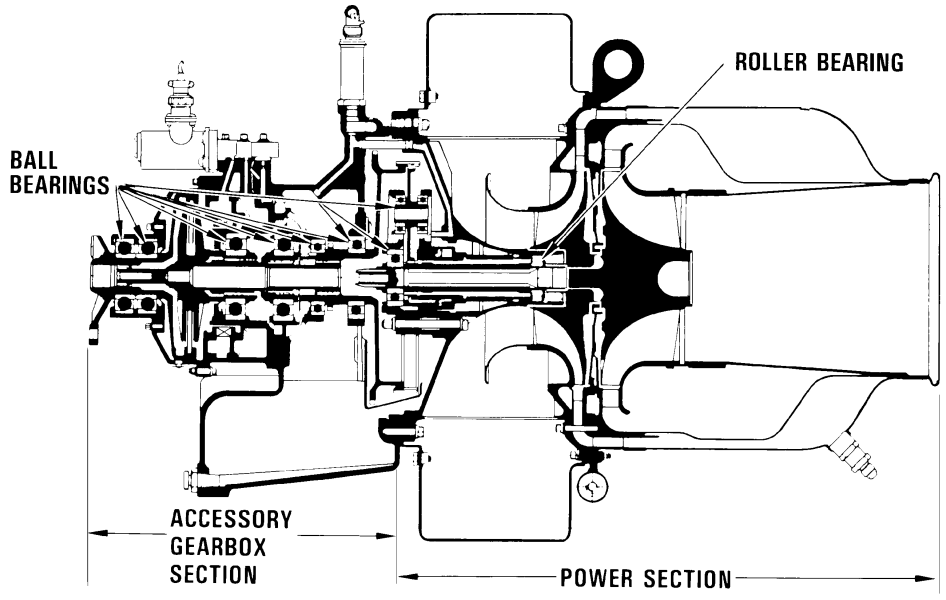
(a) A ring gear carrier which is coupled to the PTO clutch input quillshaft and provides an APU output of 8216 rpm.

(b) A pinion gear that rotates an idler gear at 4615.7 rpm.

1) Idler gear drives the oil pump gear (2069.1 rpm).

2) The oil pump drives the fuel control unit via a (dog bone) quill shaft.

APU CROSS SECTION



83-126D

NOTES

9. APU bearings

   a. Provide support for the APU main rotating components.

   b. Mounted in the accessory gearbox section and the forward end of the power section.

   c. Two ball bearings in the PTO clutch support the output drive assembly (grease packed).

   d. The input of the PTO clutch supports the sliding plate, piston assembly, and input quill shaft.

   e. Two ball bearings support the APU power output (ring gear carrier).

   f. Each planetary gear is supported by two ball bearings.

   g. A ball and roller bearing supports the main rotating shaft.

      (1) The ball bearing at the accessory end of the shaft absorbs the radial and thrust shaft loads.

      (2) A roller bearing adjacent to the compressor absorbs the radial loads of the impeller and turbine.

C

APU RELATED SYSTEMS

LUBRICATION SYSTEM

FUEL SYSTEM

ELECTRICAL SYSTEM

START SYSTEM

APU FIRE DETECTION AND EXTINGUISHING SYSTEM

APU FAULT DETECTION AND LOCATION SYSTEM

15-89-01

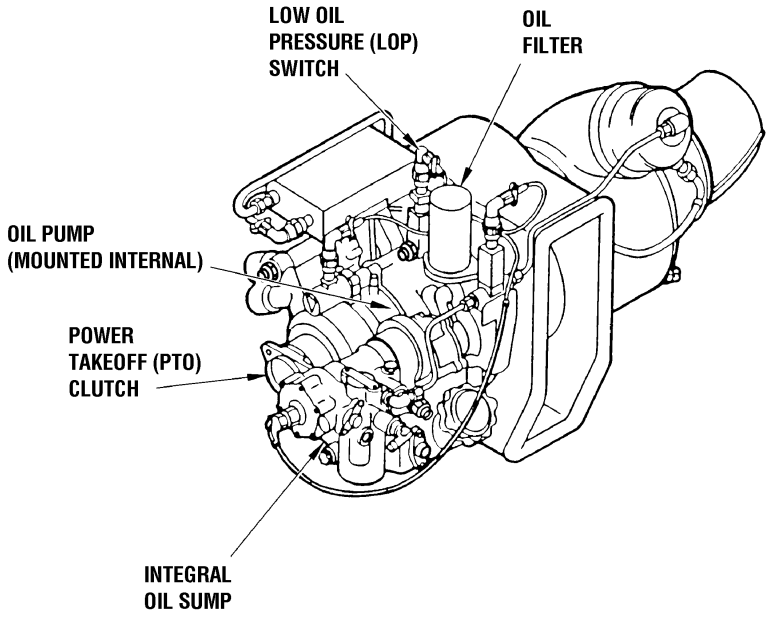
NOTES

A. APU related systems provide for the operation and control of the APU.

B. Major APU related systems:

1. Lubrication system
2. Fuel system
3. Electrical system
4. Start system
5. APU fire detection and extinguishing system
6. APU fault detection and location system (FD/LS)

APU LUBRICATION SYSTEM COMPONENTS



83-2157B

NOTES

C. Lubrication system

1. Engine oil does more than lubricate internal engine components. Engine oil performs these functions:

   a. It lubricates, thus reducing the friction between moving parts.

   b. It cools the various parts of the engine.

   c. It tends to seal mating surfaces, and the film of oil on various surfaces is an effective pressure seal.

   d. It cleans the engine by carrying sludge and other residues away from the moving engine parts and depositing them in the engine oil filter.

   e. It aids in preventing corrosion by protecting the metal from oxygen, water, and other corrosive agents.

   f. It serves as a cushion between parts where impact loads are involved.

2. Oil sumps. In turbine engine lubrication systems, the oil supply is contained in a reservoir. The classification of an engines lubrication system as wet-sump or dry-sump denotes the location of its oil reservoir.

   a. Dry-sump - In a turbine dry-sump lubrication system, the oil supply is carried in a tank mounted externally on or near the engine. With this type of system, a larger oil supply can be carried and the oil temperature can be controlled.

   b. Wet sump - Reservoirs for wet-sump systems are an integral part of the engine and contain the bulk of the engine oil supply.

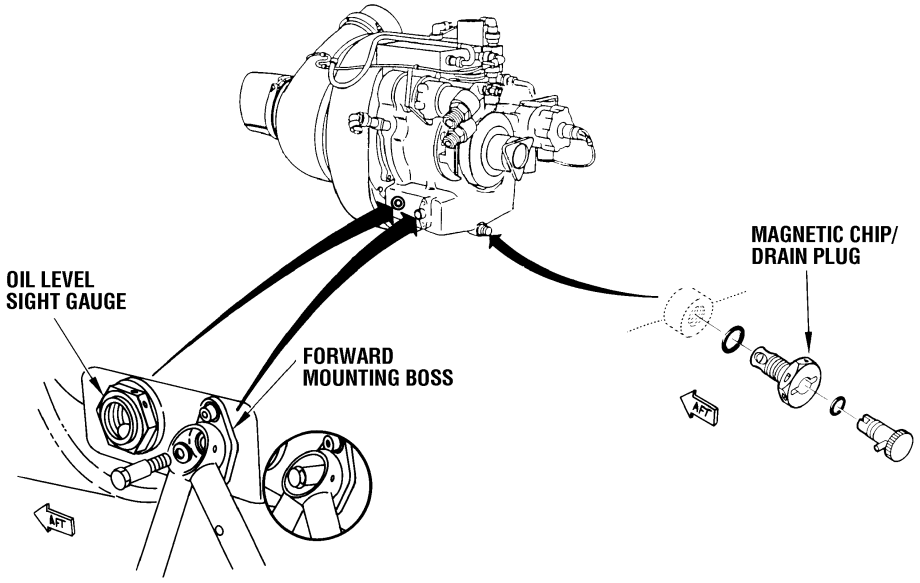
3. APU lubrication system

   a. Stores and distributes engine oil for lubrication and cooling of vital engine components.

   b. Supplies pressurized oil flow for operations of the power take-off (PTO) clutch.

   c. The APU lubrication system contains the following components; integral oil sump, oil pump, oil filter, low oil pressure (LOP) switch, and PTO clutch.

APU OIL SUMP



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NOTES

(1) Oil Sump (integral)

(a) Provides a container for the lubricating oil.

(b) Located in the lower portion of the accessory gearbox.

(c) Wet type oil sump with a capacity of 2.0 U.S. quarts (1.89 liters).

(d) Major components consist of the oil level sight gauge, magnetic chip/drain plug, forward mounting boss (right and left), and oil filler cap.

1) Oil level sight gauge

a) Allows visual inspection of oil level in oil sump.

b) Located on the lower right side of oil sump.

c) Circular type sight gauge with aluminum float ball that is at the top of gauge when full.

d) The oil level can be checked from outside the helicopter through a small access panel on the right-hand side under the number two engine nacelle.

2) Magnetic Chip/Drain Plug

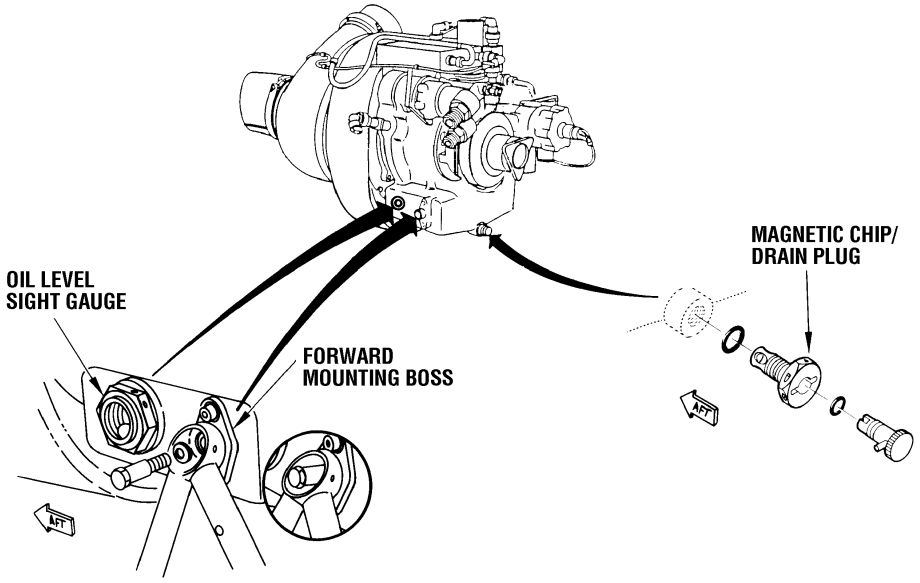
a) Magnetic chip plug is used to check for metal particles in the oil, and is not electrically connected to the caution/warning/advisory panel.

b) Drain plug allows for draining the APU oil sump.

c) Located on the forward lower center section of accessory gearbox.

d) Magnetic chip plug is easily removed by pushing in and turning the knurled knob counterclockwise.

APU OIL SUMP



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NOTES

e) Magnetic chip plug incorporates a permanent magnet that attracts ferrous metal particles.

f) A check valve and spring within the drain plug prevents oil in the sump from leaking when the chip plug is removed.

g) To drain oil from the sump, a special unit is installed in place of the chip detector. It holds open the valve and allows oil to drain.

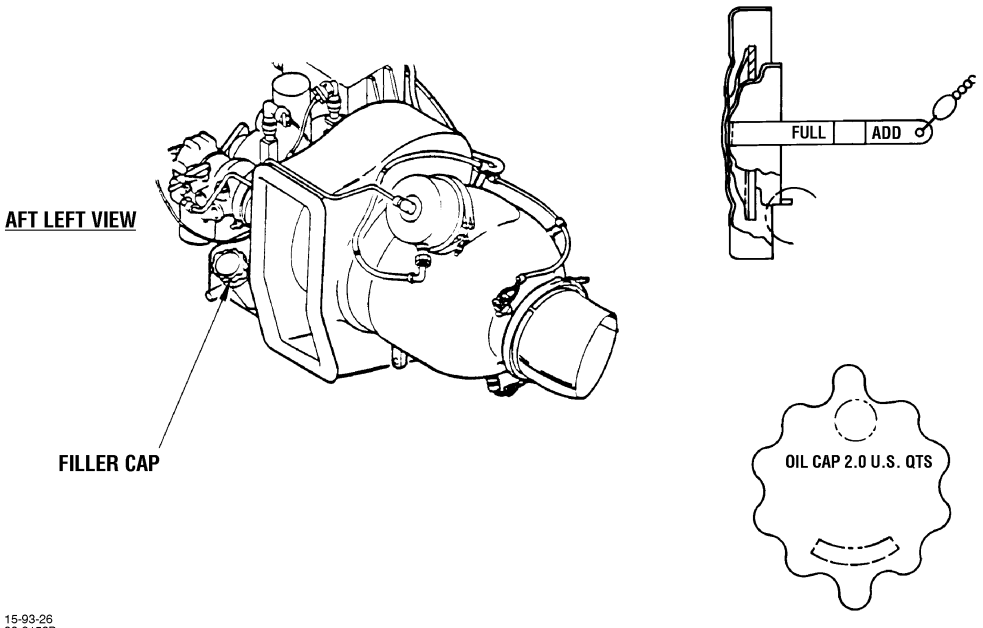
3) Forward Mounting Boss (right and left)

a) Provides for aligning and attaching the forward APU mounts.

b) Located on the forward outboard portion of the oil sump; one left and one right.

c) Has a center alignment recess and two bolt holes, which provide boss attachment to the sump.

APU OIL SUMP FILLER CAP



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83-2159B

NOTES

4) Filler cap

a) Provides access for servicing APU oil system.

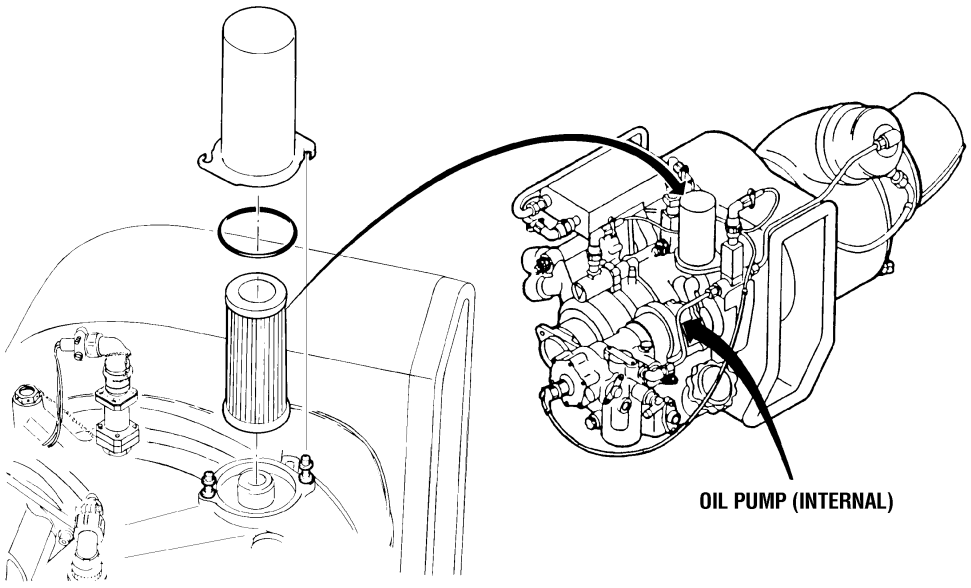
b) Determines level of oil in sump.

c) Located on the left hand side of the accessory gearbox and attached by a chain.

d) Filler cap is installed clockwise on filler neck.

e) A dipstick is affixed to the underside of the filler cap for checking oil level.

APU OIL PUMP AND OIL FILTER



15-93-24
83-2055C

NOTES

(2) Oil pump

(a) Provides pressurized oil lubrication to the main bearings, gear meshes, and gear shafts.

(b) Provides oil pressure for actuation of the PTO clutch.

(c) Mounted internally in the accessory gearbox, abutting the fuel control.

(d) A positive-displacement, two spur gear type pump, capable of delivering approximately 3.0 gpm (11.3 liters per minute). (A positive displacement pump is a pump in which a measured quantity of liquid is trapped in a space, its pressure raised, and then delivered; for example, a gear mechanism).

(e) Driven by the same internal shaft that drives the fuel control unit.

(f) Internal oil passages are used to transport pressurized oil to oil jets for lubrication of the main bearings, gear meshes, and gear shafts.

(g) Mist lubrication is used for low-load components.

(h) Regulated by a pressure regulating valve

1) Adjusts the oil pressure output of the pump to meet operating standards.

2) Internally mounted in the gearcase.

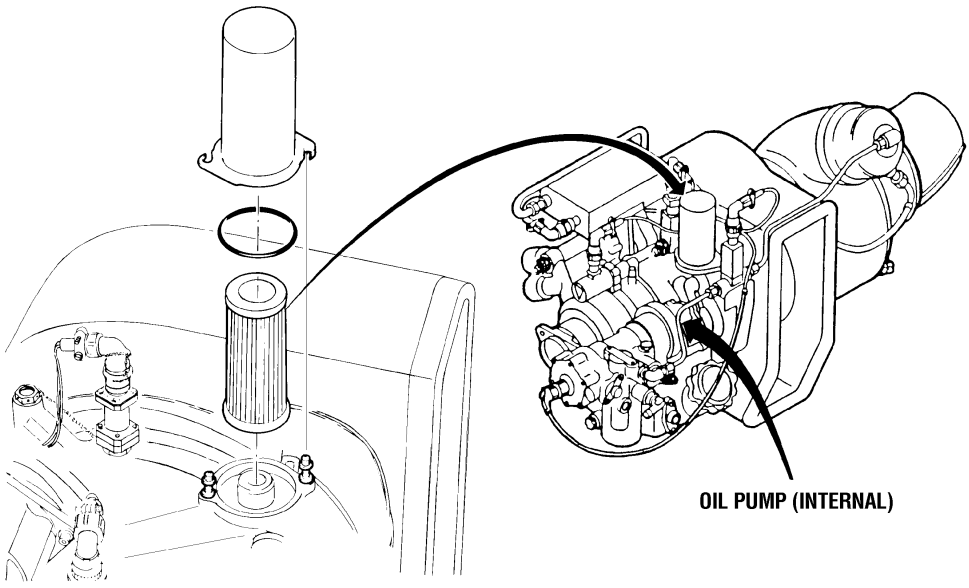
3) Consists of a slide valve and a spring retained by a snap ring.

4) Designed to regulate system pressure between 95 and 105 psi (655 to 724 kPa) over a flow rate of 2 to 4 gpm (7.5 to 15 liters per minute).

5) Spring adjustment is accomplished during initial assembly by shimming under spring.

6) Not field adjustable or line replaceable.

APU OIL PUMP AND OIL FILTER



15-93-24
83-2055C

NOTES

(3) Oil filter

(a) Removes contaminants from the APU's oil system.

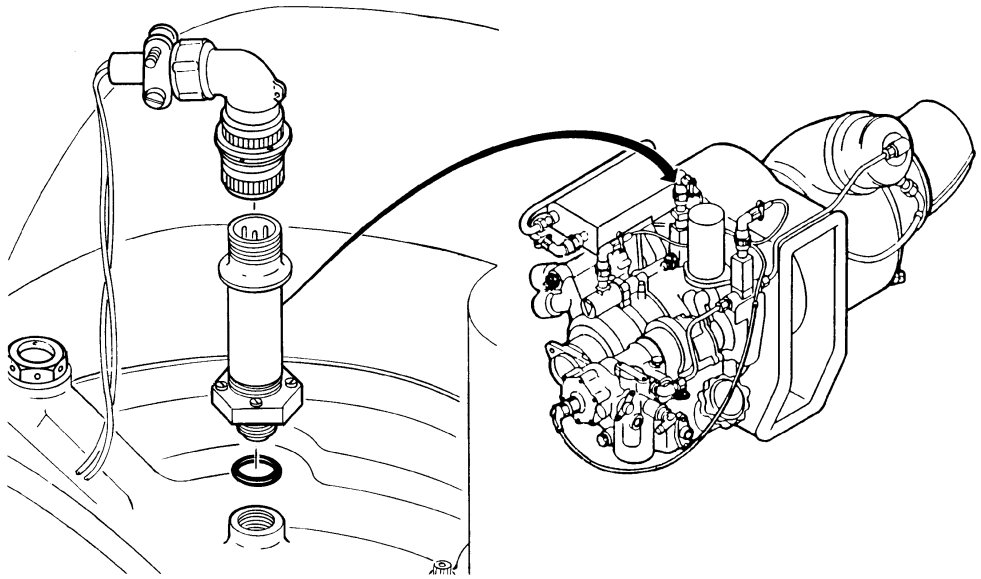
(b) Mounted on top of the accessory gearbox, left side, approximately the 11 o'clock position.

(c) Throw-away paper type filter, with a filter capability of 10 microns nominal and 25 microns absolute.

(d) No bypass capabilities.

(e) A clogged filter will cause loss of oil pressure, which will result in immediate APU shutdown.

APU LOW OIL PRESSURE (LOP) SWITCH



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83-2056E

NOTES

(4) Low oil pressure (LOP) switch

(a) Provides APU protection by initiating action through the APU Controller (ECU) to terminate operation whenever the oil pressure downstream of the filter is insufficient.

(b) Signals the controller to extinguish the APU FAIL caution light on the pilot's C/W/A panel when oil pressure is between 76 and 90 psig (524 to 621 kPa) increasing.

(c) Signals the controller to turn on the APU FAIL light and automatically shut down the APU when oil pressure decreases to 75 psig (517 kPa).

(d) Located on top of the accessory gearbox section, to the right of the oil filter.

(e) Solenoid operated pressure switch activated at 75 psig (517 kPa).

(f) Normally closed switch.

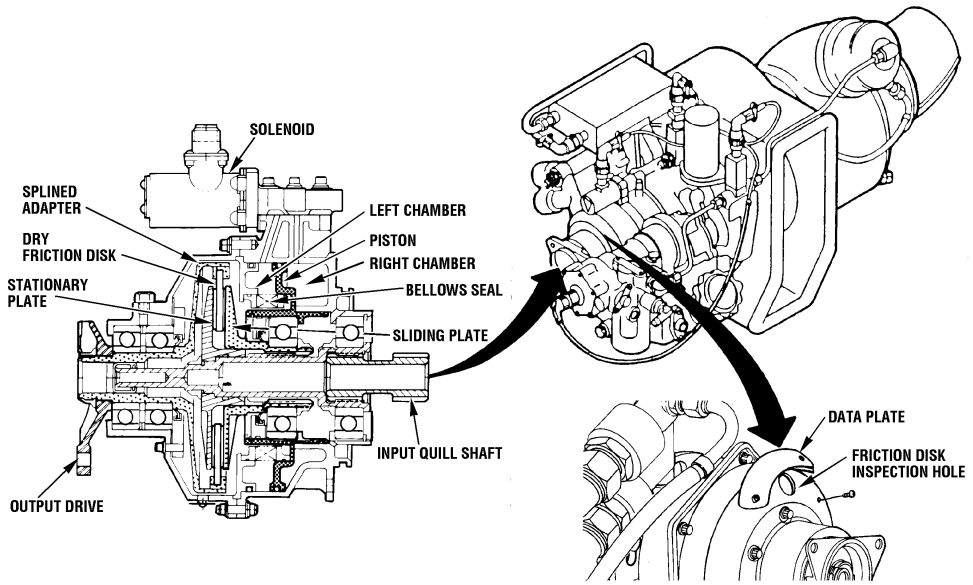
(g) Operation

1) The LOP switch is normally closed to ground prior to start. When the switch is closed, it completes a lamp circuit between the "APU FAIL" caution/warning light and ground.

2) During APU acceleration, oil pressure increases. When oil pressure reaches a pressure between 76 to 90 psig (524 to 621 kPa), the switch will open, interrupting the circuit between the "APU FAIL" light and ground. As a result, the light will extinguish.

3) If the oil pressure is not sufficient to open the switch, or if the switch remains closed at 95% for five (5) seconds the controller will shutdown the APU.

APU POWER TAKEOFF CLUTCH (PTO)



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83-2057E

NOTES

(5) Power takeoff clutch

CAUTION

Avoid prolonged operation at 94% - 96% N_r with the APU running. The APU clutch will oscillate from engaged to disengaged. This creates high loads on the clutch and shall be avoided.

(a) Provides a means of coupling the power section of the APU to the drive shaft which drives the main transmission accessory drive section.

(b) The PTO clutch is mounted on the forward center section of the APU accessory gearbox.

(c) An electrically controlled, two-way, ball type valve directs oil into piston chambers to engage or disengage the clutch.

(d) Two internal oil chambers (left and right) are separated by a piston.

(e) A steel bellows seal is attached to the piston and the left chamber wall. In addition to sealing, while permitting axial movement, the bellows acts like a spring and exerts a hold-back force of 45 pounds (20 kilograms) that tends to push the piston toward the disengage position.

(f) A sliding plate is mounted on an input quill shaft.

(g) A single dry friction disk which is good for approximately 1000 engagements.

(h) The friction disk is made from a proprietary bronze compound.

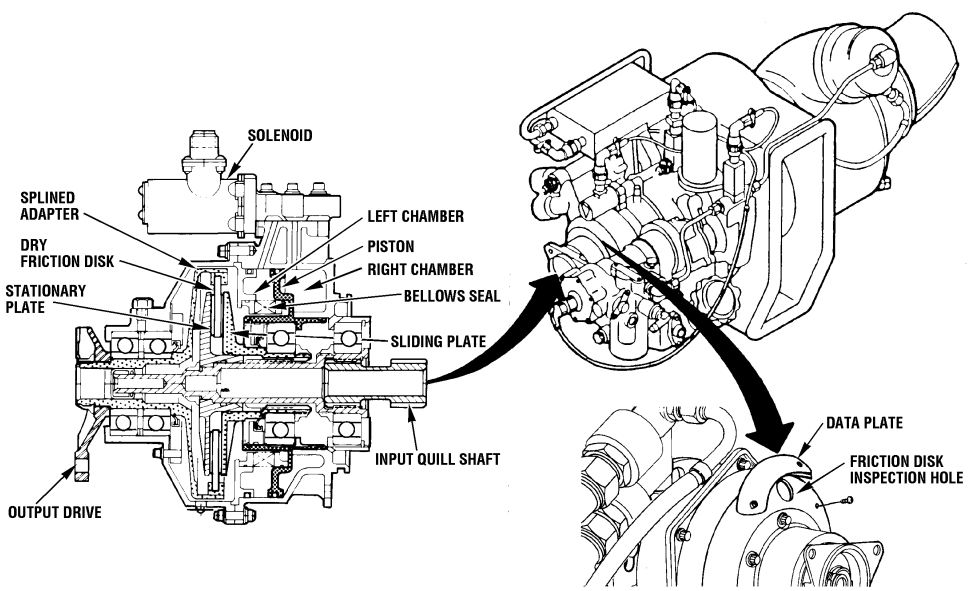
(i) Teeth on the friction disk mate with the splined adapter which will transmit shaft power to the output flange when the sliding plate comes into contact with the disk.

(j) A stationary plate supports the dry friction disk as the sliding plate makes contact.

(k) A line replaceable unit (LRU).

(l) The friction disk inspection hole provides a means to check for internal oil leakage, heat blackening, and friction disk wear.

APU POWER TAKEOFF CLUTCH (PTO)



15-93-23
83-2057E

NOTES

(m) PTO clutch operation

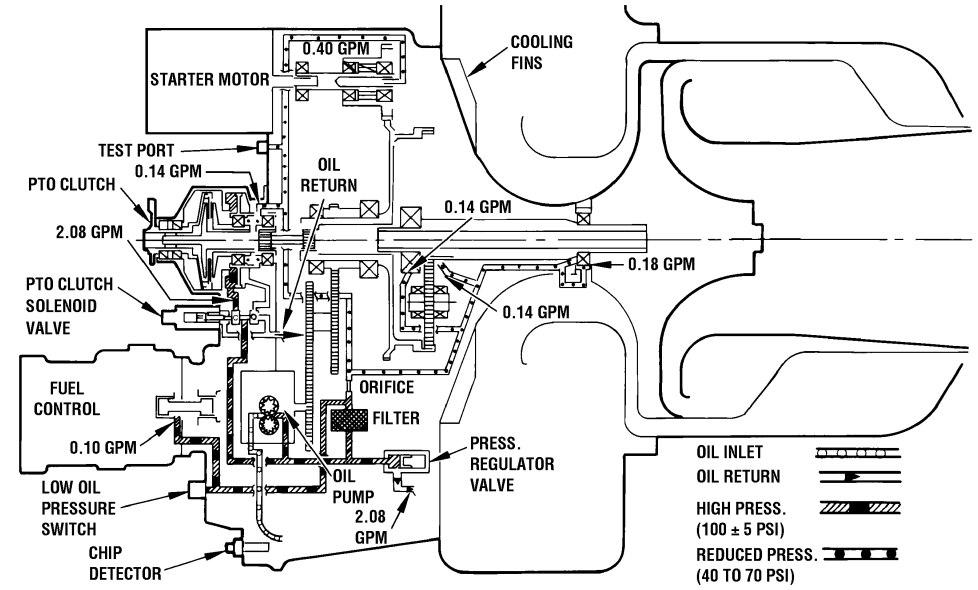
1) Clutch engagement is controlled by the APU Controller (ECU).

2) The PTO clutch is hydraulically actuated using the APU lube system through the PTO clutch solenoid.

3) When the PTO clutch solenoid is energized, oil is directed to the right chamber. Oil pressure in the right chamber overcomes the force of the bellows and pushes the piston forward, thereby initiating clutch engagement which transmits torque to the main transmission accessory gearbox via the number seven drive shaft.

4) When the PTO clutch solenoid is de-energized, oil is directed to the left chamber and the right chamber is opened to the oil return passage (oil returns to the sump by gravity). The oil pressure forces the sliding plate away from the friction disk, disengaging the clutch.

APU LUBRICATION SYSTEM



15-93-21
83-1100H

NOTES

d. APU lubrication system operation

(1) The pump draws oil directly from the sump through a pickup tube. The positive displacement action of the pump forces the oil to flow through passageways and jets. The pump is designed to produce a greater volume of flow than is normally required by the system.

(2) All excess oil pressure is relieved by returning to the sump through the pressure regulator valve. The valve is calibrated to regulate the pressure at 95 to 105 psig (655 to 724 kPa), which provides for the optimum flow of oil to all gear meshes and bearings.

(3) From start to 59 percent APU speed, the PTO clutch solenoid is de-energized and high pressure oil is directed to the left chamber of the PTO clutch. The combined forces of the bellows and oil pressure holds the PTO clutch in the disengaged position.

(4) When the APU speed reaches 60 percent, the controller will energize the PTO clutch solenoid valve. The oil is then directed to the right chamber, and the left chamber opened to the return passage; returning to the sump by gravity. Oil pressure in the right chamber overcomes the bellows spring force and forces the piston to the left thereby engaging the PTO clutch. (If the main rotor speed is above 95 percent the engagement will not take place.)

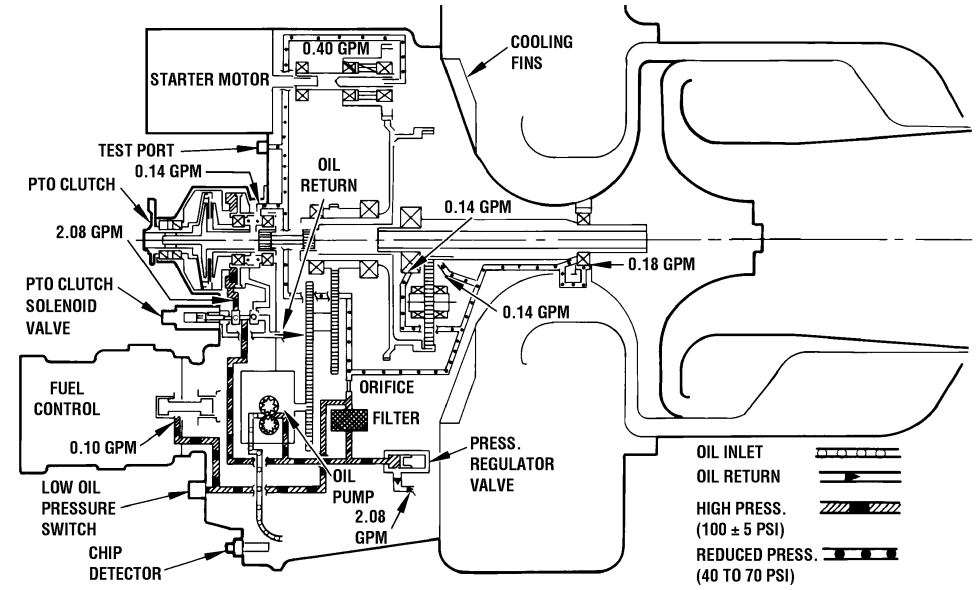
(5) As the oil passes through the filter, contaminants of 10 microns nominal and 25 microns absolute are removed from the oil. The filter assembly contains no bypass provisions. The normal drop in pressure across the filter is approximately 5 psi (34 kPa). Oil pressure at 100 +5 psig (655 to 724 kPa) is then routed to the LOP switch, fuel control unit, and the oil orifice.

(6) As the oil is directed to the LOP switch, it will activate the normally held closed switch to the open position. The APU controller will electrically verify that the oil pressure has exceeded 75 psig (517 kPa) when the APU speed has reached 95 percent, for 5 seconds; if not the APU controller will terminate APU operation.

(7) The oil directed to the fuel control unit will lubricate the dog bone quillshaft gear mesh.

(8) From the oil orifice, the reduced oil pressure (55 +15 psi [276 to 483 kPa]) is routed through oil passages to oil jets for lubrication of main shaft bearings, gear mesh points, start clutch bearings, and the planetary gear system bearings. An oil pressure test port exist at the top of the accessory section.

APU LUBRICATION SYSTEM



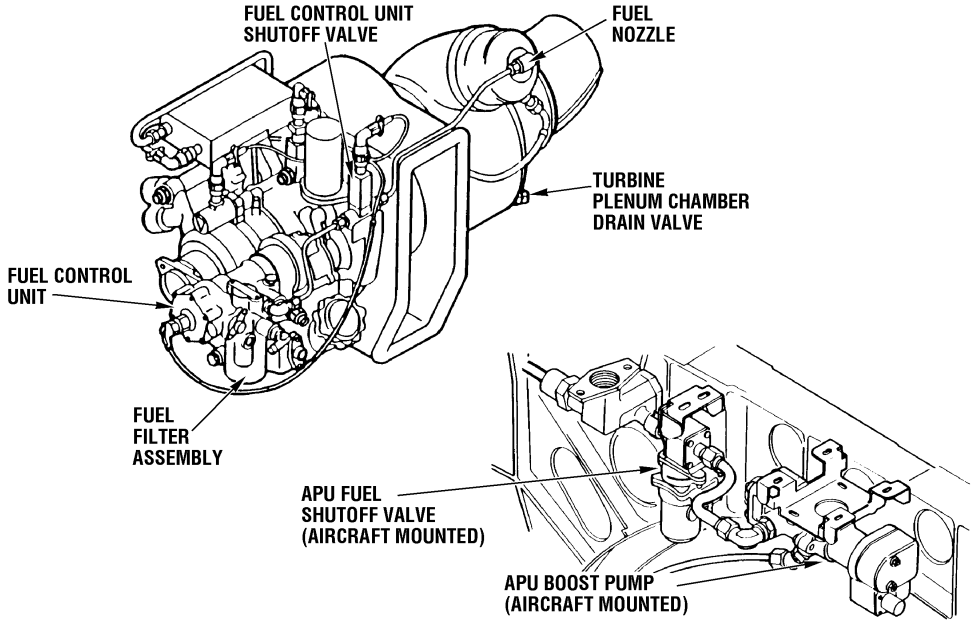
15-93-21
83-1100H

NOTES

(9) The returning oil is gravity drained back to the oil sump, eliminating the need for an oil scavenge pump. The oil is cooled through conduction to the tank walls, which have integral cast cooling fins for maximum heat dissipation.

C

APU FUEL SYSTEM MAJOR COMPONENTS



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83-2160B

NOTES

D. APU fuel system

1. The APU fuel system provides pressurized, metered fuel for starting and steady-state operations at varying loads.

2. Fuel system is a high pressure, fully automatic system that does not require any operator controls or field adjustments.

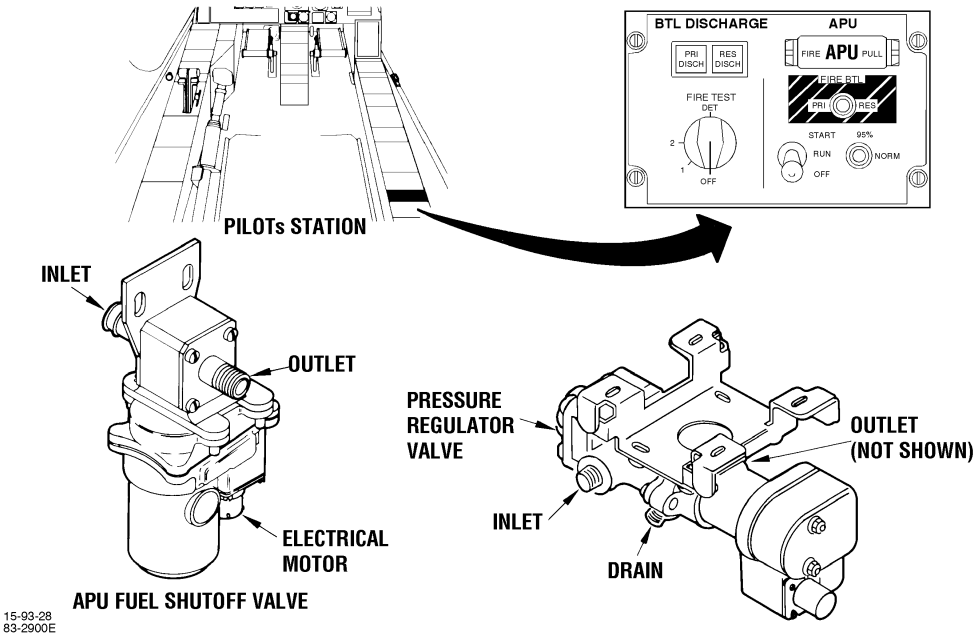
3. Fuel flow is programmed to obtain maximum acceleration without reaching over-temperature conditions.

4. Controls a varied fuel flow so that power developed equals the power required.

5. Fuel is supplied by the aft fuel cell.

6. Fuel system components consist of the: APU fuel shutoff valve, APU boost pump, fuel control unit, fuel filter assembly, fuel control unit shutoff valve, fuel nozzle (atomizer), and turbine plenum chamber drain valve.

APU FUEL SHUTOFF VALVE AND BOOST PUMP



NOTES

a. APU fuel shutoff valve (aircraft mounted)

(1) Provides automatic control of fuel flow from the helicopter aft fuel cell to the APU fuel boost pump whenever the APU START/RUN switch is placed in the RUN or START position.

(2) Attached to a mounting bracket located on the upper right aft fuselage panel in the ammunition bay (accessible through B200).

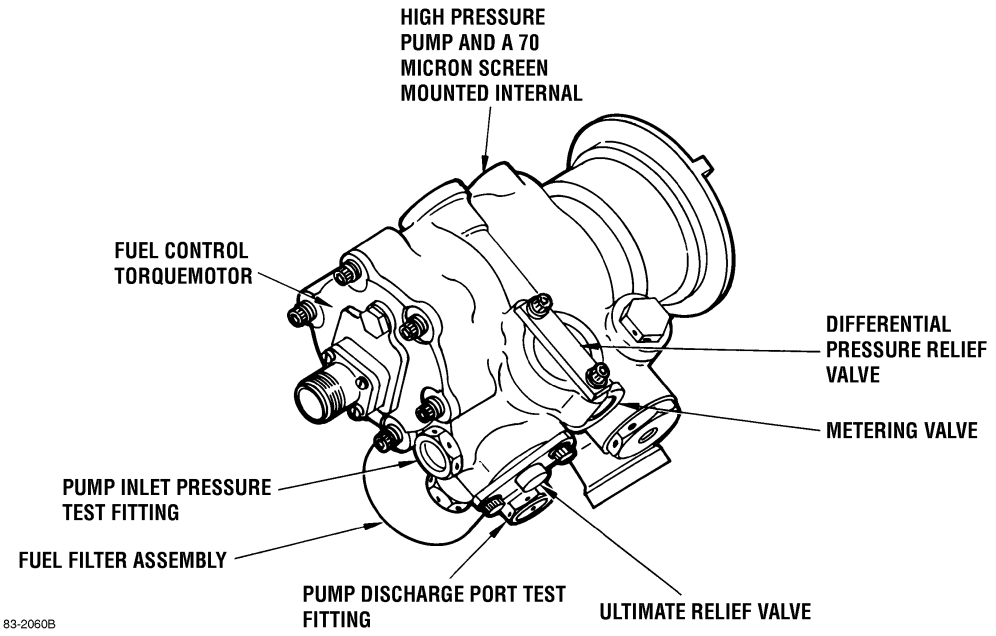
(3) Recent tests were conducted at McDonnell Douglas Helicopter Company (MDHC) to determine APU shut-down times after pulling the APU fire handle. Testing revealed that the APU shut-down time differed in the same aircraft, as well as differing from other aircraft. The difference in shut-down times is not due to any design or configuration changes, but is a result of APU loading, tolerance and wear within the APU fuel shut-off valve, tolerances within the APU fuel control, and environmental conditions. It should be noted that when the APU fire handle is pulled, fuel flow is shut off only at the APU shut-off valve. To shut off fuel at the APU fuel control unit shut-off valve, electrical power must be removed from the APU controller. (Place the APU START/RUN switch to the OFF position).

b. APU boost pump

(1) Ensures a positive flow of fuel to the APU fuel control any time the APU is operating.

(2) Attached to a mounting bracket on the upper center aft fuselage panel in the ammunition bay to the left of the APU fuel shutoff valve (accessible through B200).

APU FUEL CONTROL UNIT



NOTES

c. Fuel control unit

(1) Provides a metered fuel flow schedule to control starting for proper light-off, smooth acceleration, and normal operation under varying loads.

(2) Mounted on the forward left side of the accessory gearbox by a standard V-band clamp.

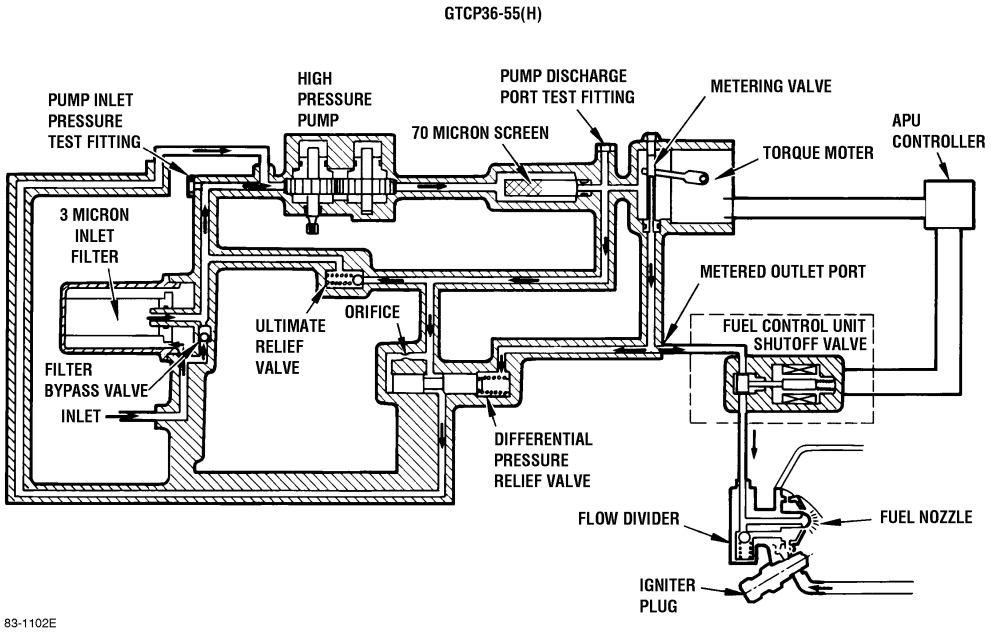
(3) Consists of a hydro-mechanical fuel pumping and metering system regulated by the APU controller.

(4) The mounting flange of the fuel control unit is equipped with an alignment pin that engages in a slot on the APU mounting flange. The pin and slot maintain the angular orientation of the fuel control to the offset drive shaft.

(5) The fuel control pump assembly is driven by the quill shaft via the oil pump.

(6) The fuel control unit contains the following components: fuel filter assembly, pump inlet pressure test fitting, high pressure pump, 70 micron screen, pump discharge port test fitting, metering valve, fuel control torque motor, differential pressure relief valve, and ultimate relief valve.

APU FUEL CONTROL SCHEMATIC



NOTES

(7) APU fuel control components

(a) Pump inlet pressure test fitting:

1) Provides a means of checking airframe fuel boost pump discharge fuel pressure downstream of the fuel filter.

2) Located on the upper right side of fuel control.

(b) High pressure pump

1) Increases fuel pressure.

2) Located inside the fuel control unit.

3) A two-gear, positive-displacement type pump driven by the quill shaft that mates with the splined drive shaft in the oil pump.

(c) 70 micron screen

1) Filters possible wear debris discharged from the pump before it can enter the metering valve.

2) Located inside the fuel control unit.

3) Non-replaceable.

(d) Pump discharge port test fitting

1) Provides a means of checking fuel pressures downstream of APU high pressure pump. Bench test pressure is 300 to 350 psig (2068 to 2413 kPa).
2) Located on top of the fuel control.

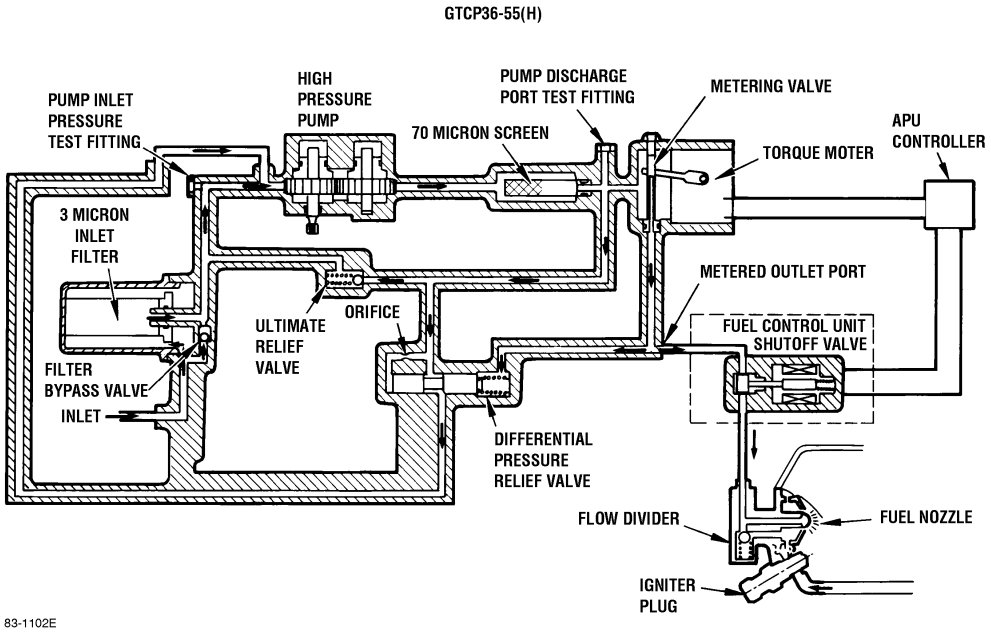
(e) Metering valve

1) Establishes high pressure fuel flow to the APU fuel nozzle 250 to 300 psig (1724 to 2068 kPa).

2) Located inside the torque motor assembly portion of the fuel control unit.

3) Consists of a balanced clevis that slides across an orifice. As the clevis assembly moves across the orifice, it increases or decreases the area of the orifice, which allows more or less fuel to flow.

APU FUEL CONTROL SCHEMATIC



NOTES

4) The clevis is driven by a torque motor that receives controlling signals from the APU controller.

(f) Fuel control torque motor

1) Drives the metering valve to maintain proper speed under all operating conditions.

2) Mounted on the fuel control unit.

3) Electronically controlled unit.

(g) Differential pressure relief valve

1) Maintains a constant fuel pressure drop across the metering valve.

2) Located inside the fuel control unit.

3) Consists of a preset tension spring and plunger.

4) Operation:

a) The differential pressure relief valve is designed to maintain a constant pressure drop across the metering valve by relieving excess fuel pressure upstream of the metering valve back to the pump inlet.

b) With a constant pressure drop across the metering valve, the fuel flow is proportional to the metering valve flow area.

(h) Ultimate relief valve

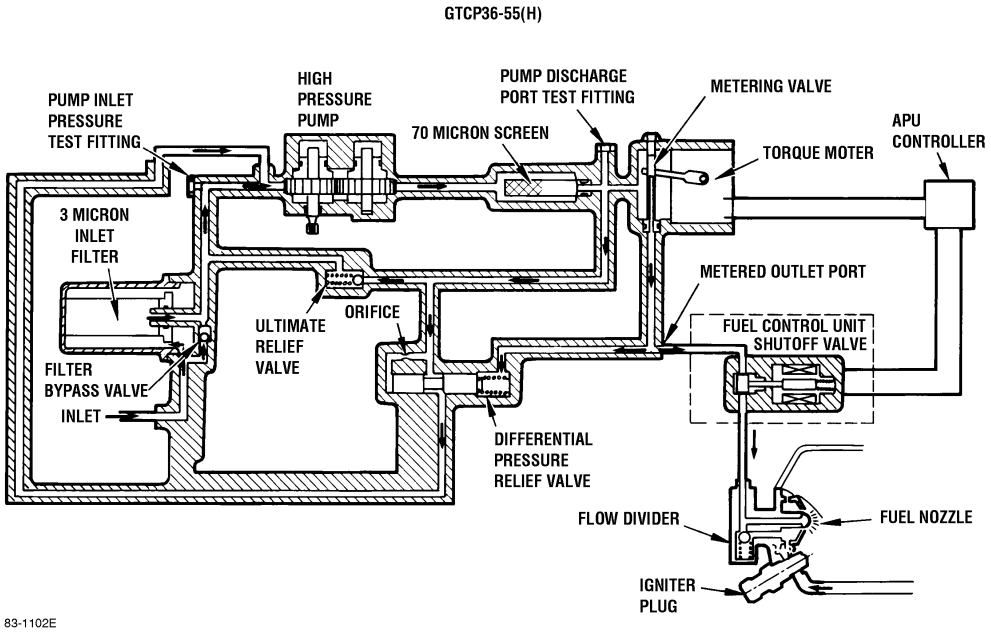
1) Provides the means of bypassing excess fuel pressure whenever the pressure cannot be relieved by the differential pressure valve.

2) Located inside the fuel control unit.

3) Consists of a preset tension spring and ball.

4) The ultimate relief valve will open to allow any abnormal high pressure fuel (525 psig/3620 kPa or higher) to be rerouted back into the high pressure pump inlet.

APU FUEL CONTROL SCHEMATIC



NOTES

5) Typically, the valve functions when the APU RPM is above 95 percent and a shutdown occurs.

(8) Fuel control operation

(a) Fuel is routed to the fuel control inlet and through the three-micron inlet filter which removes contaminants from the fuel.

(b) Should the three-micron disposable filter become clogged, the fuel would be routed through a filter bypass valve. At a predetermined pressure drop the filter is completely bypassed.

(c) Fuel is then routed to the high pressure positive displacement pump assembly; the pump increases the fuel pressure and discharges it through a 70 micron screen to the ultimate relief valve, differential pressure valve, and the metering valve.

(d) In the event of excessive pump discharge, the ultimate relief valve will open and allow the high pressure fuel to flow back into the high pressure pump inlet port.

(e) The differential pressure valve will maintain a constant fuel pressure drop across the metering valve to provide fuel flow that is proportional to the metering valve flow area.

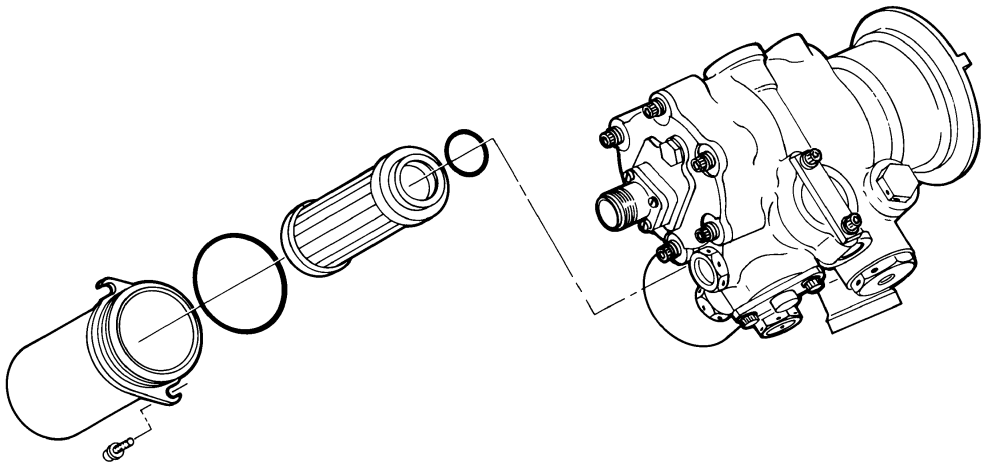
(f) High pressure fuel delivery is established by the metering valve which is driven by the torque motor.

(g) The torque motor receives input drive signals from the APU controller.

(h) High pressure fuel from the metering valve is then directed through fuel lines to the fuel control unit shutoff valve.

(i) At 5 percent APU speed, the APU control unit will open the shutoff valve and allow the high pressure fuel to be routed to the fuel nozzle.

APU FUEL FILTER ASSEMBLY



83-2061

NOTES

(9) Fuel filter assembly

(a) Removes contaminants from the APU fuel system.

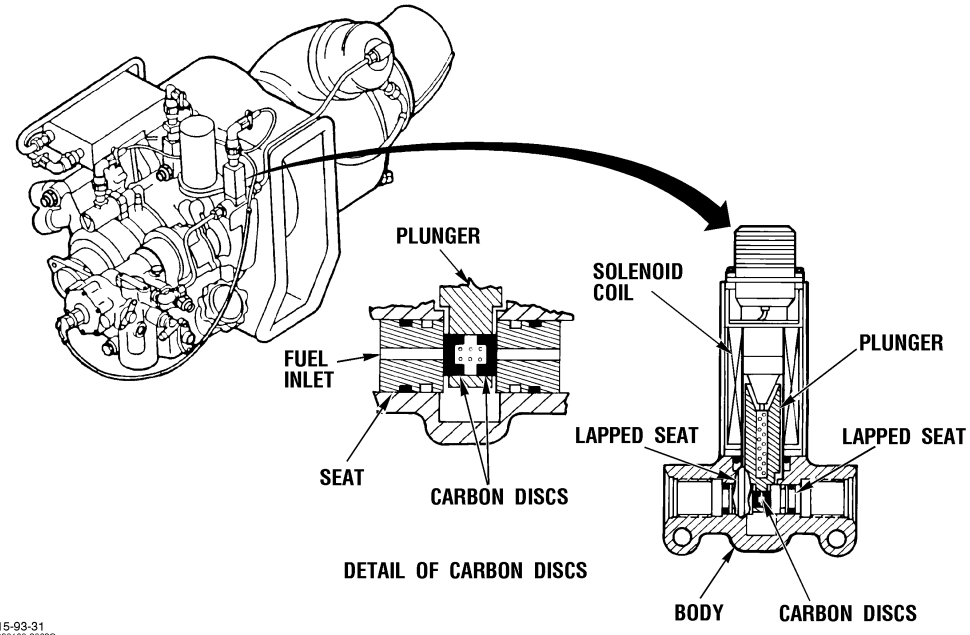
(b) Canister connected on the bottom left side of the APU fuel control unit.

(c) Three-micron disposable filter. (The only LRU on fuel control.)

(d) The filter package includes a filter bypass valve that is integral with the fuel control.

(e) The bypass valve will open and allow fuel to bypass the fuel filter at a predetermined pressure drop across the filter.

APU FUEL CONTROL UNIT SHUTOFF VALVE



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NOTES

d. Fuel control unit shutoff valve

(1) Allows fuel pressure to build up before being released to the APU fuel nozzle.

(2) Provides APU shutdown when the APU START/RUN switch is placed to the OFF position.

(3) Located on top of the accessory gearbox section, between the APU fuel control unit and APU fuel nozzle fuel line.

(4) Normally closed, straight through flow, electrically actuated, solenoid valve.

(5) Controlled by APU controller.

(6) During starts, remains closed until 5 percent APU starting speed is obtained. During the initial start period, engine speed is too slow to provide a fuel pressure high enough for light-off. This allows fuel pressure time to rise enough for APU light-off.

(7) The fuel control shutoff valve consists of:

(a) Solenoid coil

(b) Movable plunger. (The lower portion of the plunger has a hole in which two spring-loaded discs are set).

(c) Valve body. The fuel inlet and outlet ports of the valve body contain a lapped face seat assembly. (A lapped surface is one that has been finely finished to provide a seal when contacted by another surface.)

(8) Operation

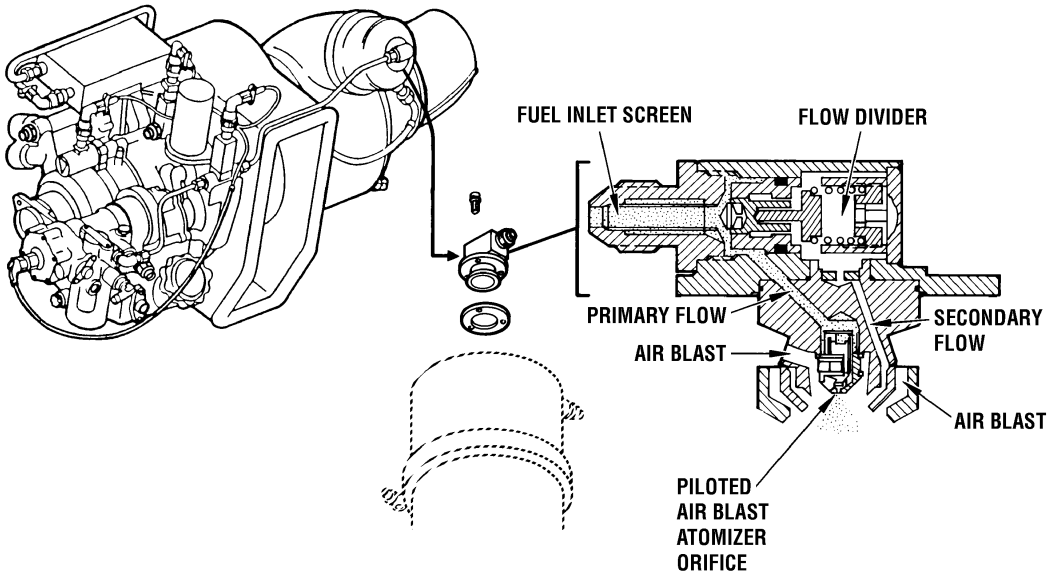
(a) With the solenoid de-energized, the plunger is positioned at the base of the valve body so that the spring between the carbon discs forces the discs to contact the seat faces, obstructing the seat holes.

(b) Incoming fuel pressure overcomes the spring force against the inlet carbon disc and gets between the carbon discs. It forces the downstream disc tightly against the lapped seat.

(c) When the solenoid is energized the plunger is magnetically retracted upward, sliding the discs over the seat faces until they clear the holes in the seats.

(d) The fuel then passes relatively unopposed through the valve body to the fuel nozzle.

APU FUEL NOZZLE



NOTES

e. APU fuel nozzle (atomizer)

(1) Provides atomized fuel to the combustor section during APU operation.

(2) Attached to the top of the combustor cap assembly via the flange of the combustion liner. (Fits into, and aligns with holes in the flange of the combustion liner.)

(3) Consists of a primary flow nozzle, secondary flow nozzle, and piloted air blast atomizer orifice. A flow divider allows fuel flow to the secondary nozzle.

(4) Operation

(a) Compressor discharge air flows through the holes of the combustion liner into the airblast ports.

(b) The air flowing through the outer ports assists in the shaping of the spray pattern of the secondary fuel flow.

(c) The air flowing through the inner port precludes fuel from carbonizing around the primary orifice while fuel is flowing, and blows across the face of the primary orifice on shutdown, reducing caking of the orifice.

(d) High pressure fuel is introduced into the inlet port and flows through an internal screen. This screen prevents the plugging of the metered orifice and flow passages.

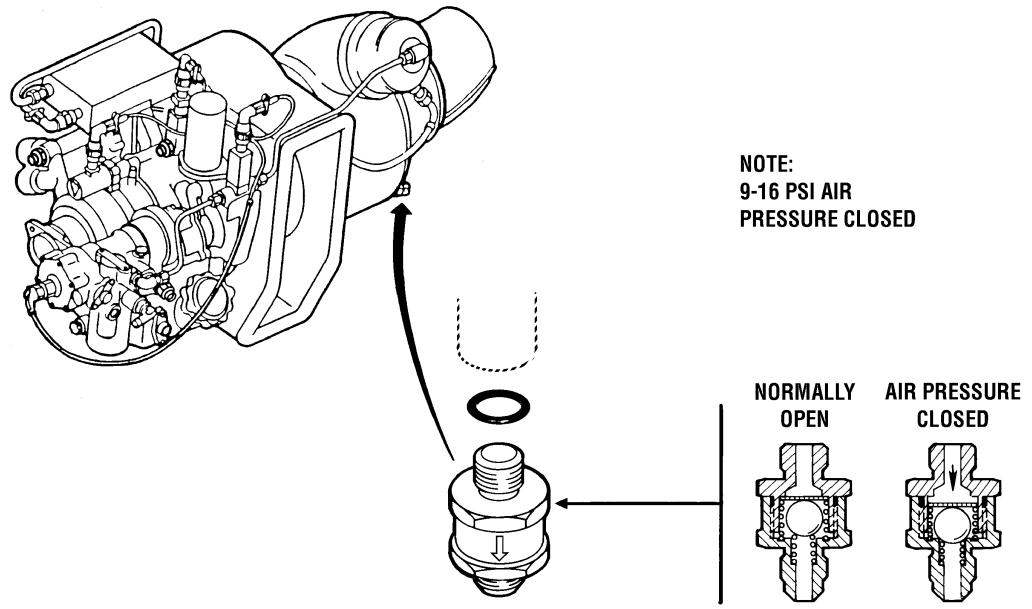
(e) The primary fuel nozzle provides atomized fuel to the combustor during the initial APU start cycle.

(f) As the APU accelerates and the fuel flow increases, the pressure drop increases across the atomizer.

(g) At a preset constant differential pressure setting, the flow divider will open and allow fuel to flow to the secondary nozzle.

(h) Both fuel flow paths (primary and secondary) supply fuel to the APU combustor section when the APU is at operating speed.

APU PLENUM CHAMBER DRAIN CHECK VALVE



NOTES

f. Plenum chamber drain check valve

(1) Allows residual fuel to drain from the turbine plenum upon completion of shutdown.

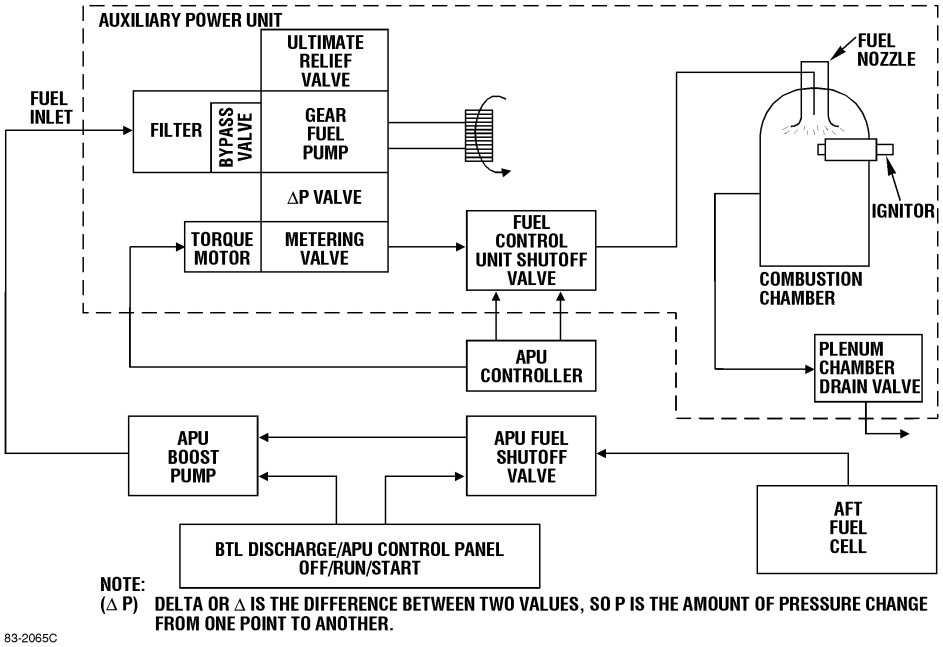
(2) Located in the bottom of the turbine plenum.

(3) Spring-loaded open ball valve that closes at 9-16 psi (62 to 110 kPa).

(4) Contains a flow arrow on the valve body.

(5) Contains a 0.020 inch-thick (0.05 to centimeters) brass screen assembly. It is perforated to provide a total of 43 per cent open area. There are several holes, 0.022 inch (0.06 centimeters) to 0.026 inch (0.07 centimeters) in diameter in the surface of the 0.480-inch (1.22 centimeters) diameter disk.

APU FUEL SYSTEM



NOTES

7. APU fuel system operation

   a. When the APU START/RUN switch is moved momentarily to the RUN or START position, the helicopter mounted APU fuel shutoff valve and the helicopter mounted APU boost pump are energized.

   b. Fuel is drawn from the aft fuel cell and routed through the APU fuel shutoff valve.

   c. The APU boost pump increases the fuel pressure to 10 psi (69 kPa) and routes it through the fuel control unit inlet filter.

   d. The 3-micron inlet fuel filter removes contaminants from the fuel.

   e. If the inlet fuel filter becomes clogged, a filter bypass valve will open.

   f. The high pressure pump increases the fuel pressure and discharges it through a 70-micron screen to the metering valve, differential pressure valve, and ultimate relief valve.

   g. The differential pressure valve will maintain a constant fuel pressure drop across the metering valve.

   h. In the event of excessive pump discharge, the ultimate relief valve will open and allow the high pressure fuel to flow back into the high pressure pump inlet port.

   i. High pressure fuel from the metering valve is directed through fuel flex lines to the fuel shutoff solenoid valve.

   j. At 5 percent APU speed the APU controller will open the fuel shutoff solenoid valve, which routes the high pressure fuel through fuel lines to the APU fuel nozzle.

   k. The fuel nozzle will direct the high pressure fuel to the primary orifices during APU start, and to primary and secondary orifices during APU normal operations.

   l. The high pressure fuel will be atomized by the fuel nozzle for combustion in the combustor chamber.

   m. A plenum chamber drain valve is normally closed during APU operations. Drain opens on shutdown to drain residual fuel.

C

APU ELECTRICAL SYSTEM COMPONENTS

CIRCUIT BREAKERS

BTL DISCHARGE/APU CONTROL PANEL

CAUTION/WARNING/ADVISORY PANEL (PILOT)

ROTOR RPM (Nr) SENSOR

ROTOR SPEED ISOLATION TRANSFORMER

MONOPOLE

IGNITION SYSTEM

EXHAUST GAS TEMPERATURE (EGT) THERMOCOUPLE

APU CONTROLLER

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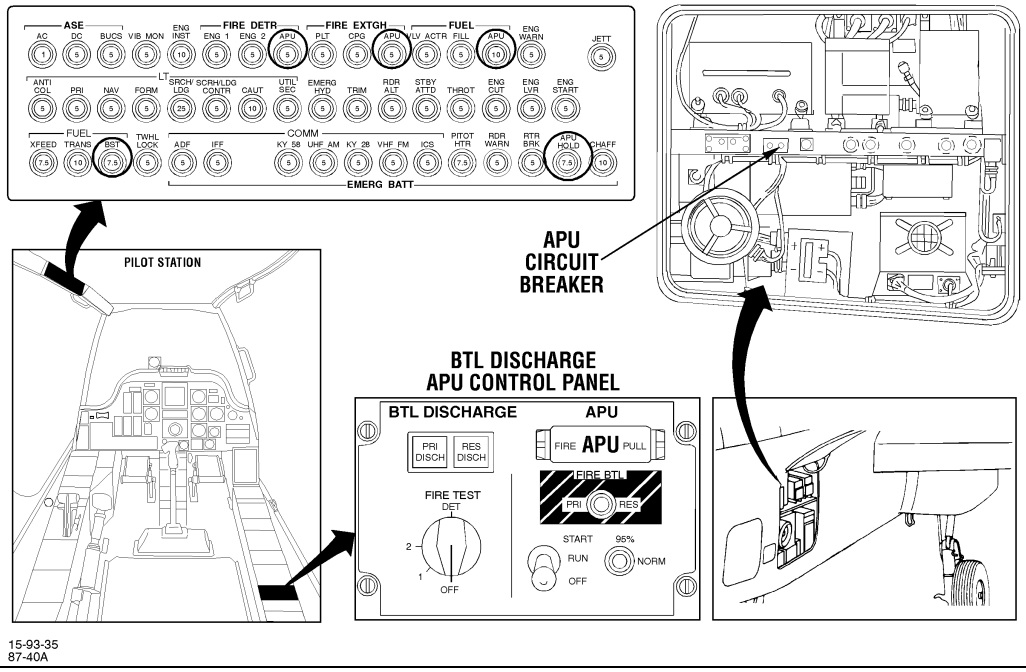
NOTES

E. APU electrical system

1. The APU electrical system provides fully automatic control for APU operations.

2. The APU electrical system consists of the following major components: circuit breakers, BTL discharge/APU control panel, caution/warning/advisory panel (pilot station), rotor rpm (N_r) sensor and rotor speed isolation transformer (T1), monopole sensor, ignition system, exhaust gas temperature (EGT) thermocouple, APU elapsed time indicator, and APU controller.

APU CONTROLS AND CIRCUIT PROTECTION DEVICES



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NOTES

a. Circuit breakers

(1) Protects the APU circuit from excessive current.

(2) Located on the pilot's center circuit breaker panel and in the aft avionics bay.

(3) APU circuit breaker is rated at 7.5 amperes, 28 vdc, and supplies power directly from the battery to the APU controller (through the start/run switch), for start, steady state operation, and monitoring.

(4) APU HOLD circuit breaker is rated at 7.5 amperes, 28 vdc, and is in series with the APU circuit breaker.

(5) FUEL APU circuit breaker is rated at 10 amperes, 28 vdc, and provides electrical power from the emergency dc bus to the APU fuel boost pump, APU shutoff valve, and the APU controller. (The Fuel APU circuit breaker also supplies power to the Fire APU Pull Switch Handle).

(6) FUEL BST circuit breaker is rated at 7.5 amperes, 28 vdc, and provides electrical power from the No. 2 dc bus to the SDC throttle valve time delay relay and the helicopter aft fuel cell boost pump circuit. During start, the SDC throttle valve time delay relay will energize and remove 28 vdc from the inlet throttle valve solenoid. When the inlet throttle valve solenoid is deenergized, spring pressure will close the inlet throttle valve (approximately 70%), thus reducing the amount of air available to the SDC. This reduction of air inhibits SDC compression and reduces the starting load on the APU.

b. BTL discharge/APU control panel

(1) Provides controls for starting, running, and stopping the APU.

(2) Provides cold weather start capability.

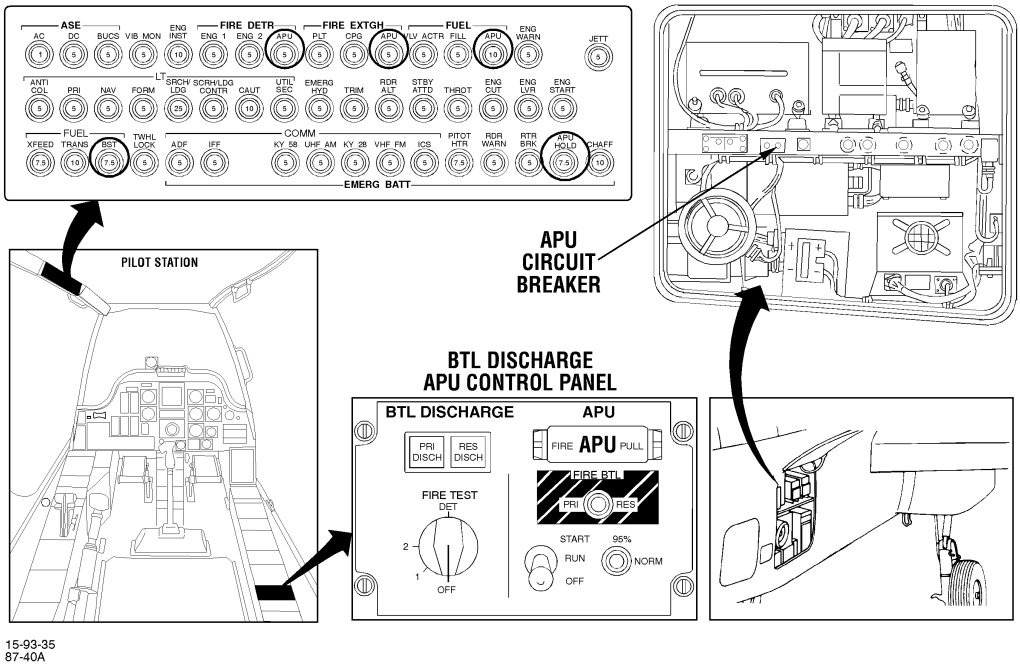
(3) Provides APU fire warning via the FIRE pull handle.

(4) Provides controls for APU fire extinguishing.

(5) Provides a means of testing the fire detection system circuitry.

(6) Located at the extreme aft end of the pilot's right-hand console.

APU CONTROLS AND CIRCUIT PROTECTION DEVICES



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NOTES

(7) APU three-position (OFF/RUN/START) cam toggle switch.

(a) OFF - the position when no power is applied to the APU.

(b) RUN - For steady state operation. This position is spring loaded from the start to run position.

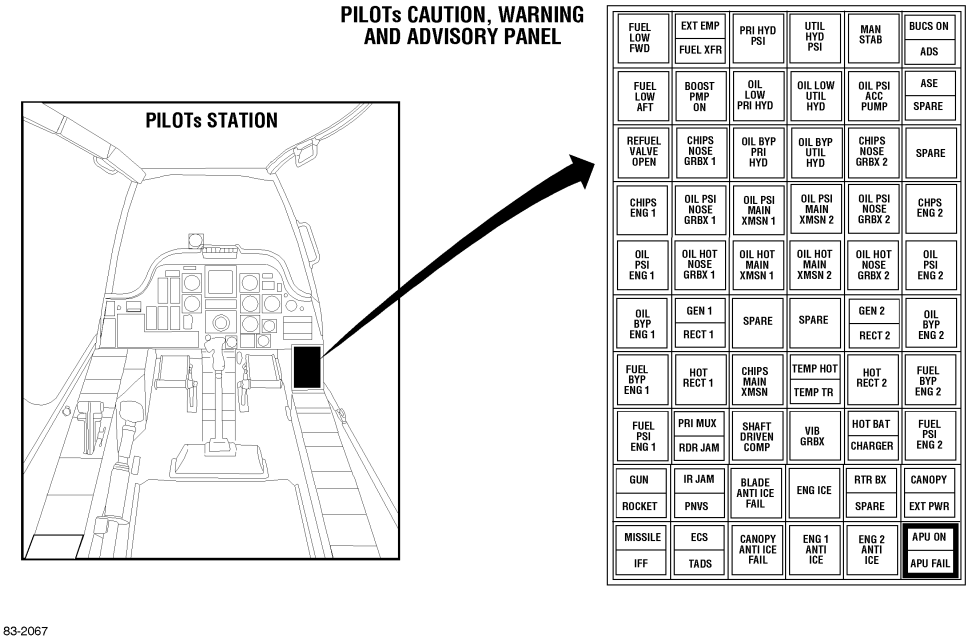
(c) START - The momentary contact for initiating automatic start mode.

CAUTION

The APU 95% cold start switch should not be used when the ambient temperature is above 0EF (-18EC) because this significantly increases component wear and may cause premature component failure.

(8) APU 95% switch. A two-position (95%/NORM), spring-loaded switch that allows the pilot to delay APU PTO clutch engagement during APU starts at temperatures below 0EF (-18EC). Delaying PTO clutch engagement until the APU is at 95% operating speed allows successful engagement in a cold weather environment. The switch is spring-loaded to the NORM position and must be held in the 95% position when used. PTO clutch engagement is inhibited until the switch is released and returned to the NORM position. The switch is used with the APU ON advisory light that indicates the APU is operating at or above 95% speed.

CAUTION/WARNING AND ADVISORY PANELS



NOTES

c. Caution/warning/advisory panel

(1) Provides the Pilot with a visual indication of system status.

(2) The APU C/W/A lights are located on the lower right-hand caution/warning/advisory panel light segment.

(3) The APU C/W/A lights are represented in a split amber light segment with black lettering.

(4) APU ON

(a) Occupies the upper segment and provides a visual indication when the APU is running.

(b) It will illuminate when the APU reaches 95 percent.

(c) The APU ON light is a grounded light - needs 28 vdc to illuminate, supplied through the hour meter.

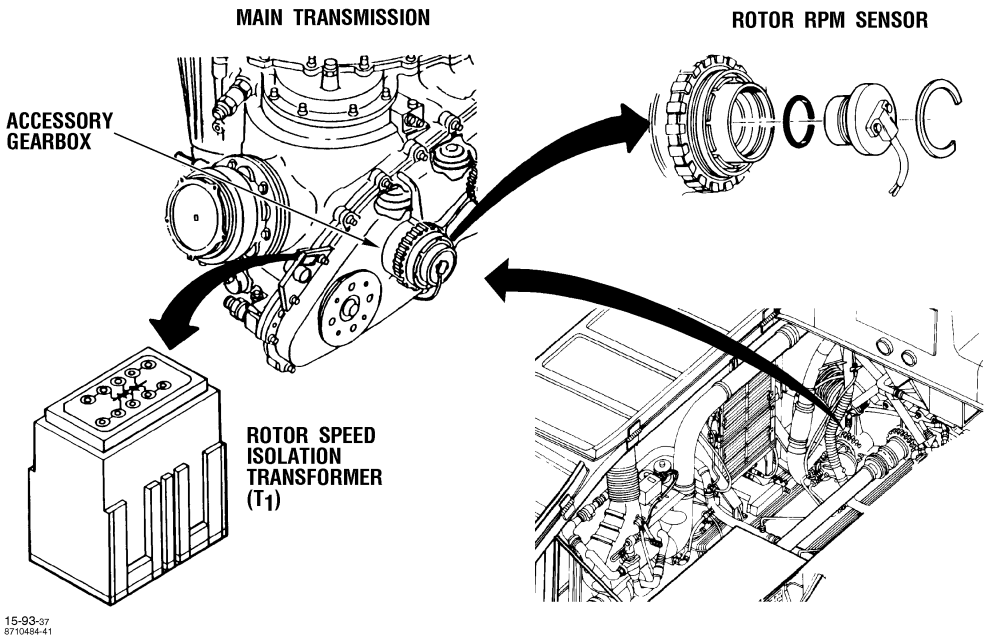
(5) APU FAIL

(a) Occupies the lower segment.

(b) Provides a visual indication whenever the APU controller or other unforeseen conditions have caused an APU shutdown.

(c) Additionally, whenever the APU OFF/RUN/START switch is placed in the RUN position prior to APU start, the APU FAIL light will illuminate.

ROTOR RPM (N_R) SENSOR AND ROTOR SPEED ISOLATION TRANSFORMER (TI) LOCATION



NOTES

d. Rotor rpm (Nr) sensor

(1) Senses main rotor speed and sends a signal to the Nr indicator on the ENG-RTR RPM % engine instrument, the LOW ROTOR or HIGH RPM lights on the master caution/ warning panel, and the APU controller.

(2) The APU controller uses the input from the sensor to determine power takeoff clutch engagement.

(3) Mounted to the aft left side of the main transmission accessory section.

(4) A monopole magnetic pickup.

(5) Measures the percent of rotor speed by electrically counting teeth of the primary geartrain in the transmission.

e. Rotor speed isolation transformer

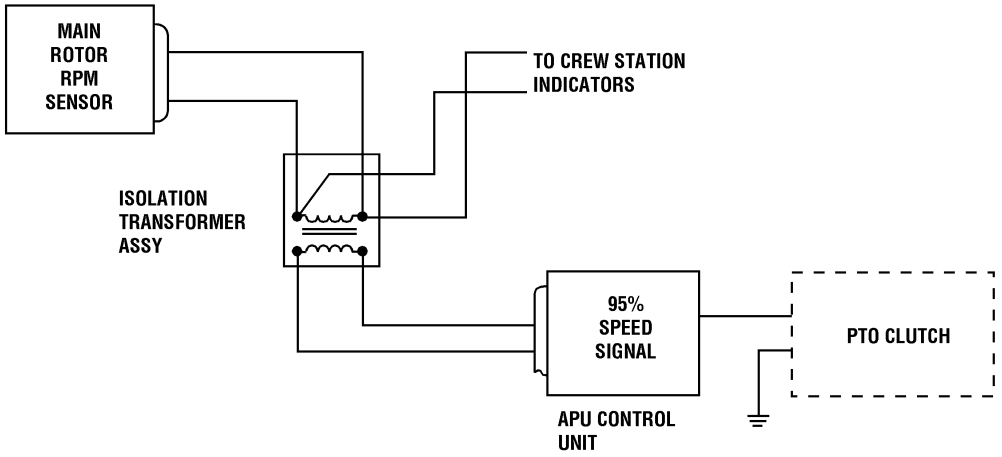
(1) Couples the rotor rpm sensor output signal to the input of the APU controller.

(2) Mounted on a bracket that is attached to the aft upper left side of the accessory section of the transmission.

(3) Approximately a one (1) inch-square module with a rigid plastic housing.

(4) Contains a decal showing circuit diagram.

MAIN ROTOR SPEED SIGNAL



NOTES

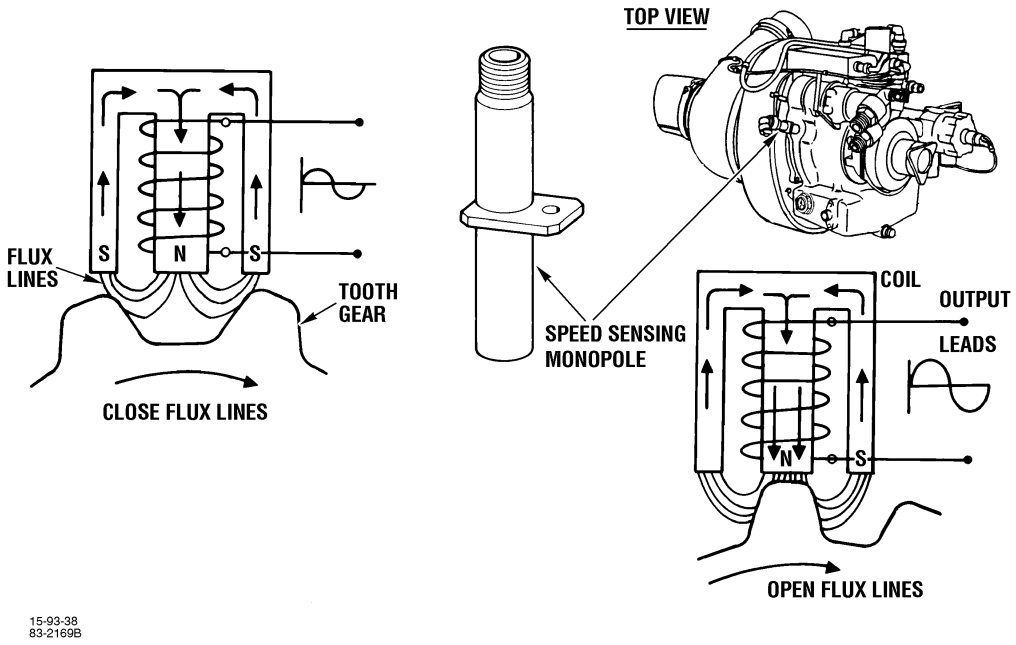
f. Functional description

(1) As the primary gears in the transmission are rotated, the monopole magnetic pickup (rotor rpm sensor) generates an output signal proportional to main rotor speed.

(2) The rotor rpm signal is sent to the crew station indicators, and to the APU controller through an isolation transformer.

(3) The APU controller will prevent PTO clutch engagement if the main rotor speed signal is above 95 percent. (The PTO clutch normally engages at 60 percent APU speed.)

APU SPEED SENSOR (MONOPOLE)



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NOTES

g. APU speed sensor

(1) Measures the percent of APU rpm by electrically counting teeth of the main drive gear and transmits a signal to the APU controller, proportional to APU rpm.

(2) Signals the APU controller to illuminate the APU ON light when APU speed reaches 95 percent.

(3) Provides an automatic shutdown signal to the APU controller in the event of an overspeed or loss of speed signal.

(4) Located on the right-hand side of the APU accessory section.

(5) It is an electro-magnetic, non-contact, variable reluctance, speed sensing device.

(6) Consists of a coil of wire around a small permanent magnet. It is contained in a metal encasement, which is connected to a mounting flange and an electrical connector.

(7) The end of the monopole sensor is positioned relatively close to the teeth of a rotating gear.

h. The clearance between the gear and the monopole is established by shimming.

(1) Operation

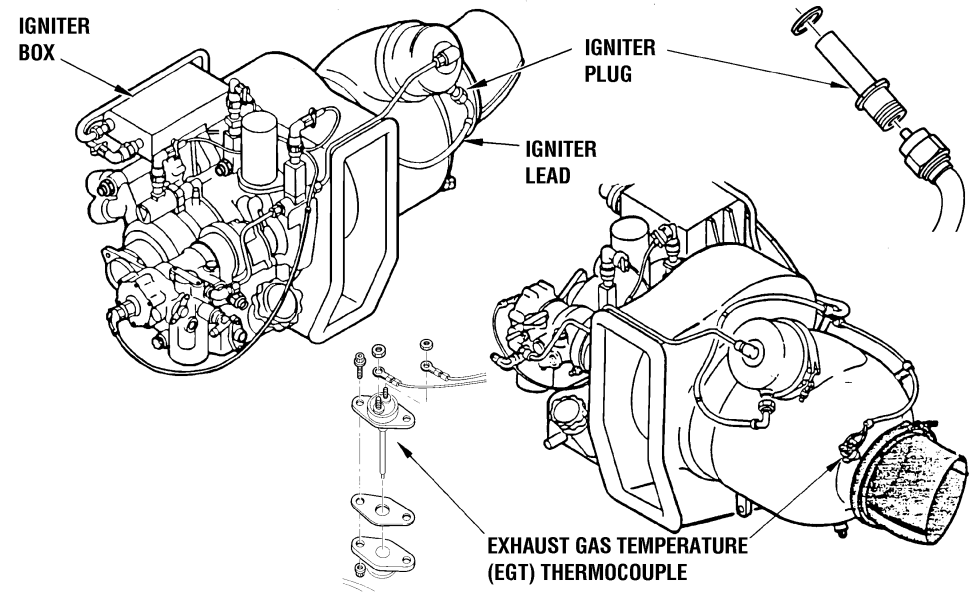
(a) Magnetic lines of flux are always present from the permanent magnet. The lines of flux exit the north pole and enter the south pole, creating a magnetic field.

(b) As the gear rotates, the teeth interrupt the magnetic field, which causes a voltage pulse to be induced into the coil. A voltage pulse is induced by each individual gear tooth.

(c) The frequency of the induced voltage pulses is representative of the speed of the rotating gear.

(d) The induced voltage pulses are applied to the APU controller as an APU speed signal.

APU IGNITER BOX, LEAD, PLUG, AND EGT THERMOCOUPLE



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NOTES

i. APU ignition system

(1) Provides electrical current for APU combustion during starting only.

(2) The ignition system consists of the following components: igniter box, igniter lead, and igniter plug.

(a) Igniter box

1) Supplies a series of high energy sparks to the APU igniter plug.

2) Mounted on the right-hand top side of the accessory gearbox, at approximately the 1:00 o'clock position.

3) Increases a low voltage (24 vdc) input signal to a high voltage output (2900 to 3200 vdc).

4) A sealed low voltage capacitive discharge system.

(b) Igniter lead

1) Carrier for the electrical current.

2) One end of lead is attached to the igniter box and the other end is attached to the igniter plug.

(c) Igniter plug

1) Provides the spark in the combustion section to ignite the fuel/air mixture during the start sequence.

2) Located on the lower portion of the combustion cap assembly.

3) The APU is designed to use a high-energy plug.

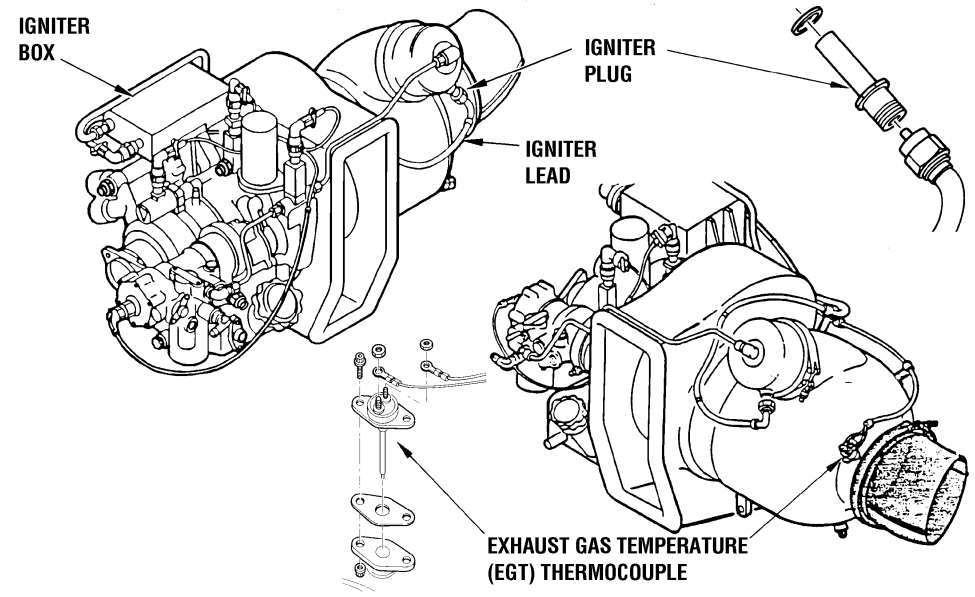
4) Consists of a center electrode, insulator, and outer shell.

(3) Ignition system operation

(a) The ignition system provides a series of sparks to ignite the atomized fuel in the combustor.

(b) The ignition system is energized at five percent APU speed by the APU controller.

APU IGNITER BOX, LEAD, PLUG, AND EGT THERMOCOUPLE



15-93-39
83-2170E

NOTES

(c) It remains energized for four (4) seconds after reaching ninety-five percent APU speed.

j. EGT thermocouple

(1) Provides an electrical signal to the APU controller that is proportional to exhaust gas temperature through all ranges of operation.

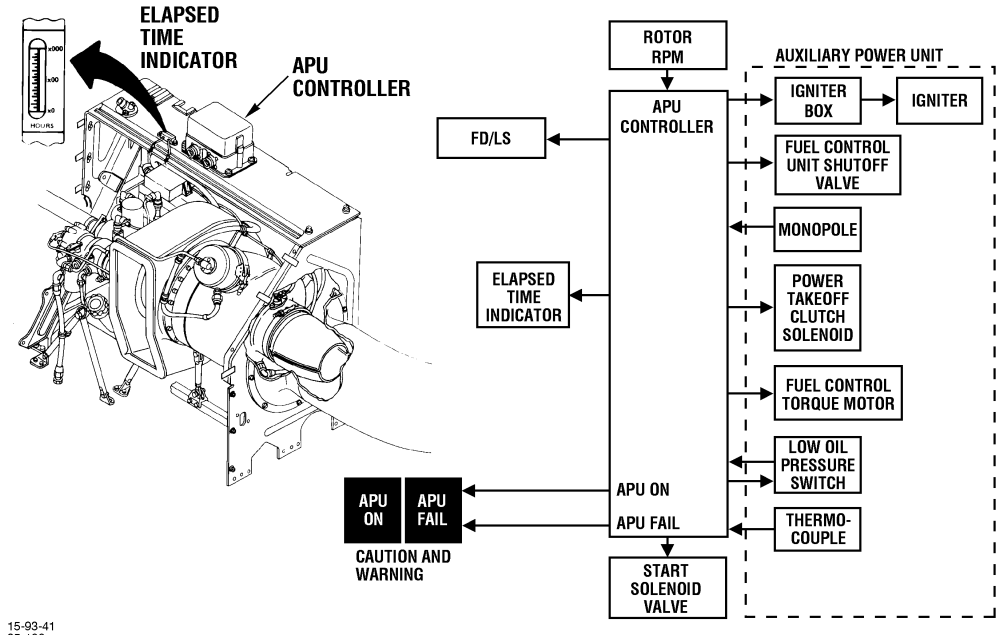
(2) Mounted at the 10 o'clock position on the exhaust section of the APU.

(3) A nonadjustable flange mount is positioned to completely immerse the thermocouple in the exhaust gas.

(4) Consists of a junction of two (2) dissimilar metals: chromel and alumel.

(5) A voltage is generated proportional to the temperature when heat is applied to these dissimilar metals.

APU CONTROLLER AND ELAPSED TIME INDICATOR



NOTES

k. APU elapsed time indicator

(1) Indicates the operating hours of the APU.

(2) Mounted on the top of the APU enclosure, forward of the APU controller.

(3) An integrated elapsed time electrochemical (mercury) indicator.

(4) The face plate is dull black, the numerals white with dull black background, and the scale is black on white background.

(5) Indicator is activated whenever power takeoff (PTO) clutch is engaged.

l. APU controller

(1) Controls and monitors the remote automatic start sequence and normal operation.

(2) Controls PTO clutch engagements and disengagements.

(3) Provides automatic shutdown protection for:

(a) Overspeed

(b) Over-temperature

(c) Loss of thermocouple signal

(d) Low oil pressure condition

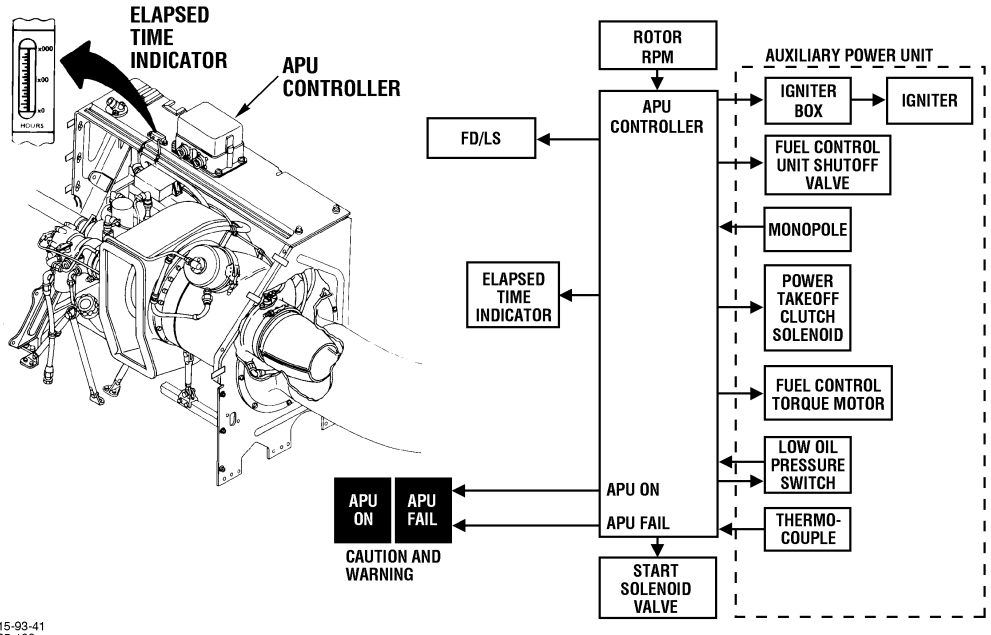
(e) Loss of monopole signal

(4) Provides protection against overcurrent or short circuit faults for the: fuel shutoff valve, ignition unit, PTO clutch solenoid, and start valve solenoid.

(5) Mounted on top of the APU enclosure to isolate it from vibration and heat.

(6) Solid-state circuit device which accepts input signals for monitoring: Nr rotor speed signal, monopole (speed sensor), low oil pressure (LOP) switch, exhaust gas temperature.

APU CONTROLLER AND ELAPSED TIME INDICATOR

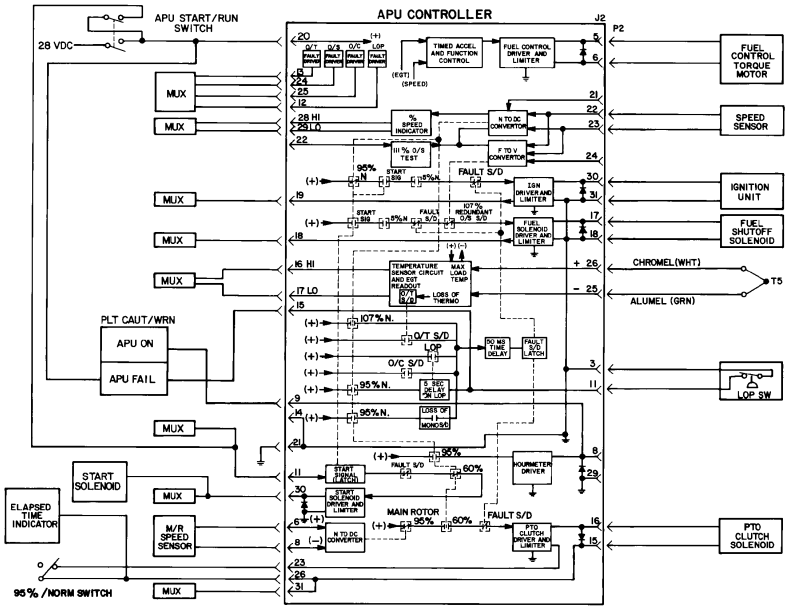


NOTES

(7) Provides output signals for APU control of: ignition system, fuel control unit shutoff valve, power takeoff (PTO) clutch solenoid, low oil pressure (LOP) switch, hydraulic start solenoid valve, FD/LS signals, caution and warning lights, fuel control operation (fuel metering), and elapsed time indicator.

(8) Contains an internal power supply regulator that conditions power input voltage for proper operation of circuitry.

APU CONTROLLER SCHEMATIC



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NOTES

NOTE: Mechanical relay symbols are utilized in the schematic to make it easier to read and follow. The controller uses transistors not mechanical relays.

(9) APU controller operation

(a) 28 vdc is supplied to the start/run switch through the APU HOLD and FUEL APU circuit breaker.

(b) When the start/run switch is placed in the start position, current is allowed to flow through pin 11 of the APU controller. The current flows through the normally closed fault shutdown (S/D) relay, then energizes the start solenoid valve.

(c) At the same time, two start signal relays are closed, arming the fuel and ignition circuits.

(d) When the start/run switch is moved to the run position, 28 vdc is supplied to pin 15 through the LOP switch to ground. This will cause the APU FAIL light to illuminate.

(e) Power is also applied through pin 20 to various circuits. The schematic identifies the application of power to each circuit by using a plus sign in parenthesis, followed by a dark arrow.

(f) With the start solenoid valve energized, the hydraulic start motor begins to rotate turning the rotating group in the APU.

(g) At 5 percent APU speed, two (2) 5 percent relays will close and energize the ignition and fuel shutoff valve solenoids. The combustion section achieves light-off and the APU accelerates.

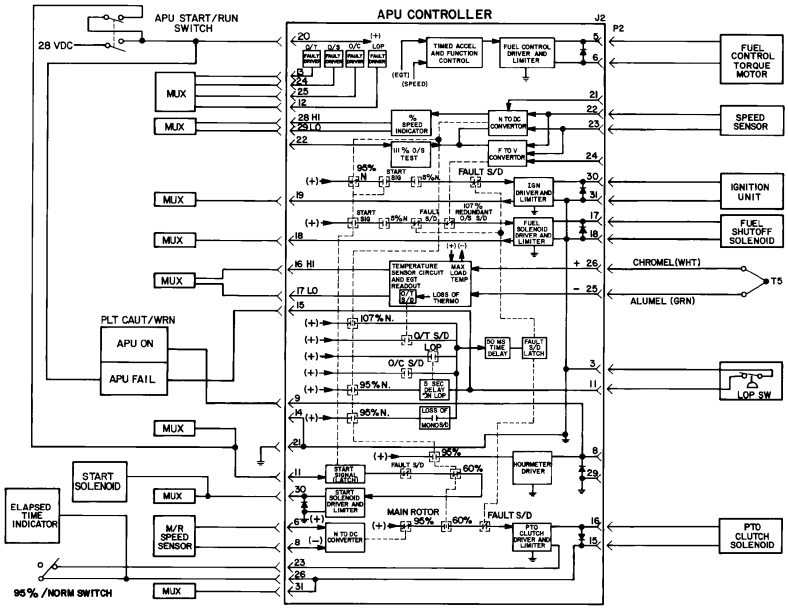
(h) At 60 percent APU speed, the upper set of points on the 60 percent relay open and de-energize the start solenoid.

(i) At the same time, the lower set of points on the 60 percent relay close. If the main rotor speed is below 95 percent, the 95 percent relay will remain closed and current will flow through the normally closed fault S/D relay to energize the PTO clutch solenoid.

(j) Current will also flow through pin 26 and provide voltage to the elapsed time indicator.

(k) At 95 percent APU speed, the center set of points on the 95 percent relay close, which arms the loss of monopole signal relay.

APU CONTROLLER SCHEMATIC



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NOTES

(l) At the same time, the upper set of points on the 95 percent relay close and arm the five-second time delay relay in the LOP circuit. The LOP switch, normally closed, will open when oil pressure exceeds 75 psig (517 kPa). (Fail light extinguishes.)

(m) If oil pressure is below 75 psig (517 kPa) when 95 percent APU speed is reached, the LOP switch will remain closed and provides a ground to complete the circuit. At that time, the five-second time delay relay is energized.

(n) Following a five-second lapse, the LOP relay closes and initiates a 50 MS (milliseconds) time delay after which a fault shutdown takes place.

(o) A fault shutdown will occur, in the same manner as described for the low oil pressure, if one of the following conditions prevails:

1) Overspeed: At 107 percent APU speed the overspeed relay closes.

2) Loss of monopole signal.

3) Over-temperature: At 1785EF (974EC), up to 60 percent APU speed the O/T S/D relay closes.

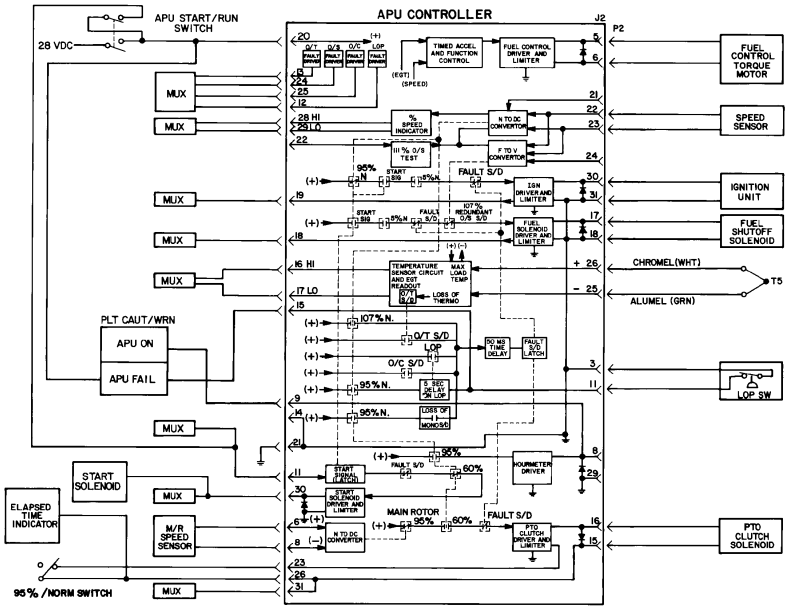
4) Loss of thermocouple signal: With no temperature signal, the O/T S/D relay closes.

5) Overcurrent: A condition of overcurrent at the start valve solenoid, ignition unit, fuel solenoid valve, or the PTO clutch solenoid will close the O/C S/D relay.

(p) The fault shutdown sequence is a latching function and the fault must be removed before a restart is permitted.

(q) In the event a fault shutdown is activated the controller will transmit a fault signal to the multiplex system for FD/LS recognition.

APU CONTROLLER SCHEMATIC



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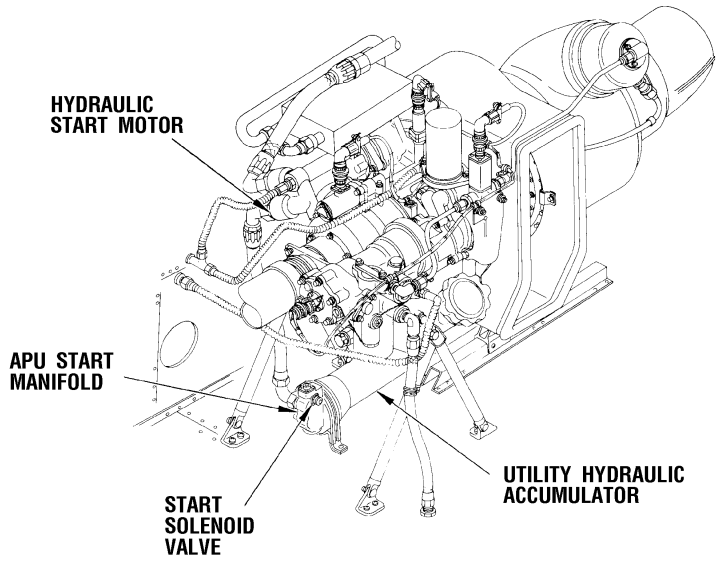
NOTES

(r) FD/LS utilizes a time clock and APU speed signal inputs from the monopole sensor to perform a functional test. The APU FD/LS test must be initiated through the data entry keyboard. The functional test consists of monitoring speed and checking the proper sequence of events from start to steady state operation.

(s) The FD/LS functional test requires inputs from the APU controller to determine the proper sequence of events.

APU START SYSTEM COMPONENTS



15-93-02

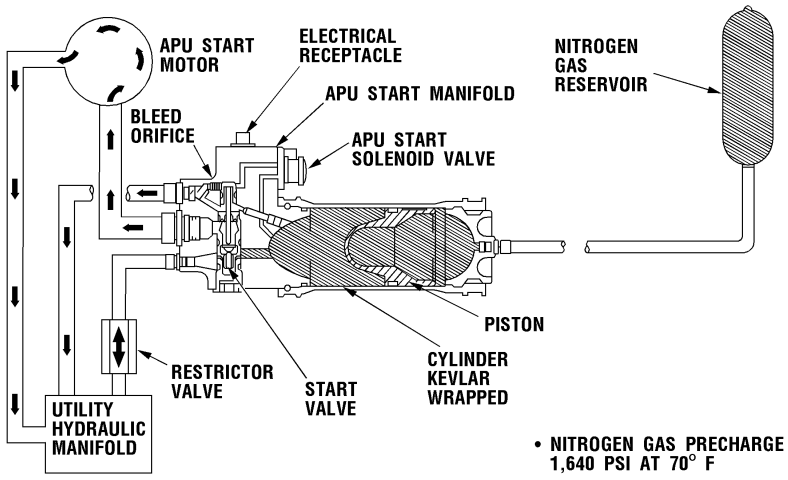
NOTES

F. APU start system

1. Provides initial rotational starting speed so that the APU can become self-sustaining.

2. The APU start system consists of the following components: utility hydraulic accumulator, APU Start manifold with start solenoid valve, hydraulic starter motor, and sprag clutch.

UTILITY HYDRAULIC ACCUMULATOR/APU START MANIFOLD WITH START SOLENOID VALVE



- NITROGEN GAS PRECHARGE 1,640 PSI AT 70° F
- HYDRAULIC FLUID CHARGE 3,000 PSI AT 70° F

15-93-03

NOTES

a. Utility hydraulic accumulator

(1) Stores hydraulic pressure for APU starting.

(2) Mounted on the aft equipment bay deck assembly below the APU.

(3) A cylinder wrapped with Kevlar for ballistic protection.

(4) It has two chambers internally separated by a piston.

(a) One chamber stores hydraulic fluid at 3000 psi (20684 kPa).

(b) The other chamber has a nitrogen gas precharge of 1650 psi (11376 kPa) at 70EF (21EC) then compressed to 3000 psi (20684 kPa).

b. APU start manifold with start solenoid valve

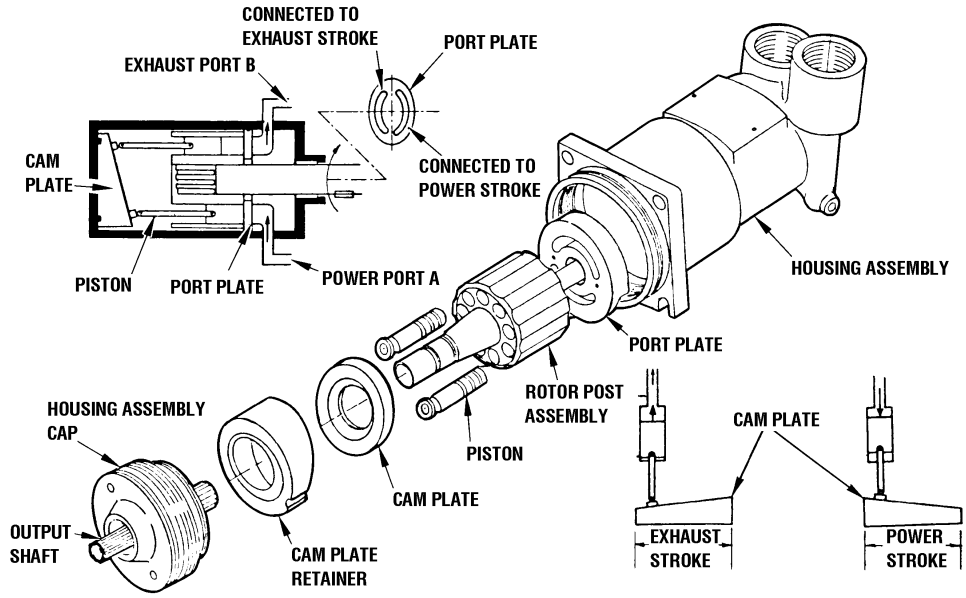
(1) Directs hydraulic pressure to the APU hydraulic start motor during APU starts.

(2) The start manifold is attached to the forward end of the utility hydraulic accumulator and provides a mounting point for the start solenoid valve.

(3) The APU start manifold is a series of chambers encased in an aluminum manifold with a start valve mounted internally.

(4) The start solenoid valve is a normally held closed valve, which is energized open by APU Controller during APU start. After the APU reaches 60 percent APU speed, the APU Controller will de-energize the start solenoid valve closed and allow the spent 3000 psi (20684 kPa) hydraulic pressure to rebuild (after accessory gearbox has rotated hydraulic pumps).

APU HYDRAULIC START MOTOR



NOTES

c. Hydraulic start motor

(1) Rotates the APU starting components to a speed where combustion can take place and APU can become self-sustaining.

(2) Attached to the APU accessory gearbox section, upper right-hand side.

(3) Lightweight (3.5 pounds/1.59 kilograms dry) LRU.

(4) High speed - 100 percent motor speed equivalent to approximately 32,000 rpm.

(5) Consists of the following components: housing assembly, port plate, rotor - post assembly, piston (9), cam plate, cam plate retainer, housing assembly cap, and output shaft.

(6) Contains a power port (inlet from accumulator) and an exhaust port (return to utility manifold).

(7) The nine piston axial motor generates power when supplied with high pressure hydraulic fluid from the accumulator.

(8) Operation

(a) Fluid entering port A from the accumulator passes through one side of the kidney shaped port plate.

(b) The fluid pushes against the piston causing it to seek the lower side of the sloping face of the cam plate.

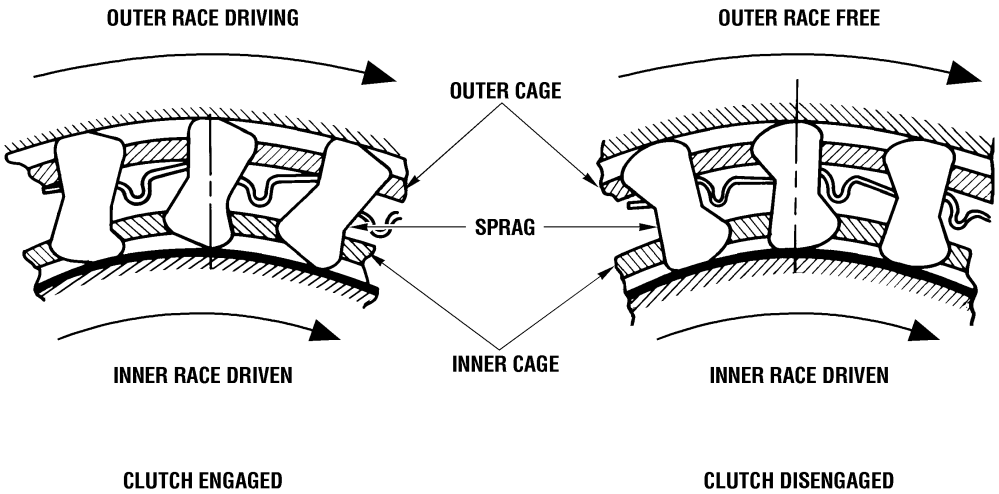
(c) As the slope of the cam plate decreases, the piston moves outward in relation to the rotating rotor post assembly.

(d) Each sequential piston imparts a tangential force to the rotor post assembly, causing it to rotate and turn the output shaft.

(e) When the piston reaches the second half of the revolution, the cam pushes the piston back into the rotor post assembly, exhausting fluid through port B of the kidney shaped port plate.

(f) Each sequential piston reacts to the cam plate in the same manner to exhaust its fluid.

SPRAG CLUTCH



04-93-04

NOTES

d. Sprag clutch

(1) Allows the starter to be coupled with the gear train rotating group in order to drive the unit to a self-sustaining speed.

(2) Will decouple the starter when the APU becomes self-sustaining.

(3) Mounted in the accessory gearbox section, accessible by removing the hydraulic start motor.

(4) Overrunning type clutch with several sprag assemblies.

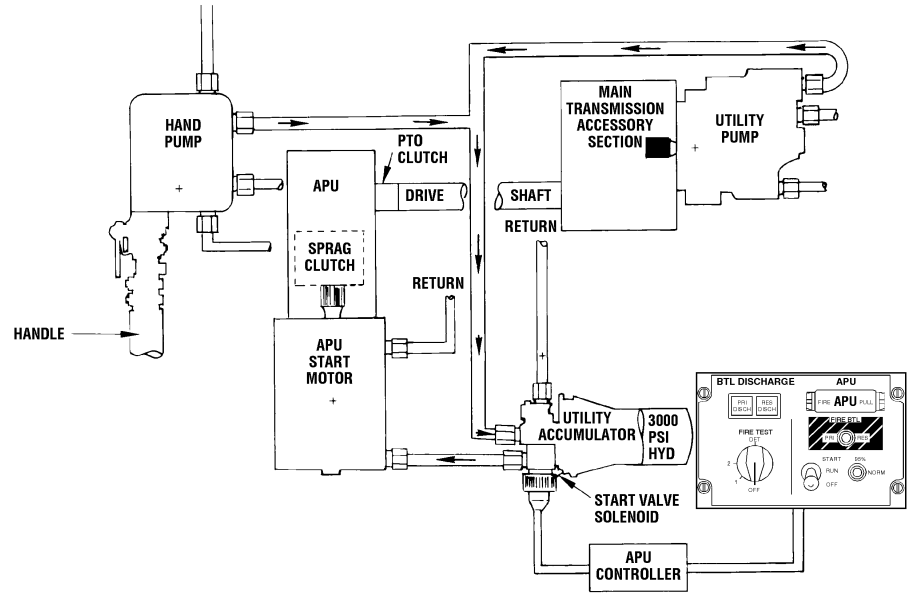
(5) Operation

(a) When starter torque is applied to the inner race the sprags move with a rolling cam action, and being larger than the space between the races, are wedged between them. (Engages the clutch.)

(b) When the start solenoid is de-energized the start motor begins to slow down and the APU continues to accelerate. The outer race overruns the inner race and the sprags roll out of engagement.

(c) As the outer race continues to increase in speed, centrifugal force moves the sprags away from the inner race.

APU START SYSTEM



15-93-05

NOTES

e. APU start system operation

(1) When the APU OFF/RUN/START switch is moved momentarily to the START position, an electrical signal is provided by the APU controller that energizes the hydraulic start valve solenoid. This will direct 3000 psi (211 kg/cm2) hydraulic pressure from the utility accumulator to the APU hydraulic start motor.

(2) Additionally, a 60-second time delay relay is also energized to delay the Shaft Driven Compressor (SDC) throttle valve from opening to reduce the APU starting load.

(3) The APU hydraulic start motor is coupled to the APU by means of a sprag clutch and will disengage at approximately 60 percent APU speed.

(4) When PTO clutch engagement takes place, it will drive the main transmission accessory gear train housing, which drives a utility hydraulic pump and other accessories.

(5) The utility hydraulic pump recharges or pressurizes the utility accumulator with 3000 psi (211 kg/cm2) hydraulic pressure.

(6) In the event the hydraulic pressure from the utility accumulator is not sufficient to start the APU, a hand pump is provided to manually replenish the 3,000 psi (211 kg/cm2) in the utility accumulator (approximately 300 strokes).

C

APU FIRE DETECTION AND EXTINGUISHING SYSTEM MAJOR COMPONENTS

FLAME DETECTORS (2)

FLAME DETECTOR AMPLIFIER

MASTER CAUTION/WARNING PANEL

BTL DISCHARGE/APU CONTROL PANEL

CIRCUIT BREAKERS

FIRE EXTINGUISHING AGENT, TRIPLE VALVE CONTAINER (2)
(FIRE BOTTLE)

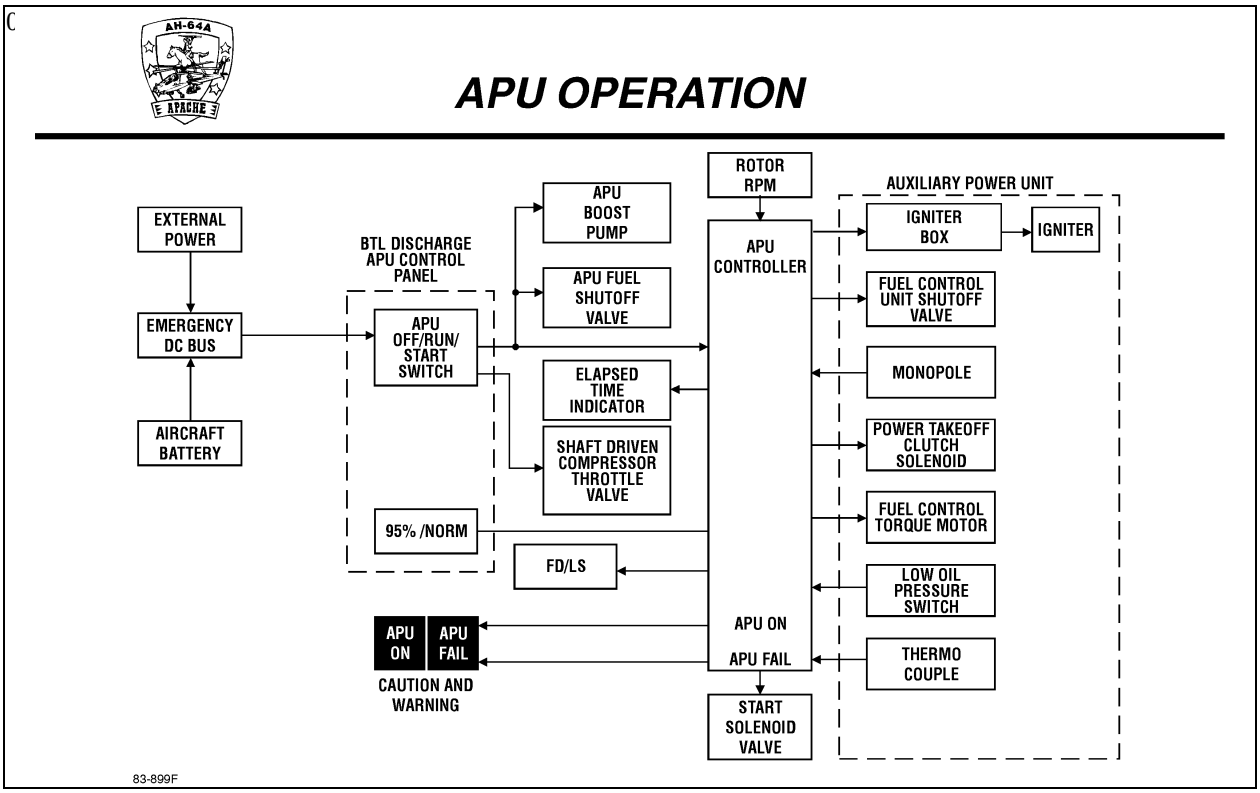
15-93-46

NOTES

G. The APU fire detection and extinguishing system

1. The detection system provides a visual fire alarm signal for the Pilot and CPG.

2. The extinguishing system provides a means for putting out a fire.


AH-64A
APACHE
APU OPERATION
EXTERNAL POWER
EMERGENCY DC BUS
AIRCRAFT BATTERY
BTL DISCHARGE APU CONTROL PANEL
APU OFF/RUN/ START SWITCH
95% /NORM
APU BOOST PUMP
APU FUEL SHUTOFF VALVE
ELAPSED TIME INDICATOR
SHAFT DRIVEN COMPRESSOR THROTTLE VALVE
FD/LS
APU ON
APU FAIL
CAUTION AND WARNING
ROTOR RPM
APU CONTROLLER
APU ON
APU FAIL
START SOLENOID VALVE
AUXILIARY POWER UNIT
IGNITER BOX
IGNITER
FUEL CONTROL UNIT SHUTOFF VALVE
MONOPOLE
POWER TAKEOFF CLUTCH SOLENOID
FUEL CONTROL TORQUE MOTOR
LOW OIL PRESSURE SWITCH
THERMO COUPLE
83-899F

NOTES

H. APU operation

1. Start/run power for the APU is supplied from the battery or external power unit through the emergency dc bus to the BTL Discharge/APU Control Panel.

2. When the APU START switch is moved from OFF, the APU FAIL caution light will illuminate and remain illuminated until APU oil pressure reaches 76 psig (5.3 kg/cm2).

3. When the APU switch is momentarily placed in the START position, the automatic start sequence is initiated. The switch is spring-loaded from the START position to RUN. As soon as the start is initiated, the switch should be released to the RUN position.

4. The APU boost pump is then activated and APU fuel shutoff valve is energized open.

5. The start position will close the shaft driven compressor (SDC) inlet throttle valve for 60 seconds, and energize the APU controller. The controller will energize the hydraulic start solenoid valve.

6. With hydraulic pressure rotating the APU at 5 percent APU speed, the APU controller will energize the fuel control unit shutoff valve open and excite the ignition system.

7. With fuel and ignition, the APU will light off and accelerate.

8. At 60 percent APU speed, the start solenoid valve is de-energized closed by the APU Controller.

9. Additionally, at 60 percent APU speed, if the helicopter main rotor speed is below 95 percent Nr, the PTO clutch solenoid valve then energizes, thus allowing the PTO clutch to engage.

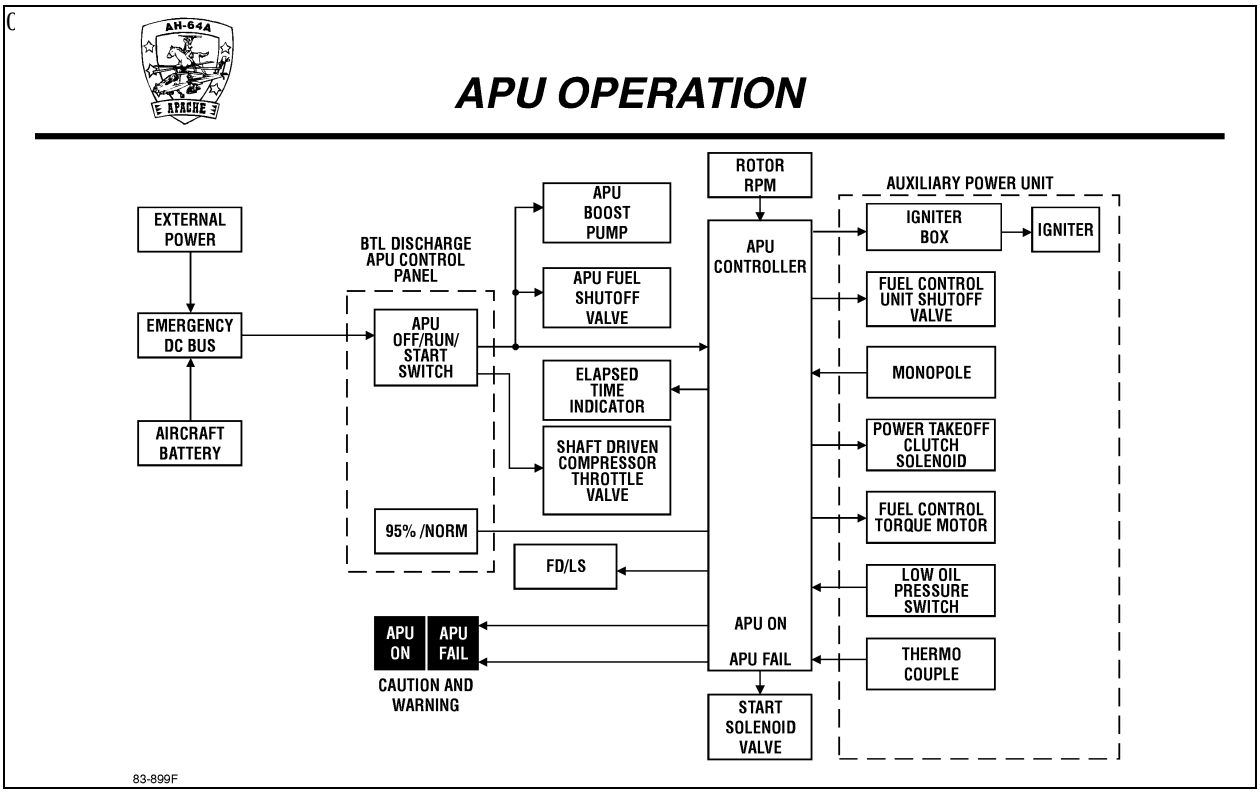
10. If the helicopter main rotor speed is above 95 percent Nr at 60 percent APU speed, the PTO clutch solenoid valve will not energize until the APU reaches 95 percent APU speed and the Nr drops below 95 percent Nr.

11. The elapsed time indicator connected to the APU controller is energized to operate whenever the PTO clutch engages.

12. At 95 percent APU speed, the APU controller will de-energize ignition system and the controller will illuminate the APU ON light.

13. If the APU start is normal, the APU rpm will stabilize at 100 percent rpm.

14. If the outside temperature is 0EF or below, the APU Cold Start switch should be held in the 95 percent position, thus delaying PTO clutch engagement until the APU ON light illuminates. The light will let the operator know the APU has reached 95 percent.


AH-64A
APACHE
APU OPERATION
EXTERNAL POWER
EMERGENCY DC BUS
AIRCRAFT BATTERY
BTL DISCHARGE APU CONTROL PANEL
APU OFF/RUN/ START SWITCH
95% /NORM
APU BOOST PUMP
APU FUEL SHUTOFF VALVE
ELAPSED TIME INDICATOR
SHAFT DRIVEN COMPRESSOR THROTTLE VALVE
FD/LS
APU ON
APU FAIL
CAUTION AND WARNING
ROTOR RPM
APU CONTROLLER
APU ON
APU FAIL
START SOLENOID VALVE
AUXILIARY POWER UNIT
IGNITER BOX
IGNITER
FUEL CONTROL UNIT SHUTOFF VALVE
MONOPOLE
POWER TAKEOFF CLUTCH SOLENOID
FUEL CONTROL TORQUE MOTOR
LOW OIL PRESSURE SWITCH
THERMO COUPLE
83-899F

NOTES

15. The APU controller constantly monitors the APU for faults. The controller will automatically shut down the APU if any of the following faults occur.

16. Malfunctions causing automatic shutdown are:

    a. RPM exceeds 107 percent

    b. Over-temperatures above 1785EF (974EC) up to 60 percent

    c. Over-temperature above 1325EF (718EC) at 100 percent

    d. Loss of temperature signal from thermocouple

    e. Low oil pressure

    f. Loss of monopole signal

    g. Overcurrent signal from the fuel control unit shutoff valve, igniter box, start solenoid valve, or PTO clutch solenoid valve.

17. An automatic shutdown will turn on the APU FAIL light, which is triggered by decreasing oil pressure.

18. For normal shutdown, the APU control switch is placed in the OFF position.

19. ECP 811 has changed a procedure during APU shutdown. The ENCU control switch is now wired to the emergency DC bus instead of the No. 1 DC bus. The control switch is now left on during APU shutdown and supplies emergency DC power to the ENCU bleed air shutoff valve. This keeps the valve open when APU shutdown occurs, eliminating a surge on the shaft driven compressor, preventing damage to it.

C

FD/LS MAJOR FUNCTIONS

- PROVIDES CAUTION/ADVISORY DISPLAYS, WARNING DISPLAYS, AND AUDIBLE SIGNALS TO MONITOR FLIGHT CRITICAL AND MISSION ESSENTIAL EQUIPMENT PERFORMANCE
- DETECTS FAILED SYSTEMS AND ISOLATES LRU FAILURES IN THE SYSTEMS
- DISPLAYS OPERATIONAL STATUS (GO/NO-GO) OF SYSTEMS AND LRUs

27-93-73
85-120

NOTES

A. Fault detection and location system (FD/LS)

1. Provides caution/warning/advisory displays, and audible signals to monitor flight critical and mission essential equipment performance.

2. Detects failed systems and isolates line replaceable unit (LRU) failures in the systems.

3. Displays operational status (GO/NO-GO) of systems and LRUs.

B. APU Maintenance Test Mode Functional Description:

NOTE: Performance of APU maintenance test mode requires an external power source.

1. The APU maintenance test mode requires the APU to be started and brought up to its full speed of 100 percent rpm.

2. A 90 second time clock is used to complete the test period. During this time frame the APU controller's FD/LS outputs are tested for failures.

3. The APU FD/LS test is executed at different percentages of rpm and at certain elapsed time.

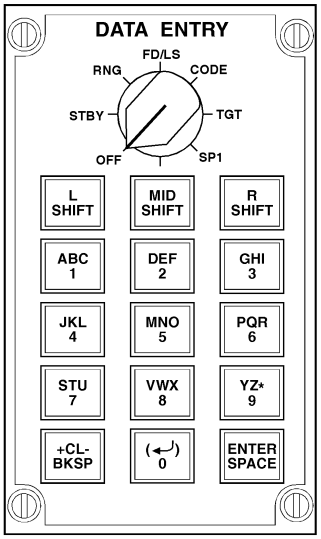
4. If the APU output source being tested does not respond in accordance with FD/LS testing, that particular output will be prompted as a NO-GO.

5. Upon any single APU controller FD/LS output failure, the APU test is aborted and that particular APU output NO-GO will be displayed with the FD/LS end of fail list message:

"ANY KEY FOR FD/LS MENU"

0

APU FD/LS PROMPTS



DATA ENTRY KEYBOARD

DISPLAY

MOVE APU START SWITCH TO START THEN RELEASE

APU TEST IN PROGRESS

15-93-50
85-123

NOTES

C. Operational checks using the FD/LS

1. Upon entry of the APU test number (17) on the data entry keyboard, the operator is prompted to start the APU.

   a. Once the APU START switch has been moved to its START position, the operator will then be prompted that FD/LS testing of the APU has begun.

   b. Upon this prompt, the FD/LS test initiates a 90 second timer and proceeds testing for the occurrence of specific percentages of rpm.

C

FOR SPEEDS < 10%

FOR SPEEDS LESS THAN 10% THE FD/LS TIMER IS CONTINUOUSLY CHECKED TO SEE IF 60 SECONDS OF TEST TIME HAS ELAPSED. IF 60 SECONDS HAS ELAPSED AND THE APU HAS NOT REACHED AN RPM SPEED GREATER THAN 90% DURING THAT 60 SECONDS TIME FRAME, THE APU IS FAILED FOR BEING UNDERSPEED AND THE FOLLOWING NO-GO IS PROMPTED:

"APU"
"NO-GO UNDERSPEED"

IF 60 SECONDS HAS NOT ELAPSED, THEN THE APU RPM IS CONTINUOUSLY TESTED UNTIL THE RPM REACHED SPEEDS GREATER THAN 10%

15-93-51
85-124A

NOTES

2. For all speeds less than 10%, the FD/LS timer is continuously checked to see if the 60 seconds of test time has elapsed.

    a. If 60 seconds has elapsed and the APU has not reached an rpm speed greater than 90% during that 60 second time frame, the APU is failed for being under-speed and the following no-go is prompted: "APU" "NO-GO UNDERSPEED."

    b. If 60 seconds has not elapsed, the APU is continuously tested until the rpm reaches speeds greater than 10%.

C

FOR SPEEDS > 10%

- **"APU"**
  "NO-GO OVERTEMP"
- **"APU"**
  "NO-GO OVERCURRENT"
- **"APU"**
  "NO-GO FUEL SOL NOT ON"
- **"APU"**
  "NO-GO OVERSPEED"

15-93-52
85-125B

NOTES

3. For all rpm speeds greater than 10%, the following APU outputs are continuously tested for failures until the APU FD/LS test is complete:

   a. FD/LS tests for an over-temperature condition. If this condition exists, the following prompt will appear: "APU" "NO-GO OVERTEMP." If over-temperature conditions do not exist, start cycle continues.

   b. FD/LS tests for overcurrent conditions. If this condition exists, the following prompt will appear: "APU" "NO-GO OVERCURRENT." If overcurrent conditions do not exist, start cycle continues.

   c. FD/LS tests to ensure that the fuel solenoid is on continuously. If the solenoid is off, the following prompt will appear: "APU" "NO-GO FUEL SOL NOT ON." If solenoid is on, start cycle continues.

   d. FD/LS tests for an overspeed condition. If this condition exists, the following prompt will appear: "APU" "NO-GO OVERSPEED." If overspeed condition does not exist, start cycle continues.

   e. FD/LS tests for APU rpm speed. For each specific range of rpm speed, different sequences of testing are executed.

C

FOR 10% > SPEEDS < 45%

- **"APU"**
  "NO-GO PTO CLUTCH"
- **"APU"**
  "NO-GO START RELAY"
- **"APU"**
  "NO-GO IGNITION NOT ON"
- **"APU"**
  "NO-GO UNDERSPEED"

15-93-53
85-126B

NOTES

4. For rpm speeds greater than 10% but less than 45%, the following sequences of APU outputs are tested for their specific occurrence.

   a. FD/LS tests for PTO clutch engagement. Clutch should be disengaged during this speed range. If the clutch is engaged the following prompt will appear: "APU" "NO-GO PTO CLUTCH." If PTO clutch is disengaged, start cycle continues.

   b. FD/LS tests the start relay. Relay should be in its start cycle. If the relay is off, the following prompt will appear: "APU" "NO-GO START RELAY." If start relay is on, start cycle continues.

   c. FD/LS tests that the ignition is on. If the ignition is off, the following prompt will appear: "APU" "NO-GO IGNITION NOT ON." If ignition is on, start cycle continues.

   d. FD/LS tests to see if the 60 second timer has elapsed. If time has elapsed and the APU has not reached 90% the unit is failed for under-speed and the following prompt will appear: "APU" "NO-GO UNDERSPEED." If time has not elapsed, start cycle continues.

   e. FD/LS tests APU outputs for speeds greater than 10%. This test continues until the APU speed is greater than 45%.

C

FOR 45% > SPEEDS < 75%

- **"APU"**
  "NO-GO IGNITION NOT ON"

- **"APU"**
  "NO-GO UNDERSPEED"

15-93-54
85-127B

NOTES

5. For all rpm speeds greater than 45% but less than 75%, the following sequence of APU outputs are tested for their specific occurrence.

   a. FD/LS tests for APU ignition on. If the ignition is off, the following prompt will appear: "APU" "NO-GO IGNITION NOT ON." If ignition is on, start cycle continues.

   b. FD/LS tests the timer to see if 60 seconds has elapsed. If time has elapsed, the following prompt will appear: "APU" "NO-GO UNDERSPEED." If time has not elapsed, start cycle continues.

C

FOR 75% > SPEEDS < 90%

- **"APU"**
  "NO-GO PTO CLUTCH"

- **"APU"**
  "NO-GO START RELAY"

- **"APU"**
  "NO-GO UNDERSPEED"

15-93-55
85-128B

NOTES

6. For all rpm speeds greater than 75% but less than 90%, the following sequence of APU outputs are tested for their specific occurrence.

   a. FD/LS tests for PTO clutch engagement. If clutch is not engaged, the following prompt will appear: "APU" "NO-GO PTO CLUTCH." If clutch is engaged, start cycle continues.

   b. When the PTO clutch is engaged, the start relay should be off. FD/LS tests to see if the relay is still in its start cycle. If the relay is still in its start cycle the following prompt will appear: "APU" "NO-GO START RELAY."

   c. If the start relay is off, the test timer is checked to see if the 60 seconds has elapsed. If time has elapsed and the APU has not reached an rpm speed greater than 90%, the APU is failed for under-speed. The following prompt will appear: "APU" "NO-GO UNDERSPEND."

   d. If 60 seconds has not elapsed, then the APU output for speeds greater than 10% are retested for failures. Tests continue until rpm speeds greater than 90% are reached.

FOR SPEEDS > 90%

- "APU"
  "NO-GO IGNITION NOT OFF"
- "APU"
  "NO-GO LOW OIL PRESS"
- "APU"
  "NO-GO PTO CLUTCH"
- "APU"
  "NO-GO START RELAY"
- "APU"
  "GO"
  "ANY KEY FOR FDLS MENU"

15-93-56
85-129A

NOTES

7. For all speeds greater than 90%, the following sequence of APU outputs are tested for their specific occurrence.

   a. At this speed, the ignition should be off. If ignition is still on, the following prompt will appear: APU" "NO-GO IGNITION NOT OFF."

   b. If the ignition is off, the oil pressure should be at normal conditions of pressure. If a low pressure condition exists, the following prompt will appear: "APU" "NO-GO LOW OIL PRESS."

   c. The test timer is checked to see if 90 seconds has elapsed. If 90 seconds has not elapsed, the APU outputs for speeds greater than 10% and the APU output for speeds greater than 90% are retested until the 90 second test timer has elapsed. This ensures the APU has reached its full speed of 100% rpm. When the 90 second timer elapses, the following prompt will appear: "APU" "GO" "ANY KEY FOR FD/LS MENU."

8. APU testing is now complete.