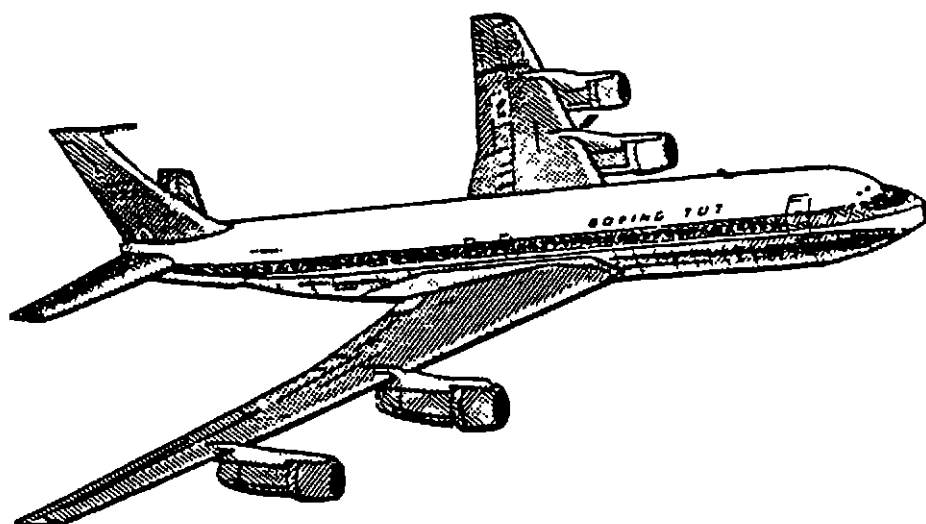


# **BOEING 707**



## **MAINTENANCE MANUAL**

### **FOR NATO TRAINER CARGO AIRCRAFT**

**NATO DOC.: TCA D6-6003**

**SABENA REGISTRATION NO. 180 SABENA**



# MAINTENANCE MANUAL

TEMPORARY REVISION NR. DFW 49-02

INSERT COVER PAGE OF THIS TR IN FRONT OF CHAPTER 49

REASON FOR CHANGE: SFAR88 and AD note 2008-04-11

INSTRUCTION: Insert following pages of this TR facing the original page:

CHAPTER	PAGE OF THIS TR	ORIGINAL PAGE
49-00-2	3	8
49-00-2	5	201
49-31-1	7	1
49-32-31	9	502

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NOTE: The insertion of this TR has to be listed in the Record of Temporary Revisions at the beginning of Volume 1.

TCA: LX-N20199

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**49-00-2**

TR-Nr. 49-02

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Febr 25/2010



## MAINTENANCE MANUAL

TEMPORARY REVISION NR. DFW 49-01

INSERT COVER PAGE OF THIS TR IN FRONT OF CHAPTER 49

REASON FOR CHANGE: SFAR88 and AD note 2008-04-11

INSTRUCTION: Insert chapter 49-32-12 of this TR following the original chapter 49-32-12, page 402.

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TCA: LX-N20199

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**49-00-00**

TR-Nr. 49-01

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CHAPTER 49

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- 1 TCA LX-N20198, LX-N20199
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AUXILIARY POWER UNIT INSTALLATION

DESCRIPTION AND OPERATION

1. GENERAL

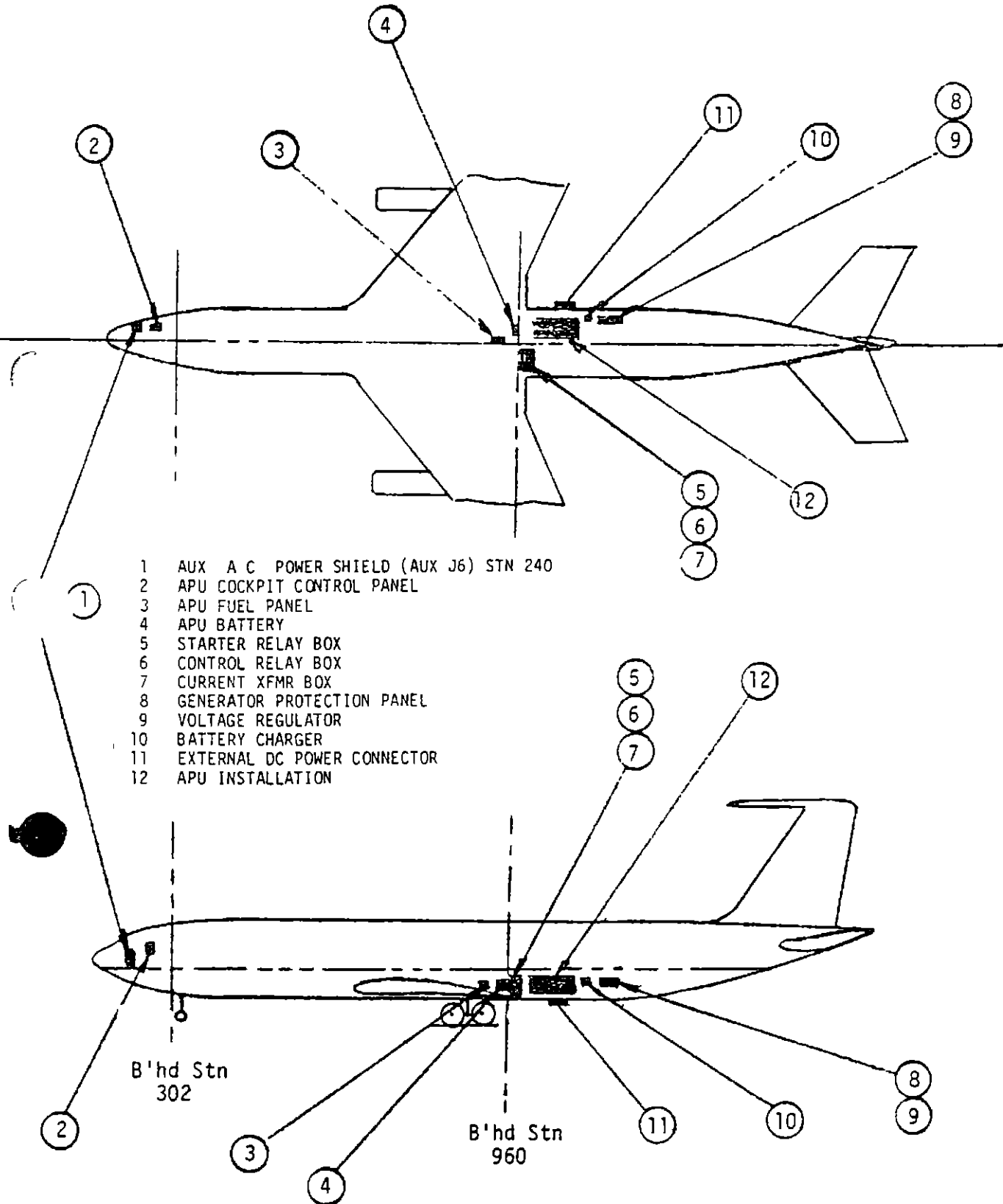
- A. The Auxiliary Power Unit (APU) installation provides pneumatic and AC electric power to the airplane systems during ground operations and makes the airplane independent of ground support equipment. The installation is certified for ground use only and the APU must be shut down prior to the start of takeoff. The installation consists of an APU powerplant module, inlet air and exhaust ducting, fuel supply system, battery charging system (see Chapter 24), a fire protection system (see 49-00-26), transport system for moving the module into or out of the cargo compartment, plus the necessary components to connect the APU output to the airplane pneumatic and AC electrical distribution systems. An individual control panel at the flight engineer's station provides for the start, stop and loading of the APU.
- B. The APU powerplant module is located in the forward section of the aft baggage compartment, right of the airplane centerline. The APU powerplant module consists of a gas turbine and a turbine-driven AC generator, together with controls and mountings enclosed within an insulated stainless steel housing for safe and continuous ground operation. The gas turbine compressor bleed system is connected to the airplane pneumatic system and supplies pneumatic power for main engine starting and airplane airconditioning. Refer to 49-00-36, APU Pneumatic Interface. The AC generator supplies electrical power to energize the aircraft's electrical system. (Refer to Chapter 24-00-00.) Engine compressor Inlet and Accessory cooling air is drawn from the right hand Main Landing Gear well through the bulkhead Sta. 960 and ducted separately to the module housing. The inlets are screened to prevent the ingestion of possibly damaging material by the engine turbine and accessory cooling blower. With the main landing gear door closed the wheelwell serves as a muffler to subdue external noises associated with the gas turbine engine and cooling inlets.
- C. APU turbine exhaust gases are ducted overboard through the right wing-to-body fairing. The exhaust duct assembly consists of an inner and outer duct. The hot turbine exhaust gases pass through the inner section of the duct assembly and through an eductor prior to exhausting overboard. The eductor draws accessory cooling air from the module housing through the annular section between the outer and inner duct. The cooler air from the module housing passing through the annular section serves as insulation to reduce the temperature of the exhaust duct surface and when mixed with the turbine gases downstream of the eductor, and serves to reduce the total temperature of the exhaust gases. An exhaust gas door provides an aerodynamically clean closure over the exhaust exit and prevents the entry of foreign material into the APU engine when it is not operating.

- D. Operation and control of the APU is completely automatic through the ignition/starting and engine fuel and control systems provided in the gas turbine engine installation. With the APU battery switch in the ON position and the APU master switch in the ON position, depressing the START switch-lite momentarily will initiate a series of automatically controlled operations to start the APU engine quickly and safely. After running at governed, no load, speed for one minute, pneumatic or electrical power may be obtained by actuating the appropriate controls. If electrical power is being used in conjunction with pneumatic power, the amount of shaft horsepower available driving the generator will be governed automatically to maintain a safe exhaust gas temperature. Therefore, if maximum pneumatic power is required, such as for a main engine start, the electrical load must be reduced to provide a priority to the pneumatic load. (Refer to Chapter 49-00-2, Sub-chapter D Operation - APU Loading, Item (3)(b) and notes Page 207.) After the electrical and pneumatic loads have been removed for three minutes, the APU is shut down by depressing the OVERSPEED TEST switch momentarily and opening the master relay by depressing the MASTER SWITCH-LITE.
- E. The APU battery charging circuit is self-regulating and connected directly to the aircraft synchronizing bus. The APU battery will be on charge, as required, at all times that power is available at the synchronizing bus.
- F. The transport system provides a means for moving the APU module from the cargo door to the installed position in the forward section of the aft cargo compartment. The system consists of a track section attached to the compartment ceiling and a trolley assembly for lifting and moving the module to and from the door.

## 2. APU MODULE

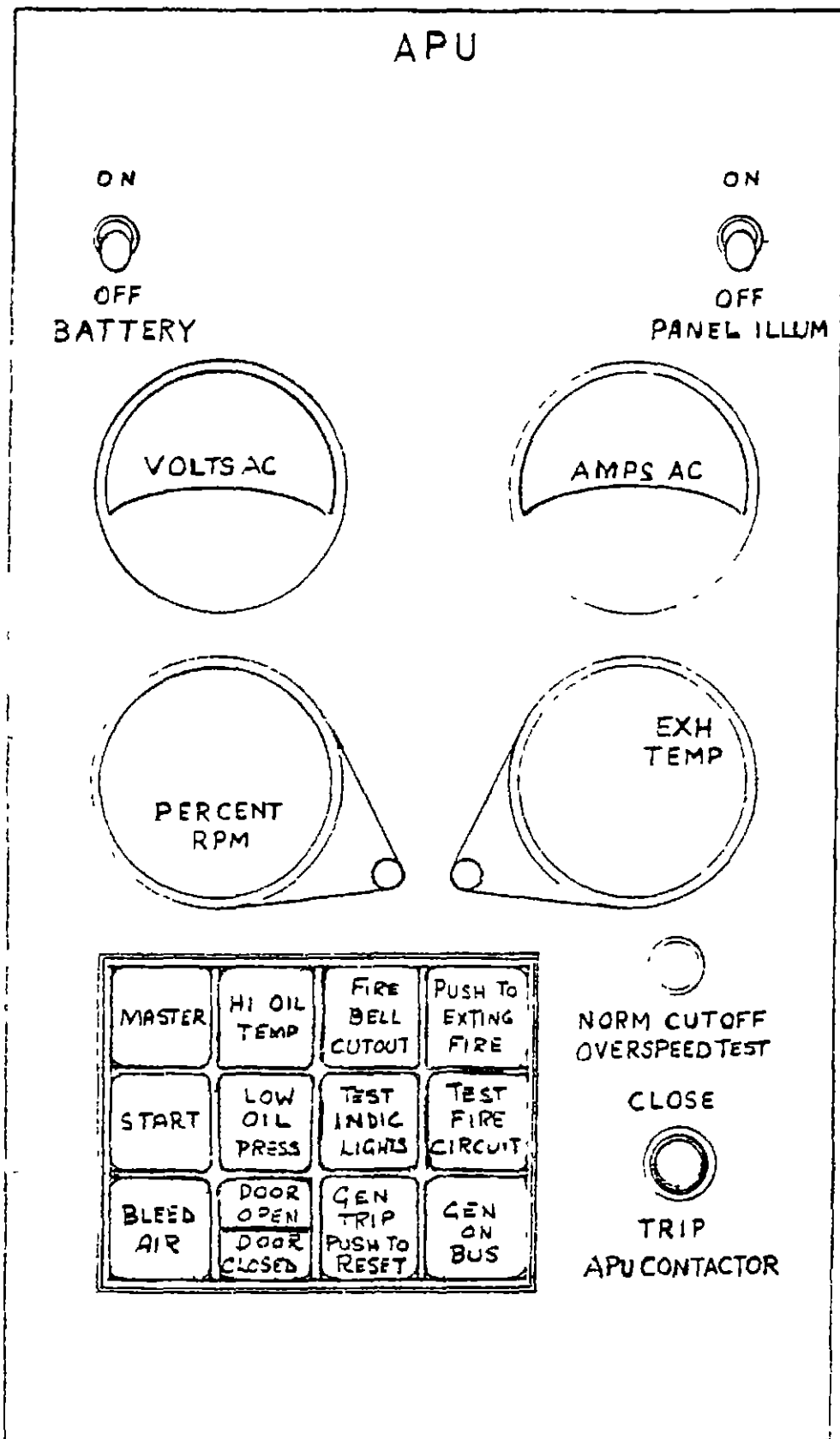
- A. The APU module consists of a gas turbine engine, AC generator, engine mounted accessories, and necessary wiring and plumbing enclosed in a pressure-tight housing.
- B. The APU gas turbine engine provides mechanical shaft power for driving the generator and provides pneumatic bleed-air power for starting the main engines and for cabin airconditioning during airplane ground operations. The AC generator mounts on an engine accessory pad and is directly driven through the accessory gear train.
- C. The APU module housing consists of four sections to provide access to the turbine engine and its accessories for normal line maintenance procedures. The housing is insulated to muffle the APU operating noise, to reduce the heat load imposed on the airplane airconditioning system when the APU is operating, and to protect the airplane and equipment if an APU fire should occur. The housing provides quick-disconnects for all fluid lines, air and exhaust ducts, electrical cables and wiring to expedite the removal and installation of the module.

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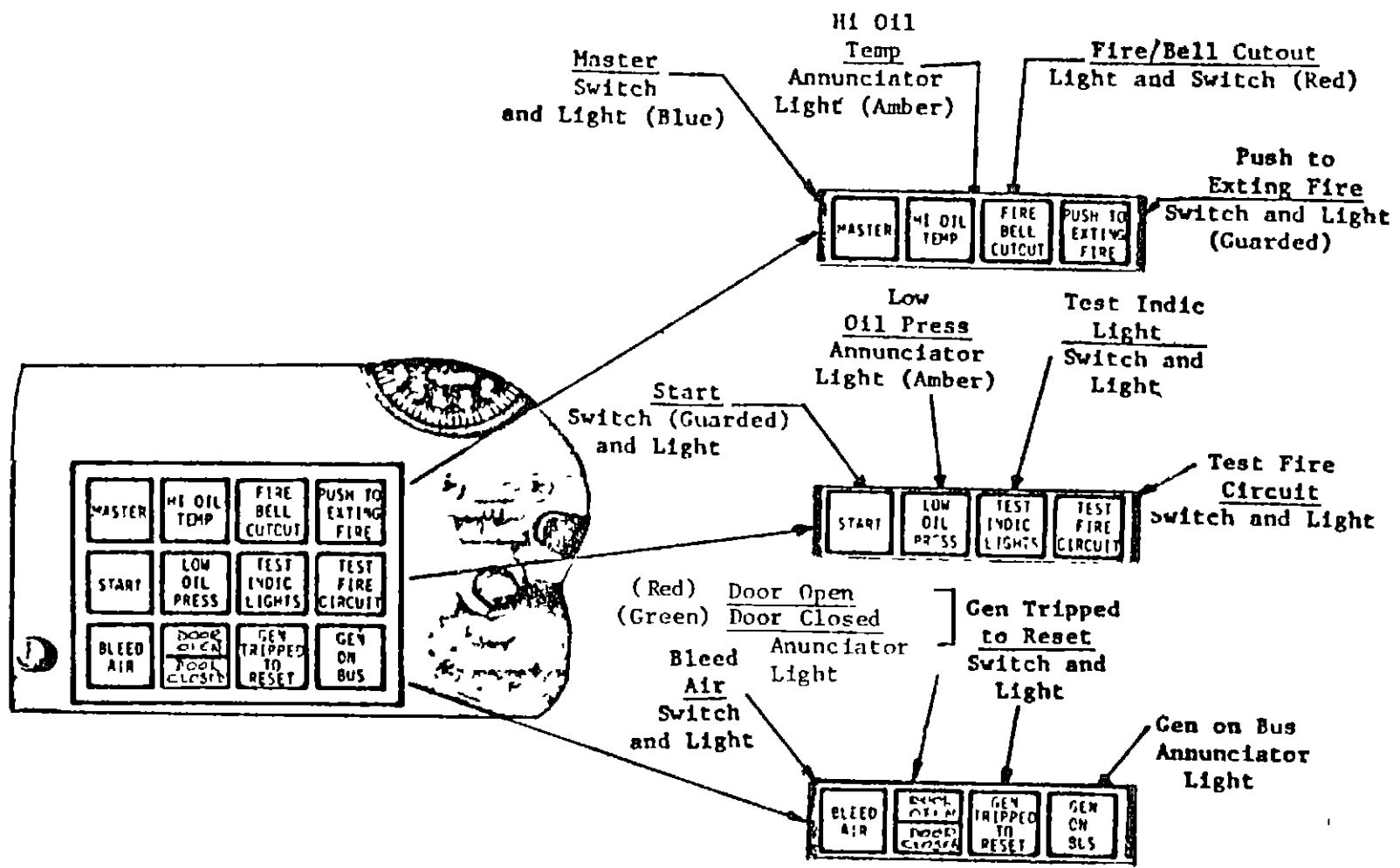


- 1 AUX A C POWER SHIELD (AUX J6) STN 240
- 2 APU COCKPIT CONTROL PANEL
- 3 APU FUEL PANEL
- 4 APU BATTERY
- 5 STARTER RELAY BOX
- 6 CONTROL RELAY BOX
- 7 CURRENT XFMR BOX
- 8 GENERATOR PROTECTION PANEL
- 9 VOLTAGE REGULATOR
- 10 BATTERY CHARGER
- 11 EXTERNAL DC POWER CONNECTOR
- 12 APU INSTALLATION

Figure 1  
 APU COMPONENT LOCATION



APU COCKPIT CONTROL PANEL  
 Figure 2



APU CONTROL MODULE  
Figure 3

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### 3. APU ENGINE

- A. The APU engine is a gas turbine basically composed of a two-stage centrifugal compressor directly coupled to a single-stage inward flow turbine. The turbine shaft is coupled to the accessory drive section to provide power for driving the engine accessories and the generator.

### 4. APU FUEL SUPPLY AND ENGINE FUEL CONTROL SYSTEMS

- A. The APU fuel supply and engine fuel control system delivers clean, metered fuel under pressure to the turbine engine combustion chamber as required to accelerate the engine during starting and to maintain a constant engine speed under all load conditions
- B. The APU fuel supply system filters and pressurizes fuel from the airplane main tank No 3 and delivers it to the engine fuel control system. The fuel supply system consists of a fuel tap at the wing rear spar, a manual shutoff valve, a solenoid actuated fuel supply shutoff valve, a thermal relief valve, a fuel filter and fuel boost pump, plus appropriate plumbing. The solenoid actuated fuel supply shutoff valve and the fuel boost pump are both energized when the APU master relay is closed
- C. The engine fuel control system consists of a fuel control unit mounted on the front of the turbine engine accessory section, a fuel solenoid valve, a fuel atomizer, a control thermostat and a turbine plenum drain. The system is fully automatic in operation and does not require external controls.

### 5. APU IGNITION AND STARTING

- A. The APU ignition and starting systems provides a means of cranking the engine and a predetermined RPM and igniting the fuel-air mixture in the combustion chamber. Automatic controls de-energize the starter motor and ignition circuits when the engine is rotating at approximately 35% and 95% speed respectively

### 6. APU AIR

- A. The APU air system consists of pneumatic and electromechanical components, which function automatically, to regulate the maximum amount of bleed air that may be drawn from the APU for use in the airplane pneumatic systems. Accessory cooling is accomplished by drawing ambient air into the housing, circulating it around the accessories and exhausting it overboard

- B. The engine bleed-air control system is fully automatic in operation. The system consists of a pneumatic thermostat, a three-way solenoid valve and a pneumatic shutoff (load control) valve. Bleed air is not available until the engine reaches governed speed. When engine speed reaches approximately 95% RPM, the three-way solenoid valve is actuated to direct the thermostat output to the load control valve to modulate the valve position and maintain safe exhaust gas temperature.
- C. Bleed air from the APU is carried forward in the bleed-air duct to the airplane cross-over ducting. A flapper type check valve is installed downstream from the load control valve prior to the manifold. The check valve prevents reverse flow through the compressor section of the APU when main engine turbo-compressors are operating.

#### 7. APU ENGINE CONTROL

- A. The APU engine control system provides for the selection, control and monitoring of the operation and loading of the APU engine.
- B. Instrumentation and annunciator lights on the control panel provides for monitoring the operation and loading configuration of the APU engine.
- C. The APU control system receives 28 VDC power from the APU DC bus through its master relay when the MASTER switch-lite is activated and the APU BATTERY switch is in the ON position.

#### 8. APU INDICATING

- A. The APU indicating system consists of an hourmeter, mounted on the APU, for recording the number of hours the APU has been operated, and exhaust gas temperature and RPM indicators on the APU control panel.

#### 9. APU EXHAUST

- A. The APU exhaust is an aspirated (to induce cooling air flow for the APU components), sound reducing, system of ducting that directs the APU exhaust gases overboard through a door in the right wing-to-body fairing aft of the wing flap fence.

#### 10. APU OIL

- A. The APU oil system is a self-contained, positive pressure, dry-sump system that provides pressurized and splash lubrication for all gears and bearings within the unit. The oil supply tank is located at the inboard aft end of the APU module mounted outside of the housing for easy access.

## 11. OPERATION

A. Operation of the APU consists of preparing to start, starting, loading and shutdown. Each step is manually initiated through selector switches on the APU control panel. However, the engine control circuits monitor the conditions required for safe operation of the APU engine before power is applied to actuate start and loading control components

### B Preparing to Start APU

- (1) Placing the APU BATTERY switch to the ON position actuates the APU battery relay and connects the battery bus, through a 15 ampere circuit breaker, to two dc busses.
- (2) Actuating the MASTER switch-lite to the ON position applies power to the control circuit of the master relay, the APU generator control relay, and to the MASTER switch-lite

NOTE The MASTER switch-lite indicates that the contacts of the master switch and the NC contacts of the firelockout relay are closed and that power from the APU dc busses is available to the relay. The light does not indicate the position of the master relay

(a) The master relay will actuate when control power is applied if an electrical ground is available to its coil through contacts of the squat relay. (The electrical ground is only available when the airplane is on the ground.) When the master relay actuates, control power from the APU dc bus is applied to open the APU exhaust gas door, to actuate the fuel boost relay and to energize the engine and generator control circuits

1) When the fuel boost relay actuates, control power is applied to open the fuel supply shutoff valve and to run the fuel supply boost pump

- (3) In summary, with the airplane on the ground, the APU BATTERY switch in the ON position and the MASTER switch-lite on, the APU exhaust gas door will open, pressurized fuel will be available to the engine fuel and control system, the engine and generator control circuits will be energized and the APU will be ready to start.

### C. APU Starting

- (1) Momentarily pressing the START switch will apply power from the master relay to the starter relay and start light circuits.

11. Operation

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NOTE: The MASTER switch indicates that the contacts of the master switch and the NC contacts of the firelockout relay are closed and that power from the APU dc busses is available to the relay. The light does not indicate the position of the master relay.

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- (3) In summary, with the airplane on the ground, the APU BATTERY switch in the ON position and the MASTER switch on, the APU exhaust gas door will open, pressurized fuel will be available to the engine fuel and control system, the engine and generator control circuits will be energized and the APU will be ready to start

C. APU Starting

- (1) Momentarily pressing the START switch will apply power from the master relay to the starter relay and start light circuits.

NOTE: When operating the APU unattended for an extended period of time, follow Airplane Maintenance Manual (AMM) instructions regarding necessary fuel quantity based on APU fuel burn rate.



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- (a) The START light will illuminate if power is available to the starter relay through the contacts of the start switch, the oil pressure sequence switch, and the 35% switch.
- (b) The starter relay (SR) will actuate if an electrical ground is available to its coil through the exhaust door switch No. 1. When the SR actuates, power from the APU battery bus is applied to the starter motor and power from the master relay is applied to a self-locking circuit to retain power on SR and on the START light after the start switch is released. At the same time power is applied to terminal 6 of the battery charger control. This prevents the APU battery charger from carrying the heavy electrical load required during the start cycle.
- (2) When the sequencing oil pressure switch closes, power is applied to the fuel solenoid valve and to the ignition unit. This provides fuel and ignition to initiate combustion. When combustion starts, the gases generated assist the starter motor in accelerating the engine.
- (3) When the 35% switch actuates, power is interrupted to the starter relay and start light circuit.
  - (a) The START switch-light will go out.
  - (b) The starter motor will stop.
  - (c) The APU battery charger will be re-activated.
- (4) When the 95% switch actuates, power is removed from the ignition unit and applied to the three-way solenoid valve, the speed relay, the auxiliary underspeed relay, and to the hourmeter.
  - (a) When the three-way solenoid valve actuates, the pneumatic thermostat control output is transferred from the acceleration limiter valve to the load control valve to control the pneumatic loading of the engine when bleed air is selected.
  - (b) When the speed relay actuates, its contacts close in the low oil pressure fault and bleed air valve (close) control circuits to allow a pneumatic load and low oil pressure protection to be applied to the engine.
  - (c) When the auxiliary underspeed relay actuates the generator control panel underspeed lockout circuitry is de-activated.
  - (d) The hourmeter is energized to time and totalize the hours that the engine operates.

#### D. APU Loading

NOTE After a warm-up period of one minute at governed speed the APU engine is ready for loading electrically and/or pneumatically.

APU loading is accomplished through the controls provided on the APU control panel. After the APU has warmed up, electrical and/or pneumatic power can be obtained through the positioning of controls as outlined below.

##### (1) Electrical Power only

- (a) This configuration provides shaft horsepower exceeding normal generator requirement and no pneumatic power. The turbine engine is not loaded to rated capacity. (Generator protective devices would function before the engine is overloaded.)
- (b) Control Selection and Indication
  - 1) GEN TRIPPED - Push to rest.
  - 2) Essential power selector - Position selector to APU (on flight engineer's upper center panel)
  - 3) APU CONTACTOR SW - Momentarily select the CLOSE position. Green GEN ON BUS annunciator light illuminates.
  - 4) BLEED AIR - Off, light out. Press switch-lite to close bleed air valve, if blue, light is illuminated.

##### (2) Electrical and Pneumatic Power

- (a) This configuration provides electrical power limited to 75 amps per phase and pneumatic power to load turbine engine to rated capacity.

NOTE Adequate pneumatic power for starting an airplane engine is assured when the APU is in the pneumatic and electrical load condition. However, electrical loading must be carefully monitored on the generator of the APU because its entire electric load will be dropped if the 75 ampere limit is reached in any phase of the electrical power generated.

(b) Control Selection and Indication

As in (1-b) above except the following

BLEED AIR - On - Depress switch-light momentarily to open bleed air valve. Blue cover plate will illuminate.

(4) Pneumatic Power only

(a) This configuration provides pneumatic power only and not electrical power. The turbine engine is not loaded to rated capacity.

(b) Control Selection and Indication

1) GEN TRIPPED - Reset

NOTE The generator field control relay should be closed, generator tripped light out, during all APU operations.

2) APU CONTACTOR SW - Momentarily select the TRIP position, green GEN ON BUS annunciator will extinguish.

3) BLEED AIR - On, blue light illuminated.

E. APU Shutdown

NOTE Electrical and pneumatic loads should be removed from the APU three minutes prior to engine shutdown.

(1) Momentarily pressing the OVERSPEED test switch will apply power from the master relay to the pneumatic solenoid valve and cause the 110% switch of the centrifugal switch assembly to actuate. Actuation of the 110% switch removes power from the fuel solenoid valve, causing the valve to close, and from the hold relay, removing all operating power from the engine.

(a) When the fuel solenoid valve closes, the engine shuts down due to fuel starvation.

(b) When the hold relay relaxes, the power circuits to the fuel solenoid valve, ignition unit and starter relay are interrupted until the engine rotational speed falls below 7% RPM. This prevents the fuel solenoid valve from opening and the ignition unit from being energized when the 110% and 95% switches relax as the engine spins down and it prevents the starter relay from energizing the starter when the 35% switch relaxes if a re-start were attempted before full spindown of the engine.

CAUTION. OPENING THE MASTER SWITCH PRIOR TO COMPLETE SPINDOWN OF THE ENGINE CAUSES EXCESSIVE HEAT BUILD-UP IN THE APU MODULE AND EXHAUST SYSTEM DUE TO THE RESTRICTION OF AIRFLOW THROUGH THE ENGINE AND EXHAUST DUCTS WHEN THE APU EXHAUST DOOR CLOSES

- (2) When engine spindown is completed, actuating the MASTER switch-lite to the open position (MASTER switch-lite out) will remove power from the control coil of the master relay. When the master relay opens, the following events occur
  - (a) Control power is applied to the APU exhaust door actuator to close the exhaust gas door
  - (b) Power is removed from the engine control circuits.
  - (c) Power is removed from the fuel boost relay to de-activate the APU fuel supply system
  - (d) Power is removed from the generator control relay to disconnect power from the generator control unit.
- (3) Placing the APU BATTERY switch to the OFF position completes the shutdown of the APU engine.

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APU BATTERY

1 GENERAL

- A. The 24 volt, 36 ampere-hour lead acid storage battery is located in the main landing gear wheelwell cavity. The battery support is mounted on the forward side of the aft cargo compartment (Sta 960) to the right of the keel. The battery is connected to its fire protection circuits through a circuit breaker, and to its control circuits by the common APU battery switch and individual relay. The battery is charged by its single phase charger which is energized by the essential bus through a relay controlled by the APU battery switch.
- B. The service required to maintain the APU battery is dependent on the rate and length of charge, ambient temperature and relative humidity. Chemically approved water should be added to the battery cells whenever necessary. A periodic check for electrolyte level should be made after each flight, depending on battery use and rate of charge.
- C. Both hydrogen and oxygen are generated during the charging cycle of the lead acid storage battery. Air containing 4 to 8 percent hydrogen will burn if ignited. Air mixtures containing more than 8 percent hydrogen will explode.

CAUTION. KEEP ALL OPEN FLAMES, SPARKS FROM ELECTRIC DEVICES, AND ANYONE WHO MAY BE SMOKING, AWAY FROM BATTERY, PARTICULARLY DURING AND FOLLOWING A CHARGING CYCLE

NOTE. Allow a charged battery to stand disconnected in a well ventilated area until gas bubbling stops, before using a torch or flame near the battery

2. UNIT SERVICING - STORAGE BATTERY - 24 VOLT 36 AMPERE-HOUR

- A. Addition of Water - See Para. 3, Ch 24-49-31, Page 103 - Inspection/Check of APU Storage Batteries.
- B. APU Battery Charging - See Para. 2B, Ch. 24-49-31, Page 102 - APU Battery Charging.
- C. Cleaning and Painting - See Para C(1) through (6), Ch 24-49-31, Page 102.
- D. Battery Ventilation Hoses - See Para. D(1) through (4), Ch 24-49-31, Page 103.

APU CONTROL COMPONENTS

TROUBLESHOOTING

1. GENERAL

- A. The APU control component troubleshooting section consists of troubleshooting procedures and wire trace diagrams, plus identification and location tables for circuit breakers, relays, and connectors.
- B. Troubleshooting procedures are outlined in Table 101.
- (1) Malfunctions are listed in Table 101 as they would appear in a normal APU precheck, start-up, loading and shut-down sequence. The latter procedures do not include check-out of components whose malfunction would have been identified and corrected in earlier procedures.
  - (2) The troubleshooting procedures assume that the contacts of a relay act in unison, all tripped or all actuated. Thus, establishing that one set of relay contacts are correctly positioned is sufficient evidence to accept it as functioning properly.
  - (3) Checkpoints, diodes, circuit breakers, etc., are identified for the APU circuits in the troubleshooting procedures and the wire trace diagrams.
- C. The Wire Trace Diagrams, Figures 101 through 118, are presented to simplify the tracing of wire runs from the power source through the component to ground. The diagrams are not intended for use as functional schematics.
- D. Tables 102 through 105 at the end of the troubleshooting section, identify and locate the components as abbreviated in the troubleshooting procedures and wire trace diagrams.

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APU CONTROL COMPONENTS

TROUBLE SHOOTING

TABLE 101

1. FIRE TEST

A. Test does not actuate when TEST FIRE CIRCUIT switch-lite is pressed (Test Fire Circuit and Fire/Bell Cutout lights do not come on, fire bells do not ring.) WTD, Figure 102.

(1) Check for 24 VDC at circuit breakers Fire Det 1 and Fire Det 2, Starter Relay Box.

(a) Not OK

1) Check battery condition and replace/recharge if required.

2) Correct wiring, battery to FD1 and FD2, Figure 101.

(b) OK -- Step (2)

(2) Check for 24 VDC at FLO-A2 and FT-8, Control Relay Box, Figure 102.

(a) Not OK -- Correct wiring, FD1 to FLO-A2, FD2 to FT-8.

(b) OK -- Step (3).

(3) With Fire Test switch depressed, check for 24 VDC at FT-2 and 6, Control Relay Box, Figure 102.

(a) Not OK

1) Check for continuity through Fire Test Switch when depressed (terminals 17 to 7 and 16 to 6), Figure 102.

2) If not OK, replace switch.

3) If OK, correct wiring, FLO-A2 to Fire Test switch and Fire Test Switch to FT-2 and 6.

(b) OK -- Step (4).

(4) With Fire Test switch depressed, check for 24 VDC at FT-1 and FTD-2, Control Relay Box, Figure 102.

- (a) Not OK --
  - 1) Check for open diodes CR8 and CR11
  - 2) If not OK, replace
  - 3) If OK, correct wiring FT-6 to FT-1 and FTD-2
- (b) OK -- Step (5).
- (5) With Fire Test switch depressed, check for 24 VDC at FT-3.
  - (a) If not OK - -
    - 1) Check for ground at FT-7.
    - 2) If not OK, correct wiring, FT-7 to ground
    - 3) If OK, replace Fire Test Relay.
  - (b) OK -- Step (6).
- (6) With Fire Test switch depressed, check for 24 VDC at BS-A3, Control Relay Box, Figure 103 (Note Be sure (4) (a) 3 is OK )
  - (a) Not OK -- Replace Bell Silence relay
  - (b) OK -- Step (7)
- (7) With Fire Test switch depressed, check for 24 VDC at plus terminal of Fire Warning horn, cockpit, Figure 103.
  - (a) Not OK -- Correct wiring BS-A3 to Fire Warning horn.
  - (b) OK --
    - 1) Check for ground at minus terminal of horn
    - 2) If not OK, correct wiring to ground, Figure 103
    - 3) If OK and horn does not sound, replace horn
- (8) Repeat (7) for Fire Warning horn in wheel well, Figure 103.
- (9) With Fire Test switch depressed, check for 24 VDC at Cathode (-) terminal of CR7, Control Relay Box, Figure 103 (Note Be sure (4) (a) 3 is OK )

- (a) Not OK -- Replace CR7.
  - (b) OK -- Step (10)
- (10) With Fire Test switch depressed, check for 24 VDC at cathode (-) terminal of CR30, Control Panel
- (a) Not OK -- Correct wiring (CR7 to CR30).
  - (b) OK -- Check Fire/Bell Cutout indicator light circuit per Figure 107
- B Fire Warning system (Fire/Bell Cutout indicator light and Fire Warning horns) turns on when Fire Test switch is depressed, but does not remain on when released
- (1) Check that circuit breaker, FD2, Starter Relay Box, Figure 102, is closed.
- (a) Not OK -- Close FD2.
  - (b) OK -- Step (2).
- (2) Check for 24 VDC at FT-8, Control Relay Box, Figure 102
- (a) Not OK -- Correct wiring, FD2 to FT-8
  - (b) OK -- Replace Fire Test relay
- C Fire Exting light does not come on 20<sup>±</sup>1 seconds after Fire Test switch is depressed and released (fire warning system activates normally).
- (1) With Fire Test circuit activated, Figure 102, check for 24 VDC at FTD-11, Control Relay Box
- (a) Not OK --
    - 1) Check per A(4) and (5).
    - 2) Correct wiring FT-3 to FTD-11.
  - (b) OK -- Step (2).
- (2) Depress and release Fire Test switch. After 20<sup>±</sup>1 seconds, check for 24 VDC at FTD-9, Control Relay Box, Figure 102
- (a) Not OK --
    - 1) Check for ground at FTD-10

- 2) Not OK -- Correct wiring
  - 3) OK -- Check resistor across FTD-5 and 7 (301K ohms)
  - 4) Not OK -- Replace resistor
  - 5) OK -- Replace Fire Time Delay relay
- (b) OK -- Step (3)
- (3) Depress and release Fire Test switch After  $20 \pm 1$  seconds, check for 24 VDC at cathode terminals of CR21 and CR22, Control Panel, Figure 102
- (a) Not OK -- Correct wiring FTD-9 to CR21/22
  - (b) OK -- Check Push to Extng Fire indicator light per figure 107
- D Extng Fire light remains on beyond  $30 \pm 1$  seconds after the Fire Test switch was depressed and released ( $10 \pm 1$  seconds after the Fire/Bell Cutout light and the warning horns turned off)
- (1) Check that Fire Test switch terminals, Control Panel, Figure 102, open when switch is released
- (a) Not OK -- Replace Fire Test switch
  - (b) OK -- Replace Fire Test relay
- E Bell Cutout switch does not silence Fire Warning horns during Fire Test cycle
- (1) With Fire Test circuit actuated and Bell Cutout switch depressed, check for 24 VDC at BS-A1 and X1, Control Relay Box, Figure 103 (Note: Be sure A(10) is OK.)
- (a) Not OK --
    - 1) Check continuity through Bell Cutout switch terminals 16 and 6 with Bell Cutout switch depressed
    - 2) Not OK -- Replace Bell Cutout switch
    - 3) OK -- Correct wiring Bell Cutout switch -6 to BS A1 and X1

(b) OK --

1) Check for ground at BS-X2.

2) Not OK -- Correct wiring, Figure 102 OK --  
Replace Bell Silence relay.

## 2 PANEL ILLUMINATION

A With Battery and Panel Illum switches closed, APU Control Panel edge lights do not turn on.

(1) Check for 24 VDC at circuit breakers, APU Bus Feed, and Batt SW, Starter Relay Box, Figure 105

(a) Not OK -- Follow procedure 1.A.

(b) OK --

(2) Check for 24 VDC at circuit breaker, Indicator Lights, Starter Relay Box, Figure 105.

(a) Not OK --

1) Check for 24 VDC at TB-17, Control Relay Box, Figure 105

a) Not OK -- correct wiring, Batt SW circuit breaker to TB-17

b) OK --

2) Check for 24 VDC at TB-16, Control Relay Box, Figure 105

a) Not OK -- Correct wiring, TB-17 to TB-16 and/or replace Battery switch

b) OK --

3) Check for 24 VDC at BR-X1, Starter Relay Box, Figure 105

a) Not OK -- Correct wiring, TB-16 to BR-X1

b) OK --

4) Check for 24 VDC at BR-B2

- a) Not OK -- Correct wiring, APU Bus Feed circuit breaker to BR-B2.
  - b) OK --
- 5) Check for 24 VDC at BR-B1.
- a) Not OK -- Check for ground at BR-X2
    - 1 Not OK -- Correct wiring BR-X2 to ground
    - 2 OK -- Replace Battery Relay
  - b) OK -- Correct wiring, BR-B1 to Indic Lights circuit breaker.
- (b) OK --
- (3) Check for 24 VDC at TB-12, Control Relay Box, Figure 106
- (a) Not OK -- Correct wiring, Indic Light circuit breaker to TB-12
  - (b) OK --
- (4) Check for 24 VDC at anode (plus) terminal of CR36, Control Panel, Figure 106.
- (a) Not OK -- Correct wiring, TB-12 to CR36
- (5) Check for 24 VDC at cathode (minus) terminal of CR36.
- (a) Not OK -- replace CR36.
  - (b) OK --
- (6) Check for 24 VDC at Panel Illum switch -2.
- (a) Not OK -- correct wiring, CR36 to Panel Illum switch
  - (b) OK --
- (7) Check for 24 VDC at Panel Illum switch -1 (switch closed)
- (a) Not OK -- replace switch
  - (b) OK --

- (8) Check for 24 VDC at edge light circuit board connector, Control Panel, Figure 106.
  - (a) Not OK -- correct wiring, Panel Illum switch to connector.
  - (b) OK -- replace edge light circuit board

### 3. APU INDICATOR LIGHT TEST

- A. Indicator lights do not turn on when Test Indic Lights switch is depressed
- (1) With Battery switch closed, check for 24 VDC at Panel Illum switch, terminal 2, Control Panel, Figure 106
    - (a) Not OK -- follow procedure 2.A (1) through (6)
    - (b) OK -- Trace circuitry for fault per Wire Trace Diagram, Figure 107. Replace light bulbs, switch-lite units, and diodes as necessary.

### 4. APU MASTER SWITCH

- A. Master Light does not turn on when Master switch is depressed (Battery switch closed and Indicator Light Test, Figure 107, OK )
- (1) Check for 24 VDC at circuit breaker, Control Feed 1, Starter Relay Bx, Figure 105.
    - (a) Not OK -- Follow procedure 2. A (1) thru (2) (a) substituting circuit breaker Control Feed 1 for circuit breaker Indic Lights, and BR-A2/A1 for BR-B2/B1.
    - (b) OK --
  - (2) Check for 24 VDC at TB-8, Control Relay Box, Figure 109.
    - (a) Not OK -- Correct wiring CF1 to TB-8.
    - (b) OK --
  - (3) Check for 24 VDC at FLO-B2, Control Relay Box, Figure 109.
    - (a) Not OK -- Correct wiring, TB-8 to FLO-B2 (replace Master switch-lite unit, if required).

(b) OK --

(4) Check for 24 VDC at FLO-B3

(a) Not OK --

1) Check for 24 VDC at FLO-X1, Control Relay Box,  
Figure 104

a) Not OK -- replace Fire Lockout relay

b) OK -- Open and close circuit breaker Fire Det 1,  
Starter Relay Box, Figure 101

NOTE The Fire Lockout relay should only be energized  
(24 VDC at X1 and normally closed B2/B3 open)  
if one or more of the fire detectors (APU  
Module, Figures 102 and 103) have closed. For  
trouble shooting, See Figures 102, 103, and  
and 104

(b) OK --

(5) Check for 24 VDC at cathode (minus) terminal of CR28, Control  
Panel, Figure 109

(a) Not OK -- Correct wiring, FLO-B3 to CR28. Replace diode  
CR4, Control Relay Box, Figure 109, if necessary

B Exhaust door does not open (Battery and Master switches closed,  
Master light on)

(1) Check for 24 VDC at circuit breaker Door Motor, Starter Relay  
Box, Figure 105 (Door Motor circuit breaker closed)

(a) Not OK -- Follow procedure 2 A. (1) through (2) (a)

(b) OK --

(2) Check for 24 VDC at MR-B2, Control Relay Box, Figure 110

(a) Not OK -- Correct wiring, Door Motor circuit breaker  
to MR-B2

(b) OK --

(3) Check for 24 VDC at MR-B1

(a) Not OK --

1) Check for 24 VDC at MR-X1, Control Relay Box, Figure 109

a) Not OK -- Correct wiring, FLO-B3 to MR-X1

b) OK --

2) Check for ground at MR-X2.

a) Not OK --

1 Wiring from insulated terminal to R54-D2, Anti-Skid relay is faulty

2 Wiring from R54-D3 to ground is faulty

3. R54 is faulty

NOTE The specific safety ("Squat") relay required may vary with aircraft. Refer to manufacturer's diagram

b) OK -- Replace Master Relay, Control Relay Box, Figure 109

(b) OK -- Refer to Figure 110

1) Wiring, MR-B1 to P23, Door Actuator connector, is faulty.

2) Wiring, P23 to ground, is faulty

3) Door Actuator internal sequence switches are incorrectly adjusted and/or faulty

4) Door Actuator is faulty

C. Boost Pump does not operate (Battery and Master switches closed, Master Light on).

(1) Check for 24 VDC at circuit breaker Boost Pump, Starter Relay Box, Figure 105 (Boost Pump circuit breaker closed)

(a) Not OK -- Follow procedure 4.A. (1) (a).

(b) OK --

(2) Check for 24 VDC at BP-A1, Starter Relay Box, Figure 111

- (a) Not OK -- Correct wiring, Boost Pump circuit breaker to BP-A1.
  - (b) OK --
- (3) Check for 24 VDC at BP-A2
- (a) Not OK --
    - 1) Check for 24 VDC at circuit breaker Control Feed 2, Starter Relay Box, Figure 105
      - a) Not OK -- Follow procedure 2.A (1) through (2) (a)
      - b) OK --
    - 2) Check for 24 VDC at MR-A2, Control Relay Box, Figure 111.
      - a) Not OK -- Correct wiring, Control Feed 2 circuit breaker to MR-A2
      - b) OK --
    - 3) Check for 24 VDC at MR-A1
      - a) Not OK -- Follow procedure 4 B (3) (a)
      - b) OK --
    - 4) Check for 24 VDC at TB-33
      - a) Not OK -- Correct wiring, MR-A1 to TB-33
      - b) OK --
    - 5) Check for 24 VDC at BP-X1, Starter Relay Box, Figure 111
      - a) Not OK -- Correct wiring, TB-33 to BP-X1
      - b) OK --
    - 6) Check for ground at BP-X2
      - a) Not OK -- Correct wiring, BP-X2 to ground
      - b) OK -- Replace Boost Pump relay

- (b) OK --
  - (4) Check for 24 VDC at TB-35, Control Relay Box, Figure 111.
    - (a) Not OK -- Correct wiring, BP-A2 to TB-35
    - (b) OK --
  - (5) Check for 24 VDC at P12, Boost Pump Connector, wheel well, Figure 111
    - (a) Not OK -- correct wiring, TB-35 to P12.
    - (b) OK --
      - 1) Check for ground at Boost Pump housing (Boost Pump housing must be bonded to airframe and wired to TB-21, Control Relay Box, Figure 111)
        - a) Not OK -- Correct ground of Boost Pump housing.
        - b) OK -- Replace Boost Pump.
- D. Fuel Valve does not open (Battery and Master switches closed, Master Light on, Boost Pump running.
- NOTE To avoid running boost pump with fuel system dry, disconnect P12, boost pump connector, from boost pump.
- (1) Check for 24 VDC at P13-A Fuel Valve connector, wheel well, Figure 111.
    - (a) Not OK -- Correct wiring, TB-35 to P13-A
    - (b) OK --
  - (2) Check for ground at P13-B
    - (a) Not OK -- Correct wiring, P13-B to TB-21
    - (b) OK -- Replace Fuel Valve

## 5. DOOR POSITION INDICATOR LIGHTS

- A. Door Closed light does not turn on (Battery switch closed, Master switch open, Exhaust Door closed, and Indicator Light Test, Figure 107, OK)

(1) Check for ground at TB-3, Control Relay Box, Figure 108.

(a) Not OK --

1) Correct wiring, TB-3 through Exhaust Door Switch 2 normally open contacts to ground

2) Correct adjustment of Exhaust Door Switch 2

NOTE Exhaust Door Switch 2 normally open contacts are closed when the exhaust door is fully closed

3) Replace Exhaust Door Switch 2

(b) OK -- Correct wiring, Door Closed light, Terminal 23 to TB-3.

B. APU Exhaust Door Annunciator light, in A/C Door Annunciator Warning Lights panel, does not turn on when APU Exhaust Door begins to open (A/C Door Annunciator Warning lights powered by A/C DC power system)

(1) Check APU Exhaust Door annunciator warning light with Door Annunciator Warning Lights test switch

(a) Not OK --

1) Replace bulb(s)

2) Correct wiring, Figure 108 (refer to A/C manufacturer's wiring diagrams)

(b) OK --

(2) Check for ground at TB-4, Control Relay Box, Figure 108 (APU Exhaust Door "less than" fully closed)

(a) Not OK --

1) Correct wiring, TB-4 through Exhaust Door Switch 2 normally closed contacts to ground.

2) Correct adjustment of Exhaust Door Switch 2

NOTE Exhaust Door Switch 2 normally closed contacts close when the APU Exhaust Door moves from the fully closed position

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- 3) Replace Exhaust Door Switch 2
  - (b) OK -- Correct wiring D349-N, Door Annunciator Warning Lights connector, to TB-4.
- C Door Open light does not turn on (Battery and Master switches closed, Master light on, APU Exhaust Door fully open, and Indicator Light test, Figure 107, OK)
  - (1) Check for ground at TB-5, Control Relay Box, Figure 108.
    - (a) Not OK --
      - 1) Correct wiring, TB-5 through Exhaust Door Switch 1 normally open contacts to ground
      - 2) Correct adjustment of Exhaust Door Switch 1
    - NOTE Exhaust Door Switch 1 normally open contacts close when APU Exhaust Door reaches fully open position
    - 3) Replace Exhaust Door Switch 1
  - (b) OK --
  - (2) Check for ground at TB-2, Control Relay Box, Figure 108
    - (a) Not OK --
      - 1) Check continuity of CR17, Control Relay Box, Figure 108.
        - a) Not OK -- Replace CR17.
        - b) OK -- Correct wiring, TB-2 to TB-5.
      - (b) OK -- Correct wiring, Door Open light, terminal 3 to TB-2

## 6 APU START CIRCUIT

- A Start light does not come on when Start switch is depressed (Battery and Master switches closed, Bleed Air switch open (Bleed Air Light off) APU Exhaust Door fully open, fuel system (Boost Pump and fuel valve) operating, and indicator light test, Figure 107, OK)

NOTE Before trouble shooting the start circuit, it is advisable to disconnect P/J 19 at the APU Module, Figure 113 and P12

at the Boost Pump in the wheel well, Figure 111, in order to avoid unnecessarily operating the starter and boost pump during procedure.

- (1) With the Battery and Master switches closed (Master light on) and the Bleed Air switch open (Bleed Air light off), check for 24 VDC at TB-31, 32, and 33, Control Relay Box, Figure 112 (Note TB-31, 32 and 33 are bussed together).
  - (a) Not OK --
    - 1) Check for 24 VDC at P12, wheel well, Figure 111
      - a) Not OK -- Follow procedure 3 C. (3) (a) 3) through 4)
      - b) OK -- Repair or replace bus bar, TB-31, 32 and 33.
    - (b) OK --
  - (2) With start switch held closed and conditions for (1) above maintained, check for 24 VDC at TB-27, Control Relay Box, Figure 112
    - (a) Not OK --
      - 1) Check for 24 VDC at Start switch, terminal 16, Control Panel, Figure 112
        - a) Not OK -- Correct wiring, TB-31, Control Relay Box, to Start switch
        - b) OK --
      - 2) Check for 24 VDC at Start switch terminal 6 (Start switch held closed).
        - a) Not OK -- Replace Start switch lite unit
        - b) Not OK -- Correct wiring, Start switch to TB-27
    - (b) OK --
  - (3) With Start switch held closed and conditions for (1) still maintained, check for 24 VDC at TB-36, Control Relay Box, Figure 112
    - (a) Not OK --
      - 1) Disconnect P/J18 at APU module and, with Start switch held closed, check for 24 VDC at P18-S, Figure 112

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- a) Not OK -- Correct wiring, TB-27 to P18-S.
- b) OK --
- 2) Check continuity through J18-S to P.
  - a) Not OK --
    1. Wiring J18-S/P to Airesearch engine harness connector plug -S/P, is open -- correct wiring.
    2. Wiring, Airesearch engine harness connector receptacle - S/P to Oil Pressure Sequence switch connector plug is open -- correct wiring
    3. Oil Pressure Sequence switch (Airesearch engine component) is open - - replace Oil Pressure Sequence switch.
  - b) Not OK -- correct wiring P18-P to TB-36, Figure 112
- (b) OK --
- (4) With Start switch held closed (conditions for (1) maintained), check for 24 VDC at TB-39, Control Relay Box, Figure 112
  - (a) Not OK --
    - 1) Disconnect P/J18 at APU module and, with Start switch held closed, check for 24 VDC at P18-E, Figure 112
      - a) Not OK -- Correct wiring, TB-36 to P18-E.
      - b) OK --
    - 2) Check continuity through J18-E to H
      - a) Not OK --
        1. Wiring, J18-E/H to Airesearch engine harness connector plug - I/H is open -- correct wiring
        2. Wiring, Airesearch engine harness connector receptacle - I/H to centrifugal switch connector plug - D/C is open --correct wiring
        3. 35% switch (Centrifugal switch connector

receptacle - DC) is open -- replace centrifugal switch (Airesearch component )

b) OK -- Correct wiring, P18-H to TB-39, Figure 112

(b) OK --

(5) With Start switch held closed, check for 24 VDC at cathode (minus) terminal of CR2, Control Relay Box, Figure 112

(a) Not OK --

1) Check for 24 VDC at anode (plus) terminal of CR2

a) Not OK -- Correct wiring, TB-39 to CR2.

b) OK -- Replace diode, CR2

(b) OK -- Correct wiring, CR2 to CR26, Control Panel, Figure 112.

B. Starter does not rotate when Start switch is depressed (Start light comes on and conditions for A above maintained) (see note in A above ).

(1) With Start switch held closed, check for 24 VDC at SR-X1, Starter Relay Box, Figure 112.

(a) Not OK -- Correct wiring, TB-39, Control Relay Box to SR-X1

(b) OK--

(2) Check for ground at SR-X2

(a) Not OK --

1) Check for ground at TB-5, Control Relay Box, Figure 112

a) Not OK -- Follow procedure 5 C (1) (a).

b) OK --

2) Check for ground at TB-1.

a) Not OK -- Replace diode, CR18.

b) OK -- Correct wiring, SR-X2 to TB-1

- (b) OK --
  - (3) With Start switch held closed, check for 24 VDC at SR-A1, Starter Relay Box, Figure 113.
    - (a) Not OK -- Replace Starter Relay.
    - (b) OK --
  - (4) With Start switch held closed, check for 24 VDC at P19-D, APU module, Figure 113
    - (a) Not OK -- Correct wiring, SR-A1 to P19-D
    - (b) OK --
  - (5) Check for ground at P19-B.
    - (a) Not OK -- Correct wiring, P19-B to ground stud, Starter Relay Box, Figure 113
    - (b) OK --
  - (6) Check continuity, J19-B through D.
    - (a) Not OK --
      - 1) Wiring, J19 to Starter is open -- correct wiring.
      - 2) Wiring, Starter to ground is open -- correct wiring
      - 3) Starter is faulty -- replace starter.
- C. Start circuit does not hold when Start switch is released (starter rotates and Start light comes on when Start switch is depressed but both discontinue when Start switch is released).
- (1) With Battery and Master switches closed (Master light on), check for 24 VDC at HR-B2, Control Relay Box, Figure 112.
    - (a) Not OK -- Correct wiring, TB-32 to HR-B2
    - (b) OK --
  - (2) Remove wire from HR-B1 (caution. wire will be "HOT" during following procedure) Hold Start switch closed and check for 24 VDC at HR-B1.
    - (a) Not OK

- 1) With Start switch held closed, check for 24 VDC at HR-X1, Control Relay Box, Figure 114
  - a) Not OK --
    1. Wiring, P18-G (APU module) to HR-X1, is open -- correct wiring.
    2. Wiring, J18-G to Airesearch engine harness connector plug - G, is open -- correct wiring.
    3. Wiring, Airesearch engine harness connector receptacle - G to centrifugal switch connector plug - B, is open -- correct wiring
    4. 110% switch, centrifugal switch connector receptacle - D through B, is open -- replace centrifugal switch.
  - b) OK --
- 2) Check for ground at HR-X2.
  - a) Not OK -- Correct wiring, HR- to ground
  - b) Replace Hold Realy, Control Realy Box, Figure 114
- (b) OK --
- (3) Hold Start switch closed and check for 24 VDC at terminal of wire previously removed from HR-B1, Control Relay Box, Figure 112.
  - (a) Not OK --
    - 1) Check wiring, TB-36 to HOT-A3, HOT-A2 to LOP-A3, LOP-A2 to HR-B1 end of wire.
      - (a) Not OK -- Correct wiring
      - (b) OK --
    - 2) Check continuity, HOT -A3 to A2
      - a) Not OK --

- 1 1 HOT relay, Control Relay Box,  
- Figure 116, is energized (High Oil Temp light, Control Panel, Figure 116, is on). HOT relay is normally energized through the normally open contacts of the High Oil Temp switch, in oil line adjacent to APU module, Figure 116. The High Oil Temp switch contacts are set to close at 275°F.
  - a 1 Open and close Master switch --  
- HOT relay should de-energize, High Oil Temp light should turn off, normally closed contacts, HOT-A3 to A2, should close (Fig 112)

If not -- correct wiring, Figure 116. Replace High Oil Temp switch, if necessary.
  
- 2 2 HOT relay is not energized (High Oil Temp light is not on).
  - a 1 Normally closed contacts, HOT-A3/A2 (Fig 112) are open -- replace High Oil Temp relay, Control relay box, Figure 116
  - b) OK --
  
- 3) Check continuity, LOP-A3 to A2 (Fig 112)
  - a) Not OK --
    - 1 1 LOP relay is energized (Low Oil Press light, Control Panel, Figure 116 is on) LOP relay is normally energized through the normally closed contacts of the Low Oil Pressure switch, mounted in the oil line inside the APU module, in series with normally open contacts 95%-B2 to B1, Control Relay Box, Figure 116. The 95% relay is normally energized through the normally open contacts of the 95% Centrifugal switch -E to A, Airesearch component, APU module, Figure 114, which transfers at 95% engine RPM, at which

point the Low Oil Pressure switch contacts should be open.

- a Open and close Master switch--LOP relay should de-energize, Low Oil Press light should turn off, normally closed contacts LOP-A3 to A2 should close

If not -- correct wiring, Figure 116  
Replace Low Oil Press and/or  
Centrifugal switches, if necessary

- 2 LOP relay is not energized (Low Oil Press light not on)

- a Normally closed contacts LOP-A3/A2 are open -- replace Low Oil Press relay. Control Relay Box, Figure 116

NOTE: On completion of C (3), reconnect wire previously removed to HR-B1

D. Engine light off does not occur

- (1) Check APU fuel boost pump operation, procedure 4 C.

- (a) Not OK -- Correct per procedure 4 C.
- (b) OK --

- (2) Check operation of APU fuel supply solenoid valve procedure 4.D.

- (a) Not OK -- Correct per procedure 4 D
- (b) OK --

- (3) Using appropriate container (two or more gallons) to collect fuel, remove bowl of water separator (fuel filter)

- (a) Fuel flow stops after line drainage -- Check position of manual fuel supply valve. Replace fuel supply solenoid valve if manual valve is open
- (b) Fuel flow continues, in excess of line drainage -- See (c).
- (c) Replace water separator bowl - See (d)

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- (d) Continue troubleshooting per AirResearch Maintenance Manual.
- E Starter operates, but cranks engine too slowly,
  - (1) Check battery condition.
    - (a) Not OK -- Replace/recharge battery
    - (b) OK --
  - (2) Check for adequate continuity of wiring, Battery to Starter Motor, Figures 101 and 113.
    - (a) Not OK -- Correct wiring.

(Continued on next page)

(b) OK -- Proceed per Airesearch Maintenance Manual

F. Other start malfunctions -- refer to Airesearch Maintenance Manual.

6A EXHAUST GAS TEMPERATURE INDICATION

A. Gage does not indicate properly

(1) Check wiring, Figure 118.

(a) Not OK -- Correct wiring.

(b) OK --

(2) Check resistance of total circuit -- disconnect 1 lead from EGT Gage and measure 8 ohms resistance from disconnected lead through thermocouple circuit to lead still connected to EGT gage

(a) Not OK -- Adjust resistance by adding or subtracting wire at resistor spool Control Panel, Figure 118

(b) Not OK -- Replace gage

(3) Refer to Airesearch Maintenance Manual.

6B TACHOMETER (% RPM) INDICATION

A. Gage does not indicate properly.

(1) Check wiring, Figure 118.

(a) Not OK -- Correct wiring

(b) Not OK -- Replace gage and/or tachogenerator -- refer to Airesearch Maintenance Manual

7 BLEED AIR PNEUMATIC LOADING

A. Bleed Air light does not come on when Bleed Air switch is depressed (Indicator Light Test, Figure 107, OK)

(1) With Battery, Master, and Bleed Air switches closed (Master light on), check for 24 VDC at 95% -A2, Control Relay Box, Figure 115.

(a) Not OK --

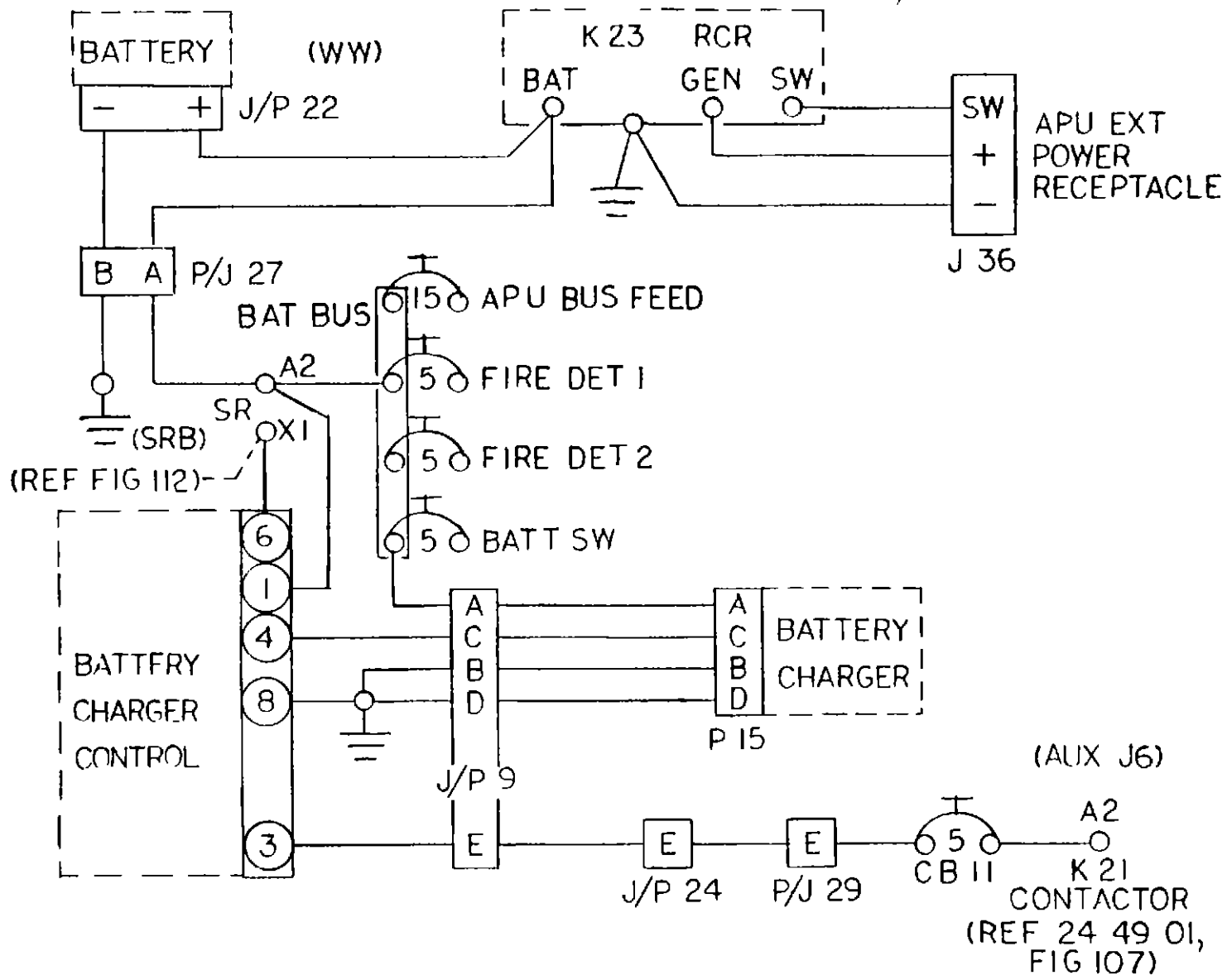
1) Check for 24 VDC at TB-31, Control Relay Box, Figure 112.

- b) OK -- Correct wiring, Overspeed Test switch to TB-34.
- (b) OK --
- (2) Hold Overspeed Test switch closed and check for 24 VDC at pneumatic solenoid valve connector plug -A, AirResearch component, APU module, Figure 117
  - (a) Not OK - Correct wiring, TB-34 to connector plug
  - (b) OK --
    - 1) Check for ground at connector plug -B.
      - a) Not OK -- Correct wiring, connector plug -B to ground
      - b) Not OK - Replace pneumatic solenoid valve
- B. High oil temperature does not shut engine down
  - (1) With Battery and Master switches closed (Master light on), check for 24 VDC at TB-31, Control Relay box, figure 116.
    - (a) Not OK -- Follow procedure 4.C(3)(a)2
    - (b) OK --
  - (2) Jumper TB-29 and 31 and check for 24 VDC at HOT-X1, Control Relay box, figure 116
    - (a) Not OK -- Correct wiring, TB-29 to HOT-X1
    - (b) OK --
  - (3) Check for Open contacts, HOT-A2 to A3, figure 112
    - (a) Not OK
      - 1) Check for ground at HOT X2
        - a) Not OK -- Correct wiring, HOT-X2 to ground
        - b) Not OK -- Replace High Oil Temp relay, Control Relay Box, Figure 116

- (b) OK -- Remove jumper TB-29 to 31.
  - 1) Wiring TB-29/31 is open - correct wiring
  - 2) High Oil Temp switch is not closing at temperature set point (Refer to 6 C (3)(a)2)a)1.) Replace High Oil Temp switch
- C. High Oil Temp light does not come on (B, above, is OK and Indicator Light Test, figure 107, is OK)
  - (1) Check continuity of diode, CR6, Control Relay box, figure 116
    - (a) Not OK -- Replace CR6
    - (b) Correct wiring, CR6, to CR29, Control Panel, Figure 116
- D. Low Oil Pressure does not shut engine down
  - (1) With Battery and Master switches closed (Master light on) check for 24 VDC at TB-31, Control Relay box, figure 116
    - (a) Not OK -- Follow procedure 4 C (3)(a)2).
    - (b) OK --
  - (2) Jumper TB-28 and 31 and check for 24 VDC at TB-30
    - (a) Not OK --
      - 1) Wiring TB-28/30 to Low Oil Press switch connector plug, APU module, figure 116, is open - correct wiring
      - 2) Normally closed contacts, Low Oil Press switch, are open (refer to 6 C.(3)(a)3)a)1.) - replace Low Oil Press switch
    - (b) OK --
  - (3) Check for 24 VDC at LOP-X1, Control Relay box, figure 116
    - (a) Not OK -- Correct wiring, TB-30 to LOP-X1
    - (b) OK --

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- (4) Check for open contacts, LOP-A2 to A3, figure 112
- (a) Not OK --
    - 1) Check for ground at LOP-X2.
      - a) Not OK -- Correct wiring, LOP-X2 to ground
      - b) OK -- Replace Low Oil Press relay, Control Relay box, figure 116.
  - (b) OK --
    - 1) Wiring, 95% -B1, Control Relay box, figure 116, to TB-28 is open - correct wiring
    - 2) Wiring, TB-31 to 95% - B2, is open - correct wiring.
    - 3) Normally open contacts, 95% - B2/B1, are not closing when engine RPM reaches 95% - check 95% relay operation, refer to function 7.B
- E. Low Oil Press does not come on (D, above, and Indicator Light Test, figure 107, is OK).
- (1) Check continuity of diode, CR5, Control Relay box, figure 116.
    - (a) Not OK -- Replace CR6
    - (b) Correct wiring, CR5, to CR27, Control Panel, Figure 116

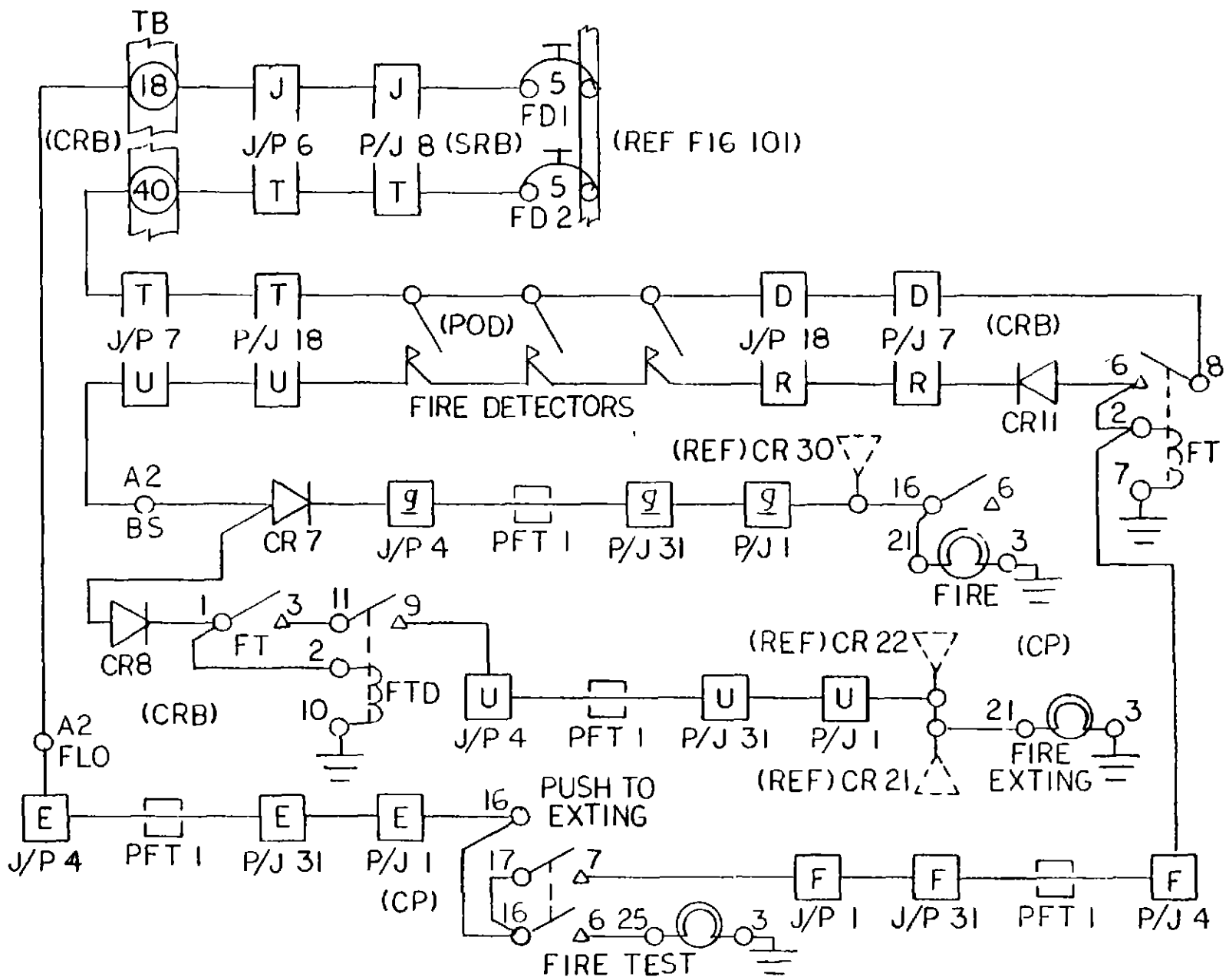


WIRE TRACE DIAGRAM  
 APU DC POWER SUPPLY  
 Figure 101

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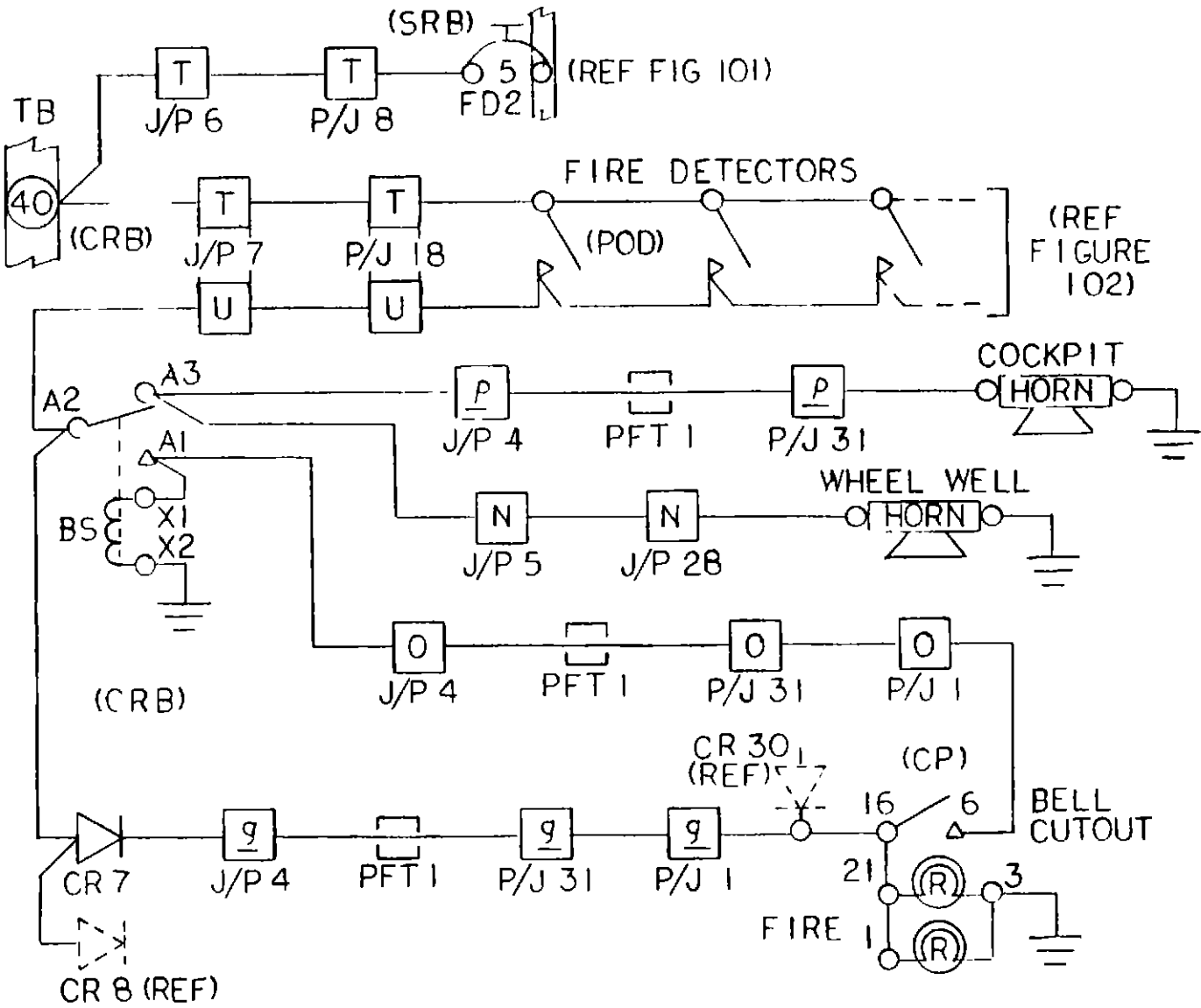
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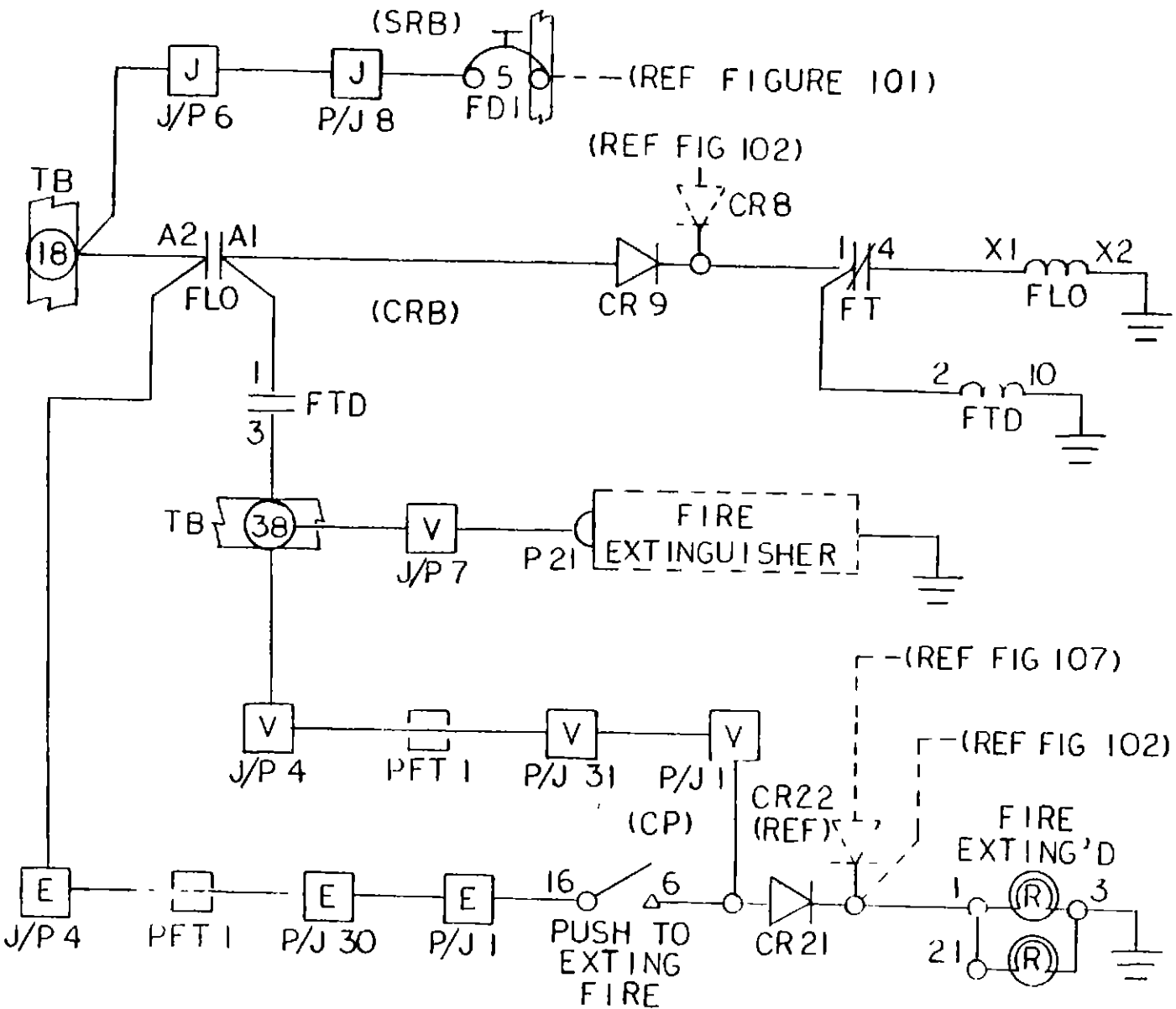
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WIRE TRACE DIAGRAM  
 APU FIRE TEST  
 Figure 102  
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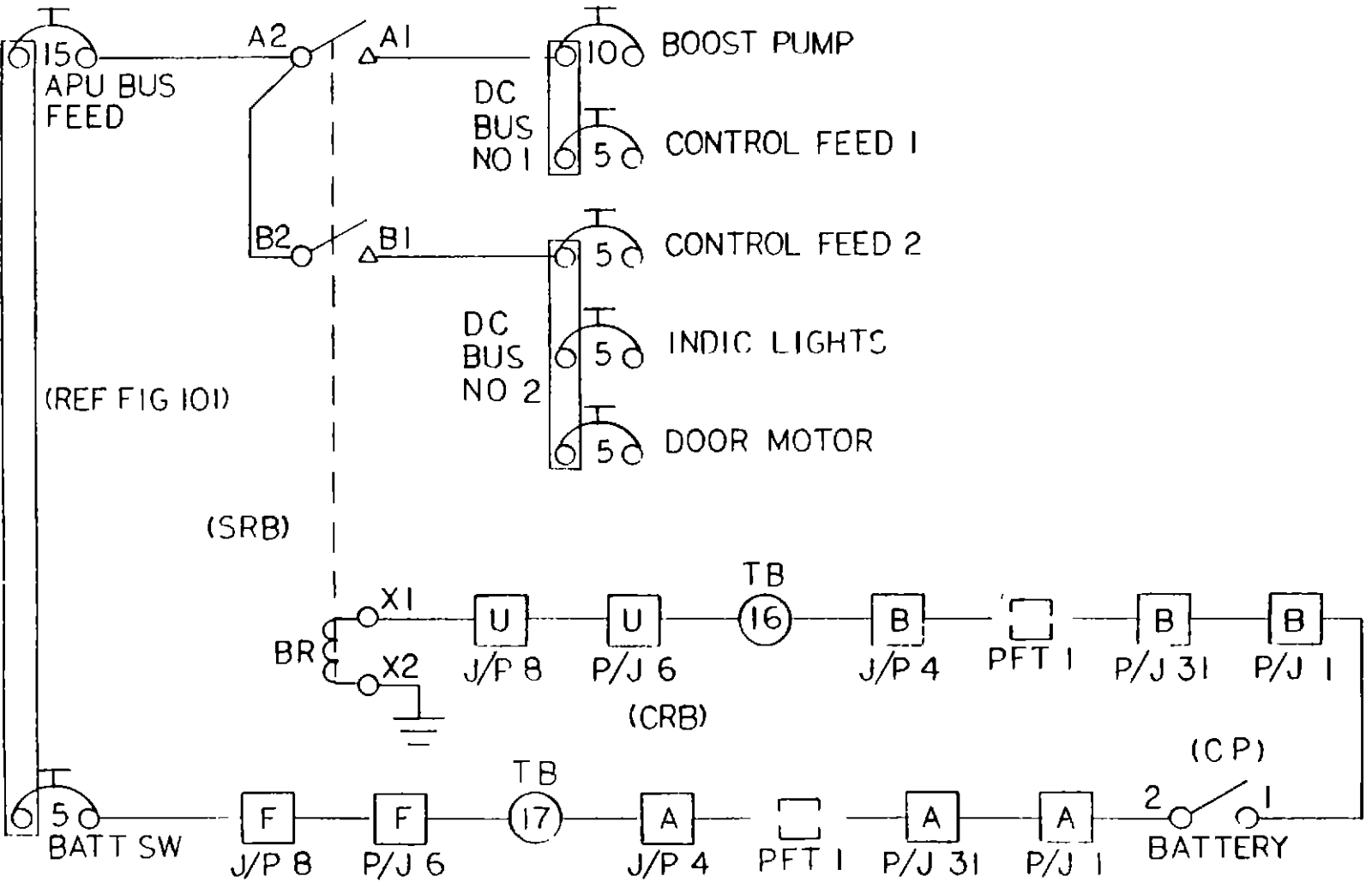
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WIRE TRACE DIAGRAM  
 APU FIRE WARNING  
 Figure 103



**WIRE TRACE DIAGRAM**  
**APU FIRE EXTINGUISHER ACTUATION**  
 Figure 104



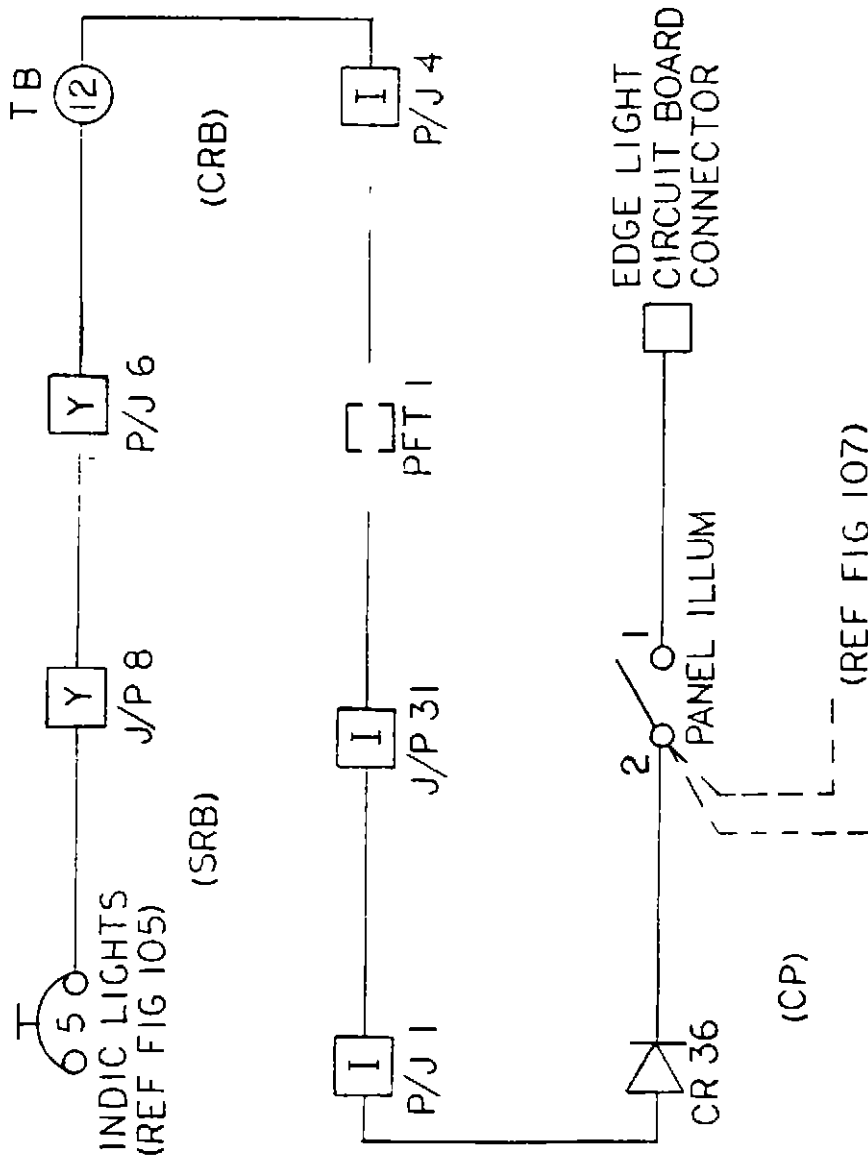
WIRE TRACE DIAGRAM  
APU BATTERY RELAY  
Figure 105

(REF FIG 101)

(SRB)

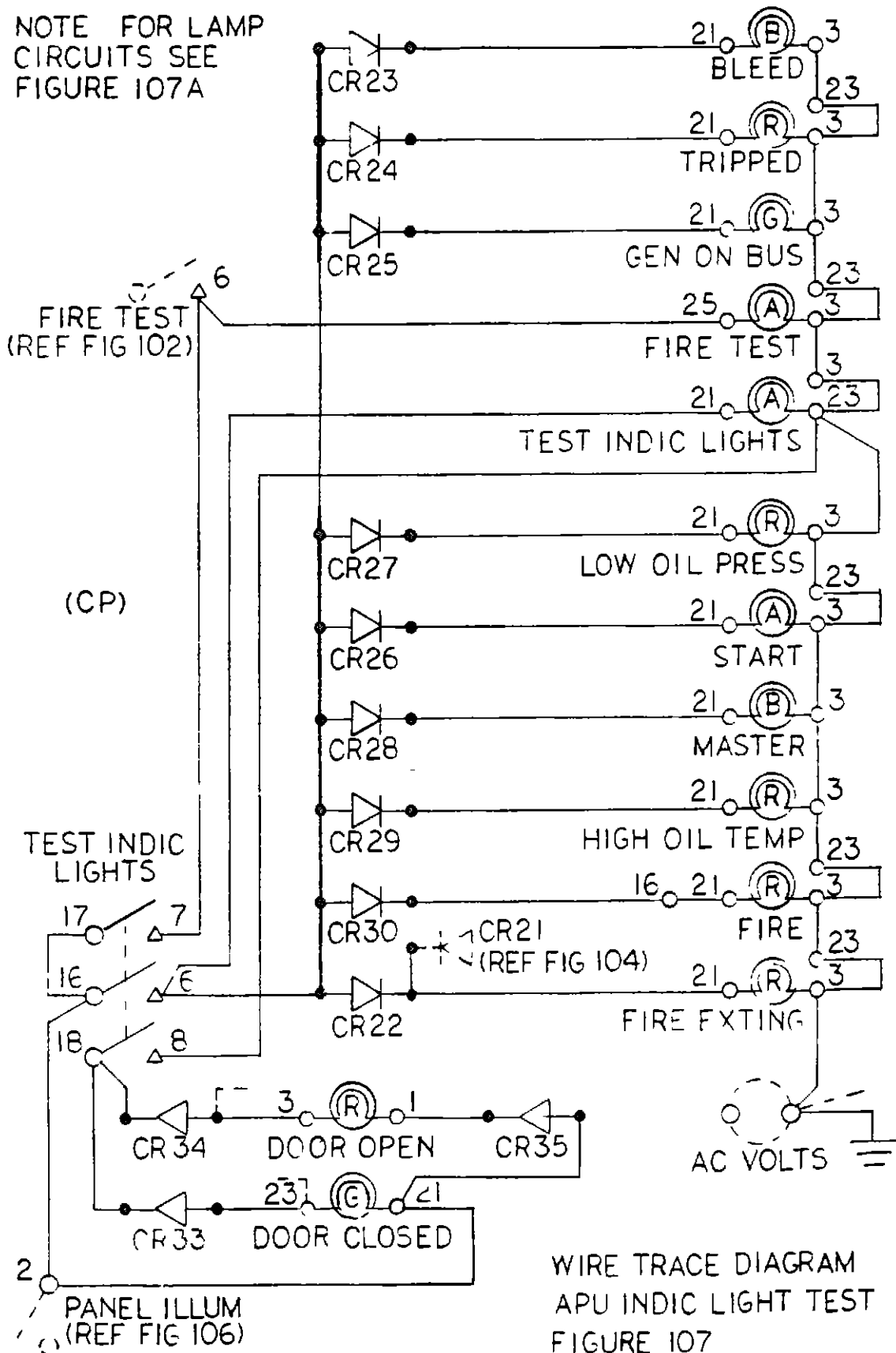
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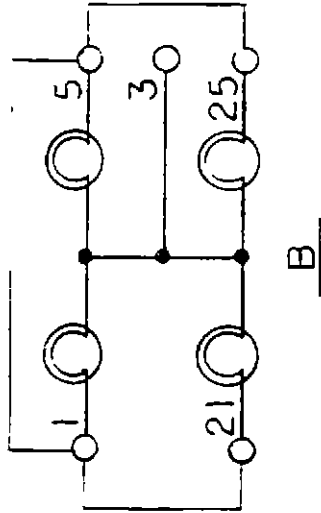
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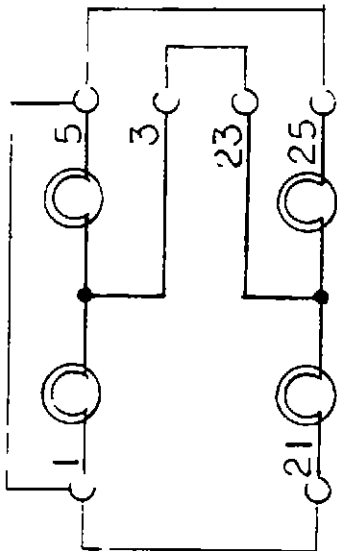
WIRE TRACE DIAGRAM  
 APU PANEL ILLUMINATION  
 Figure 106

NOTE FOR LAMP  
CIRCUITS SEE  
FIGURE 107A

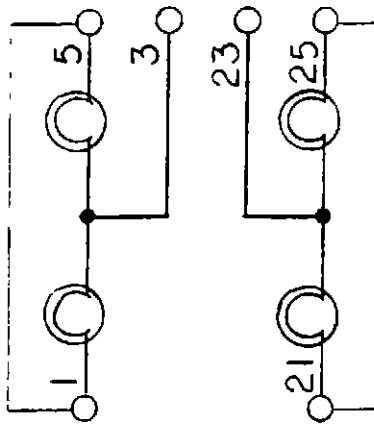




APPLICATION	
CIRCUIT	INDIC LIGHT
A	EXTING FIRE FIRE START TEST FIRE CIRCUIT TEST INDIC LIGHTS GEN TRIPPED
B	BLEED AIR GEN ON BUS HI OIL TEMP LOW OIL PRESS MASTER
C	DOOR OPEN/CLOSED

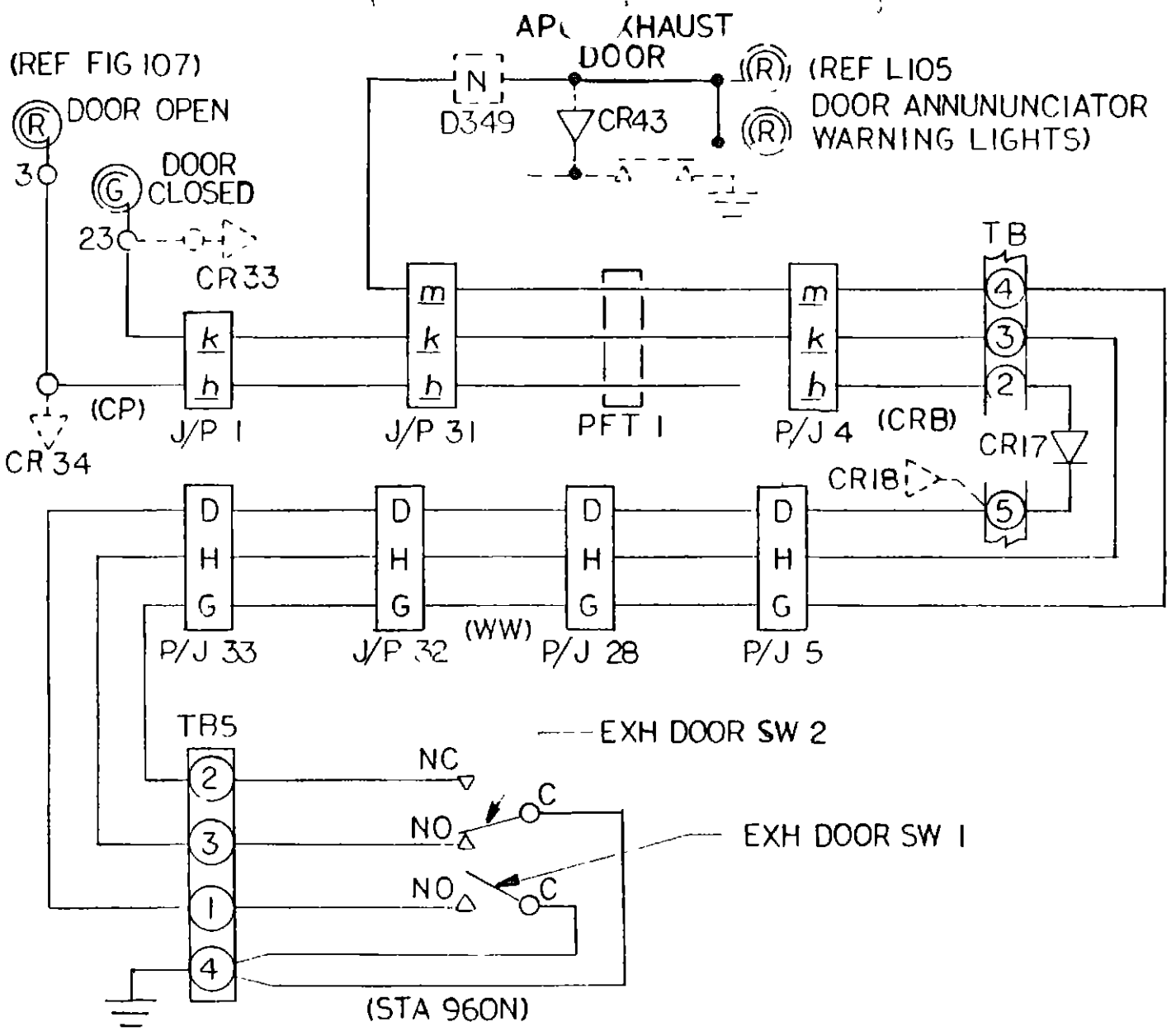


A



C

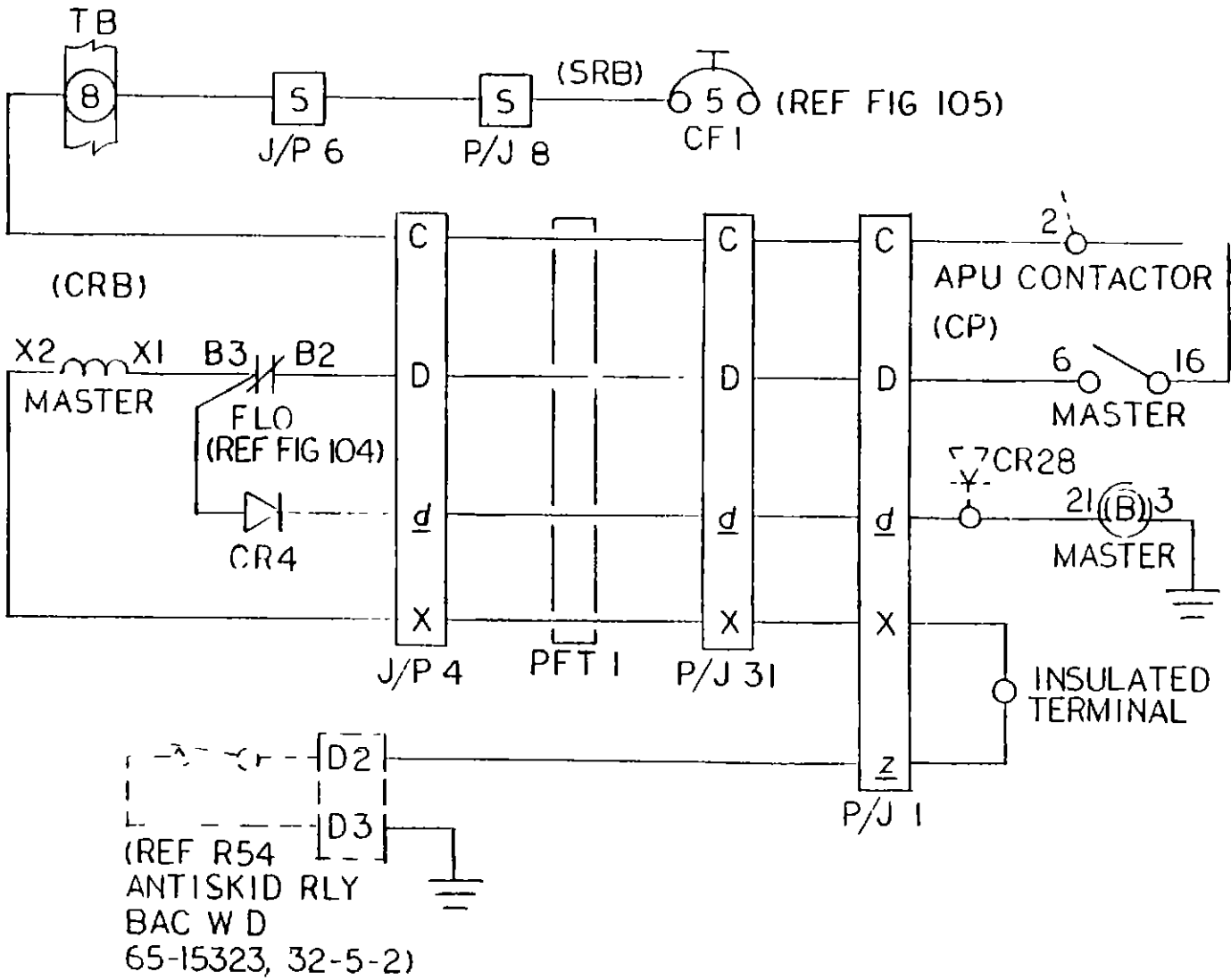
WIRE TRACE DIAGRAM  
 INDICATOR LAMP CIRCUITS  
 Figure 107A



WIRE TRACE DIAGRAM  
APU DOOR POSITION INDICATION  
Figure 108

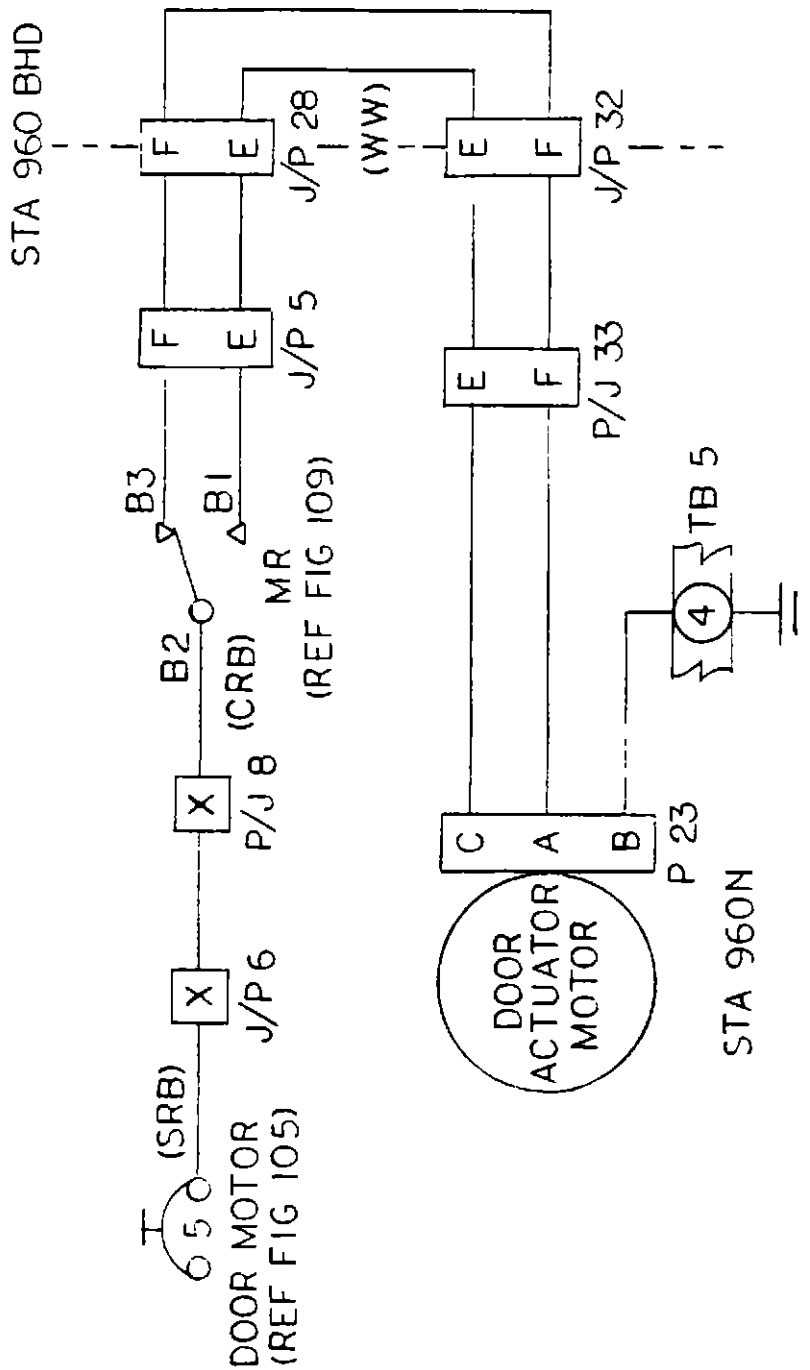
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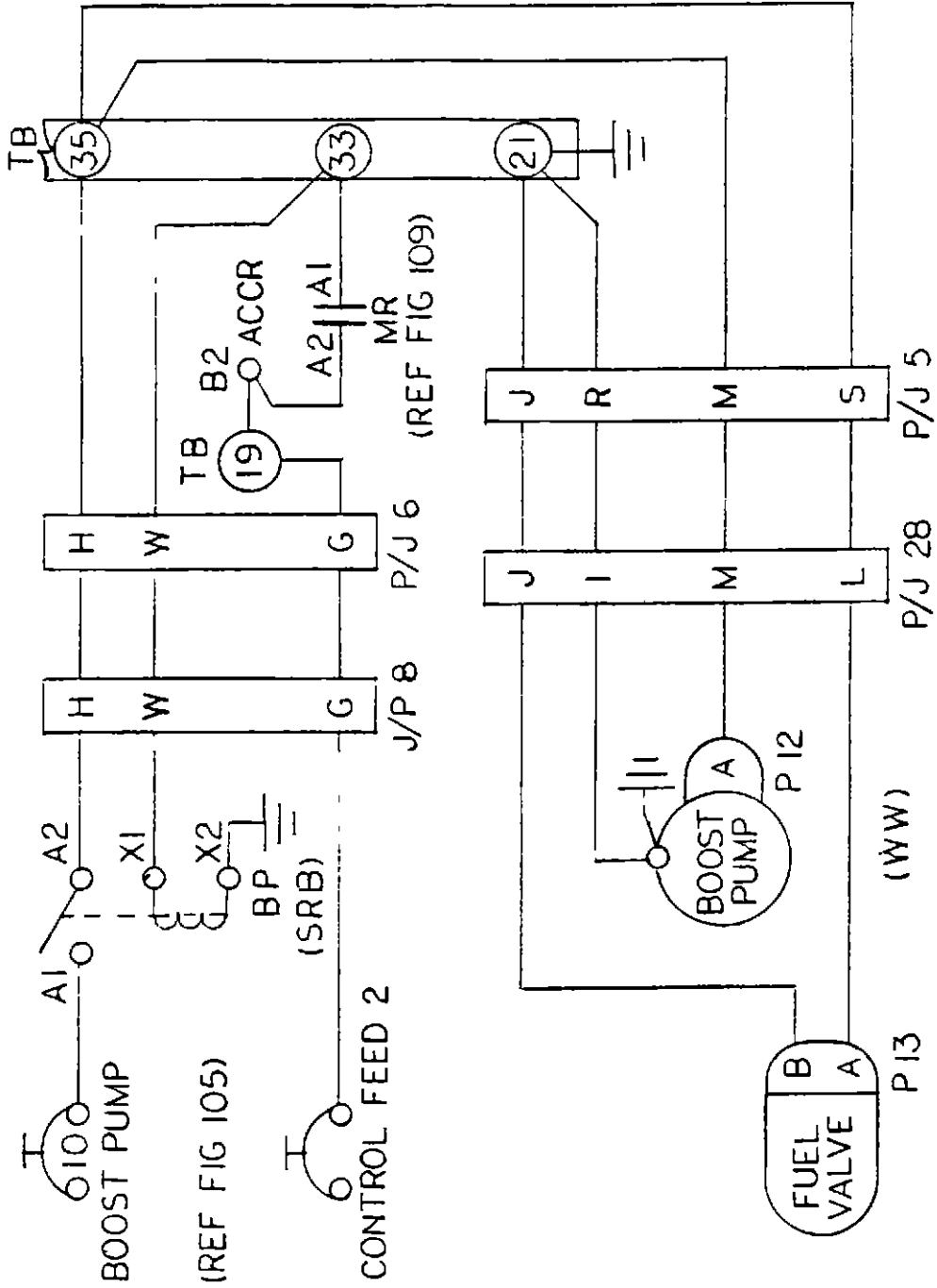


WIRE TRACE DIAGRAM  
APU MASTER SWITCH  
Figure 109

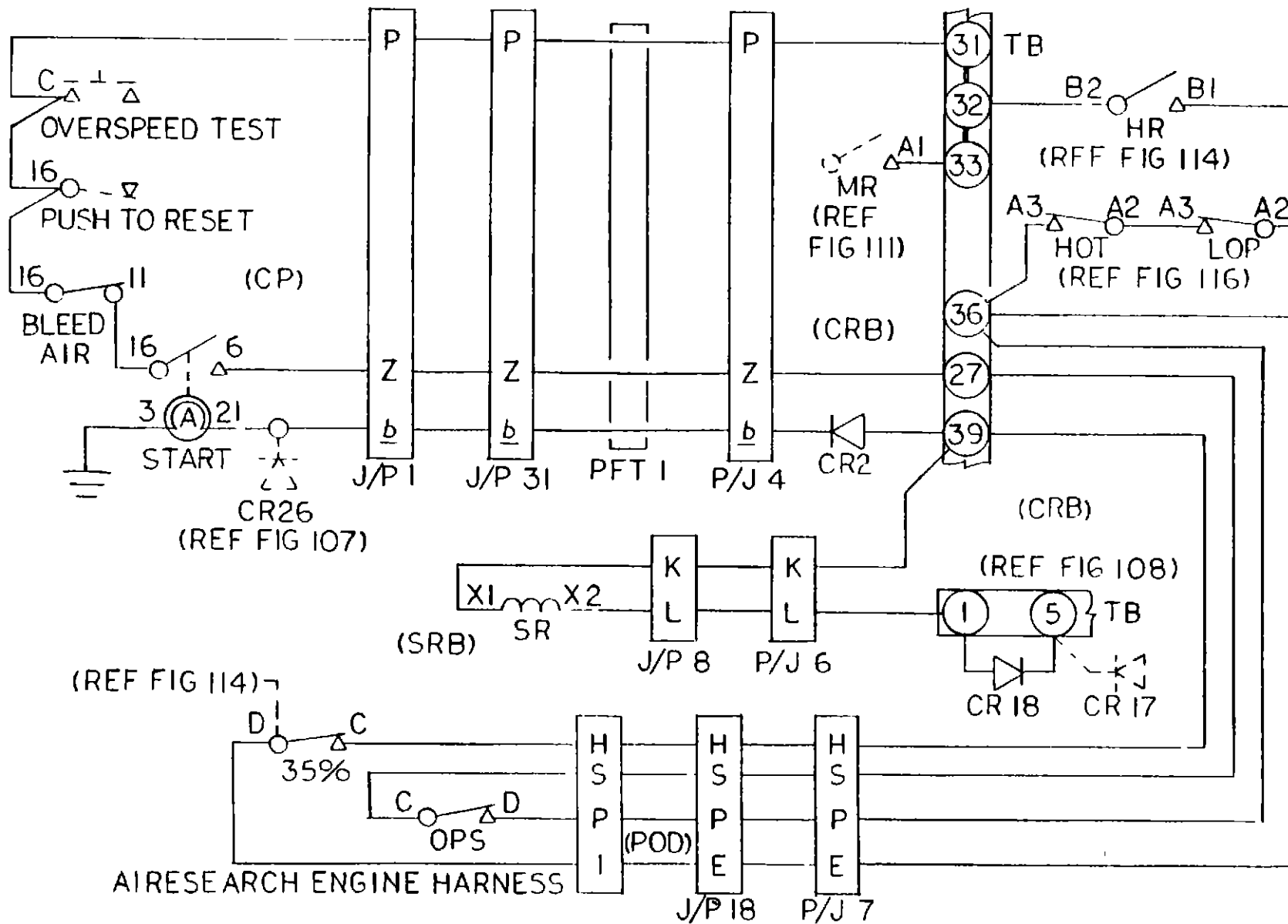
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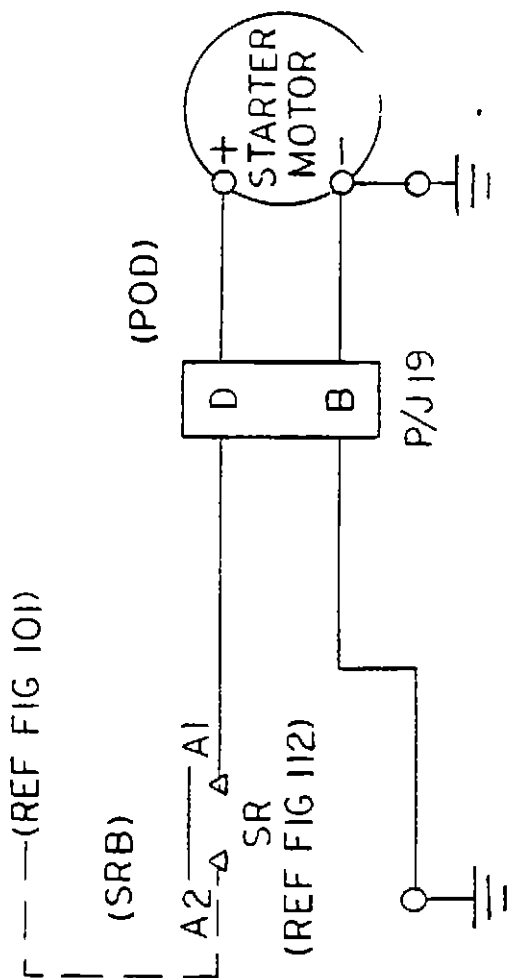


WIRE TRACE DIAGRAM  
 APU EXHAUST DOOR ACTUATOR  
 Figure 110

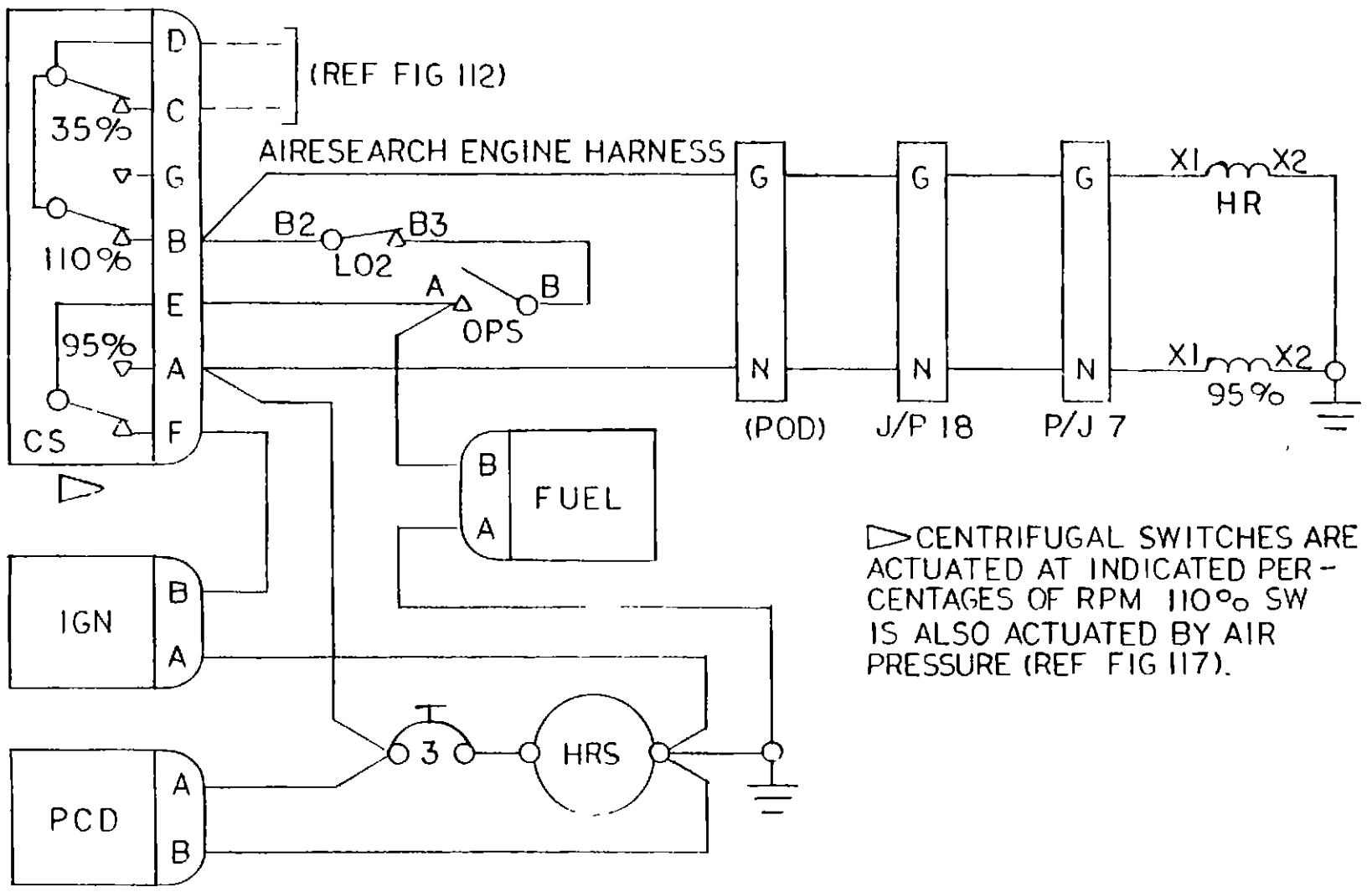


**WIRE TRACE DIAGRAM**  
**APU FUEL SUPPLY**  
**Figure 111**





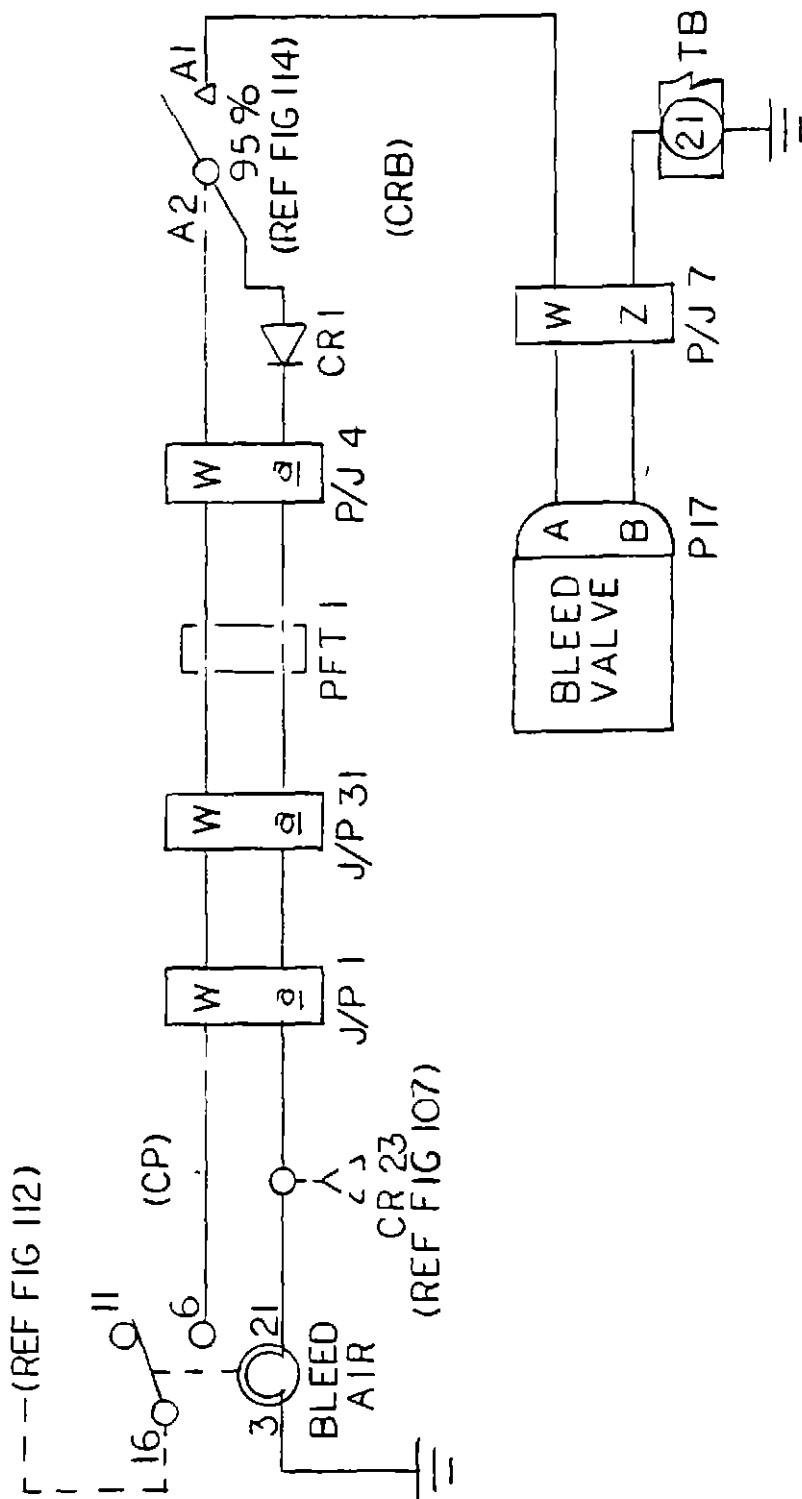
WIRE TRACE DIAGRAM  
 APU STARTER  
 Figure 113



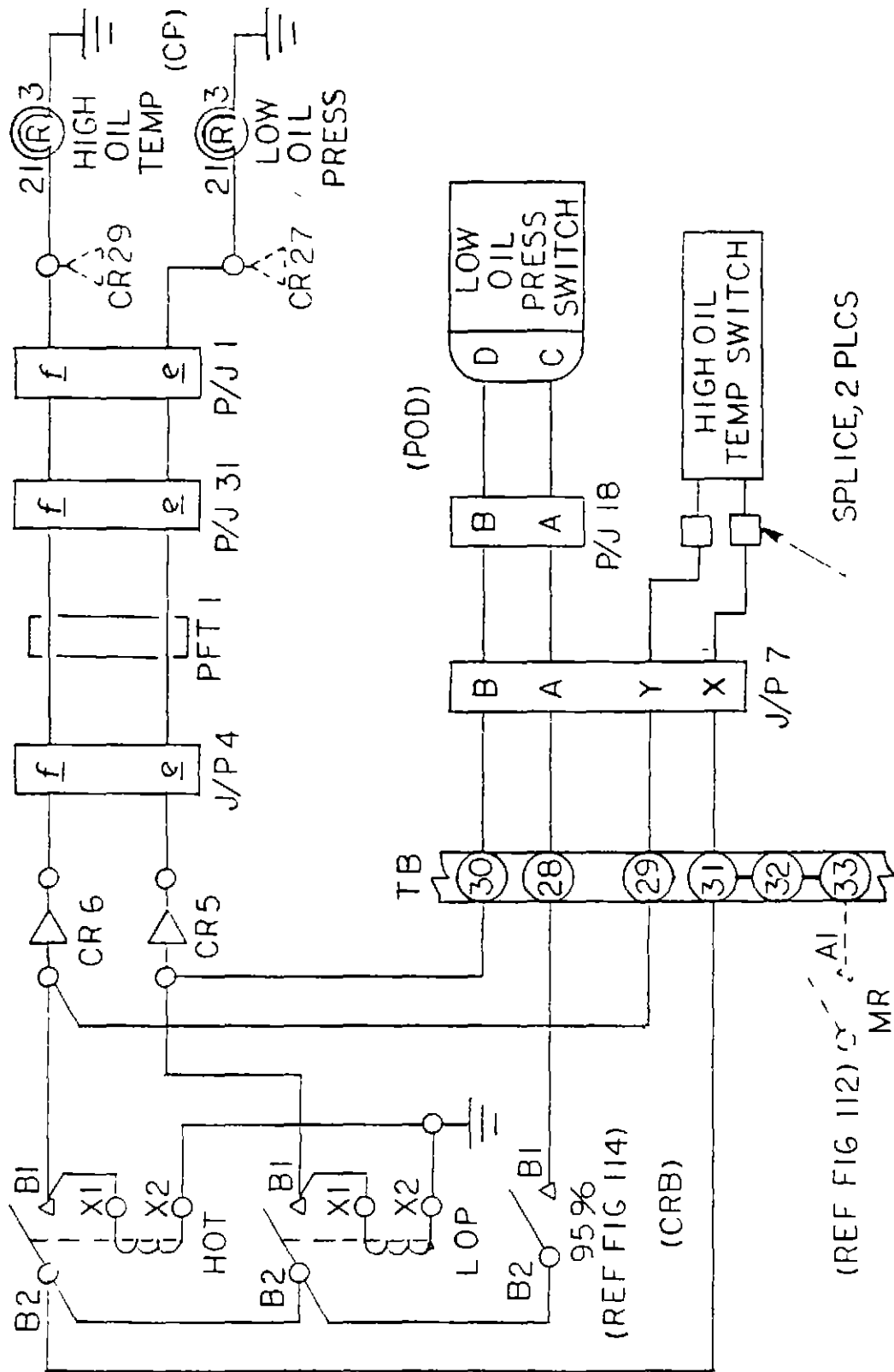
▷ CENTRIFUGAL SWITCHES ARE ACTUATED AT INDICATED PERCENTAGES OF RPM 110% SW IS ALSO ACTUATED BY AIR PRESSURE (REF FIG 117).

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WIRE TRACE DIAGRAM  
 APU SEQUENCING SWITCHES  
 Figure 114  
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WIRE TRACE DIAGRAM  
 APU BLEED VALVE  
 Figure 115

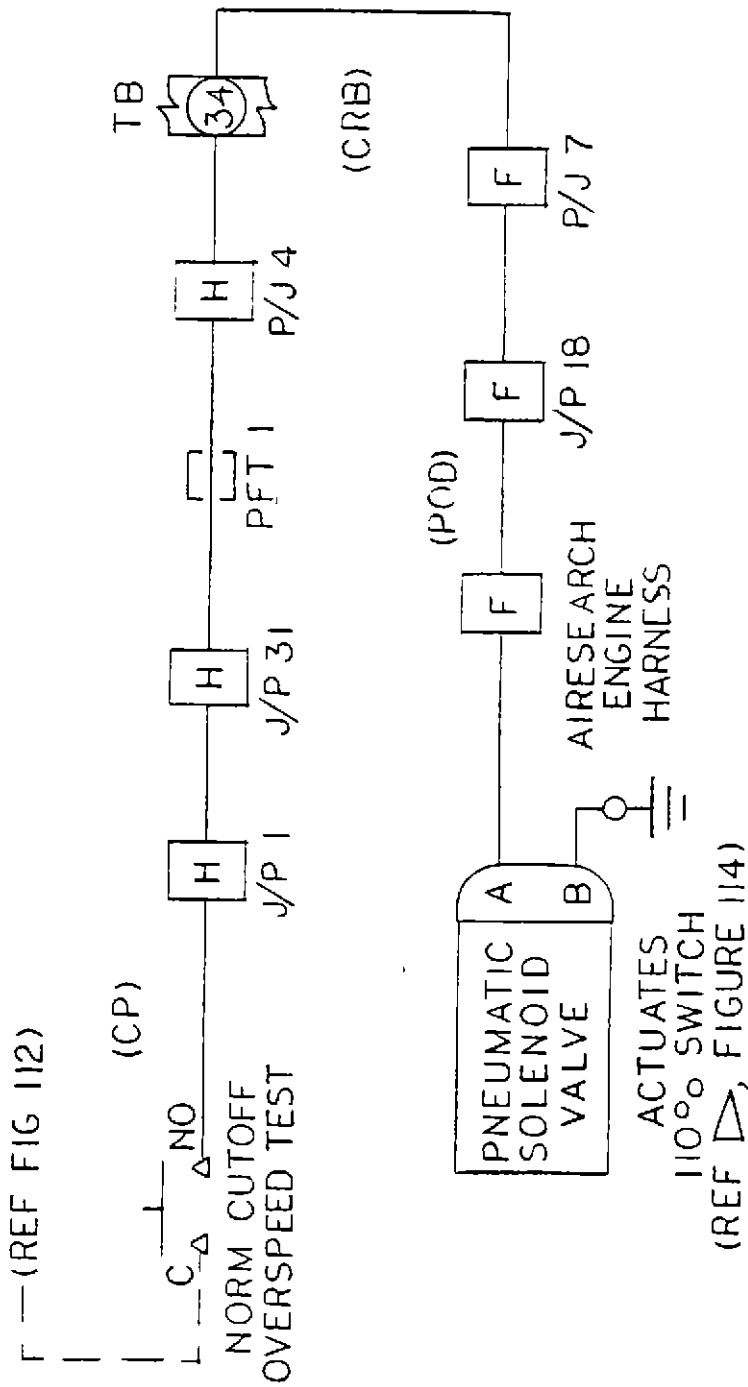


**WIRE TRACE DIAGRAM**  
**APU OIL TEMP/PRESS FAULT INDICATION**  
 Figure 116

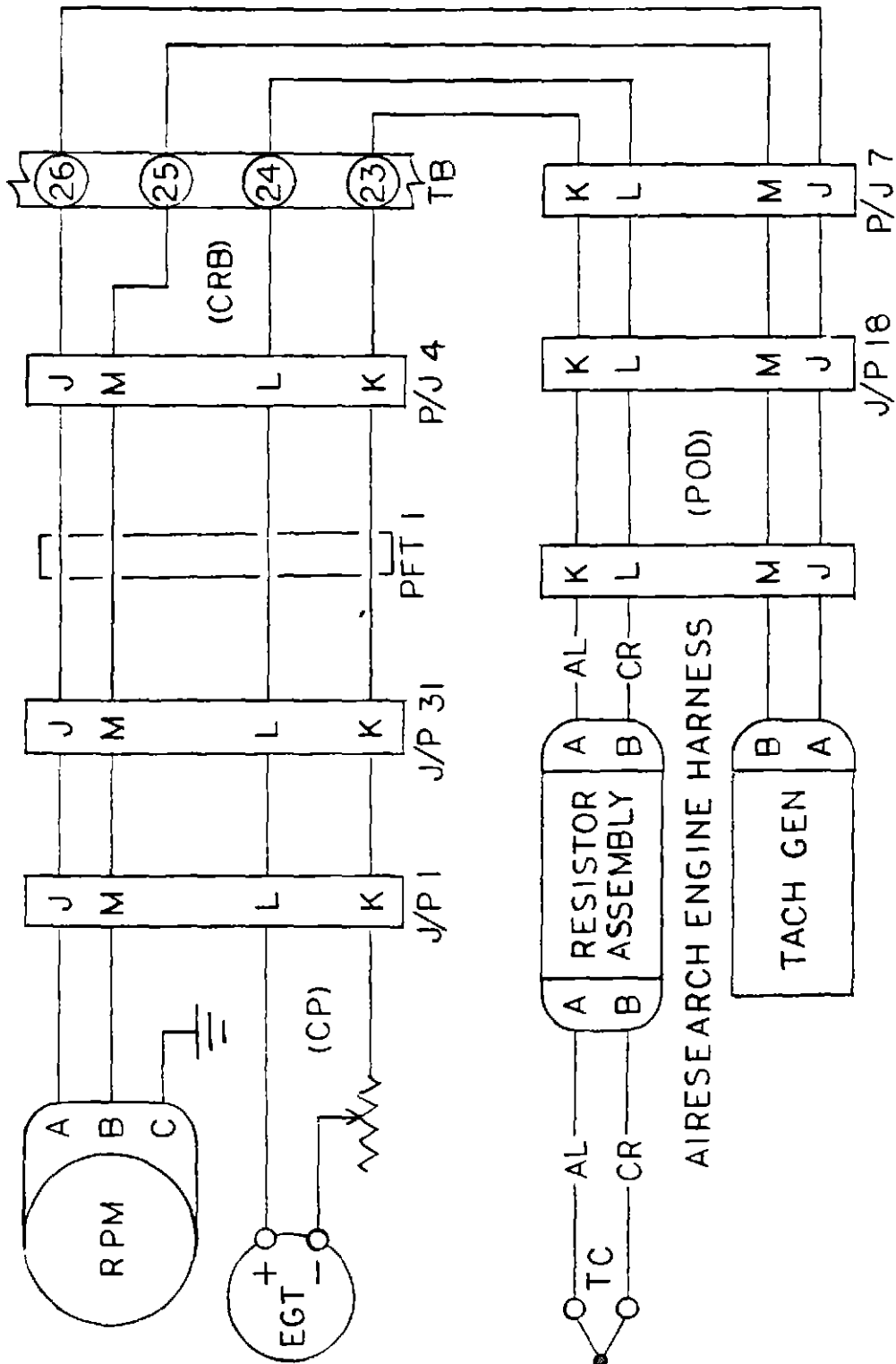
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WIRE TRACE DIAGRAM  
 APU SHUTDOWN  
 Figure 117



WIRE TRACE DIAGRAM  
 APU EXHAUST GAS TEMPERATURE  
 AND TACHOMETER INDICATION

Figure 118

TABLE 102  
 ENCLOSURES  
 IDENTIFICATION/LOCATION

<u>Abbr</u>	<u>Identification</u>	<u>Location</u>	<u>Drawing</u>	<u>Wiring Diagram</u>
AUX J6	Auxiliary Main AC Power Shield	Sta 271R		
CP	APU Control Panel	Sta 294R	90065	90065
CRB	Control Relay Box	Sta 960L	84501	84501
CXB	Current Transformer Box	Sta 960L	90516	90512
POD	APU Module	Sta 960R	84100	84504
SRB	Starter Relay Box	Sta 960L	90513	90501

TABLE 103  
 CIRCUIT BREAKERS  
 IDENTIFICATION/LOCATION

<u>Abbr /No</u>	<u>Rating (Amps)</u>	<u>Circuit</u>	<u>Location</u>
BF	15	APU Bus Feed	SRB
BP	10	Boost Pump	SRB
BS	5	Battery Switch	SRB
CB 10	5	APU AC Voltmeter	AUX J6
CB 11	5	APU Battery Charger	AUX J6
CB 12	50	APU Essential Bus Feed, ØA	AUX J6
CB 13	50	APU Essential Bus Feed, ØB	AUX J6
CB 14	50	APU Essential Bus Feed, ØC	AUX J6
CF 1	5	Control Feed 1	SRB
CF 2	5	Control Feed 2	SRB
DM	5	Door Motor	SRB
FD 1	5	Fire Detector 1	SRB
FD 2	5	Fire Detector 2	SRB
IL	5	Indicator Lights	SRB
ØA	160	APU Generator Output, ØA	CXB
ØB	160	APU Generator Output, ØB	CXB
ØC	160	APU Generator Output, ØC	CXB

  
**MAINTENANCE MANUAL**

TABLE 104  
 RELAYS  
 IDENTIFICATION/LOCATION

<u>Abbr /No.</u>	<u>Identification</u>	<u>Location</u>
ACCR	Auxiliary Contactor Control Relay	CRB
AUS	Auxiliary Underspeed	SRB
BP	Boost Pump	SRB
BR	Battery Relay	SRB
BS	Bell Silence	CRB
CS	Current Sensor	CRB
CST	Current Sensor Transfer	CRB
FLO	Fire Lockout	CRB
FT	Fire Test	CRB
FTD	Fire Time Delay	CRB
HOT	High Oil Temperature	CRB
HR	Hold Relay	CRB
LO2	Lockout Number 2	POD
LOP	Low Oil Pressure	CRB
MR	Master Relay	CRB
95%	Ninety-five Percent	CRB
OC	Overcurrent	CRB
OCTD	Overcurrent Time Delay	CRB
OCTDBP	Overcurrent Time Delay Bypass	CRB
RCR K23	Reverse Current Relay	Sta
SR	Starter Relay	SRB
K20	APU Contactor Control	AUX J6
K21	APU Contactor	AUX J6
K22	APU External Power Interlock	AUX J6
K24	APU Essential Bus	AUX J6

  
**MAINTENANCE MANUAL**

TABLE 105  
 CONNECTORS  
 IDENTIFICATION/LOCATION

P Connector Plug  
 J Connector Receptacle

<u>Number</u>	<u>Component</u>	<u>Location</u>
P/J(J/P)		
1		CP
2		
3	Differential Current Transformer	AUX J6
4		CRB
5		CRB
6		CRB
7		CRB
8		SRB
9		SRB
10		SRB
11		SRB
12	Fuel Boost Pump	WW
13	Fuel Valve	RH Fuel Jettison Mast Compartment
14	Generator Protection Panel	Sta 1000
15	Battery Charger	Sta 1000
16		
17	Bleed Valve	Sta 960M
18		POD
19		POD
20		POD
21	Fire Extinguisher	Sta 960M
22	Battery	Sta 960
23	Door Actuator Motor	Sta 960N
27	Bulkhead	Sta 960R
28	Bulkhead	Sta 960R
29	Wing Fillet (Leading Edge)	Sta 600K
30	Wing Fillet (Leading Edge)	Sta 600K
31	Wing Fillet (Leading Edge)	Sta 600K
32	Bulkhead	Sta 960
33		Sta 960N
34		CXB
35		CXB
36	APU External Power Receptacle	Sta 960NR (Fillet Frg (T/Edge)
PFT 1(2)	Pressure Feed Through, Bulkhead	Sta 960



## MAINTENANCE MANUAL

### AUXILIARY POWER UNIT - MAINTENANCE PRACTICES

#### 1. General

- A. The maintenance practices included in this section (201 through 299 page block) are general maintenance instructions that do not definitely fall within a specific category. Other maintenance instructions, such as Removal/Installation, Adjustment/Test, etc., are provided in the applicable page blocks.

#### 2. Equipment and Materials

- A. Two two gallon containers.
- B. Lubrication oil per Mil Specification MIL-L-7808 and MIL-L-23699 in accordance with Air Research Manufacturing Company of Arizona Specification GT-7800-R Rev. 6.

#### 3. APU Operation Procedure

##### A. General

- (1) Before starting the unit, all protective covers must be removed and the air inlet must be clear of all loose objects that could be ingested. Lubricating oil and fuel supply sources must be serviced, and the APU battery must be charged. It is necessary to open the main landing gear doors to perform the prestart check; after completing the check, the doors may be closed since operation of the unit does not require them to be open. Initial start of a new or completely overhauled unit must be made in accordance with procedure outlined in paragraph 3.F
- (2) The aircraft main fuel tank No. 3 must contain a minimum of 5000 pounds of fuel for the parked airplane and a minimum of 11,400 pounds of fuel for airplane taxiing conditions. For extended usage, plan an additional 275 pounds of fuel for each hour of operation.

**NOTE:** When operating the APU unattended for an extended period of time, follow Airplane Maintenance Manual (AMM) instructions regarding necessary fuel quantity based on APU fuel burn rate.

**CAUTION** DO NOT OPERATE THE APU WHEN FLAMMABLE FLUID SUCH AS A CLEANING AGENT, IS BEING USED WITHIN THE VICINITY OF THE APU IN PARTICULAR, THIS REFERS TO THE AREA NEAR THE APU COOLING AIR INLET, APU MAIN AIR INLET, AND APU EXHAUST DUCT

DO NOT, AT ANY TIME, SPRAY FLUID INTO THE APU MAIN AIR INLET OR APU COOLING AIR INLETS

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AUXILIARY POWER UNIT - MAINTENANCE PRACTICES

1. GENERAL

A. The maintenance practices included in this section (201 through 299 page block) are general maintenance instructions that do not definitely fall within a specific category. Other maintenance instructions, such as Removal/Installation, Adjustment/Test, etc., are provided in the applicable page blocks.

2. EQUIPMENT AND MATERIALS

A. Two two gallon containers.

C. Lubrication oil per Mil Specification MIL-L-7808 and MIL-L-23699 in accordance with AiResearch Manufacturing Company of Arizona Specification GT-7800-R Rev. 6.

3. APU OPERATION PROCEDURE

A. General

(1) Before starting the unit, all protective covers must be removed and the air inlet must be clear of all loose objects that could be ingested. Lubricating oil and fuel supply sources must be serviced, and the APU battery must be charged. It is necessary to open the main landing gear doors to perform the prestart check; after completing the check, the doors may be closed since operation of the unit does not require them to be open. Initial start of a new or completely overhauled unit must be made in accordance with procedure outlined in paragraph 3.F.

(2) The aircraft main fuel tank No 3 must contain a minimum of 5,000 pounds of fuel for the parked airplane and a minimum of 11,400 pounds of fuel for airplane taxiing conditions. For extended usage, plan an additional 275 pounds of fuel for each hour of operation.

CAUTION: DO NOT OPERATE THE APU WHEN FLAMMABLE FLUID SUCH AS A CLEANING AGENT, IS BEING USED WITHIN THE VICINITY OF THE APU. IN PARTICULAR, THIS REFERS TO THE AREA NEAR THE APU COOLING AIR INLET, APU MAIN AIR INLET, AND APU EXHAUST DUCT.

DO NOT, AT ANY TIME, SPRAY FLUID INTO THE APU MAIN AIR INLET OR APU COOLING AIR INLETS.

- (3) This section covers normal starting of the APU, starting of a new or overhauled unit, normal shutdown, manual fire alarm shutdown and automatic fire alarm shutdown

**B. Depreservation of APU Fuel and Oil System**

- (1) Preparing APU installation for motoring over and initial start-up
- (a) Open right hand main landing gear door and:
  - (b) Check battery is serviceable and is secure.
  - (c) Check that main APU air intake and cooling air intake are clear and free from foreign objects.
  - (d) Check all electrical connections on bulkhead 960 and fuel boost pump are secure.
  - (e) Check that overboard drains in lower surface of right hand trailing edge wing root fairing are open and free from obstruction.
  - (f) Check that aircraft fuel tank No. 3 contains minimum fuel contents. Service if necessary (Ref 3.A(2) above).
  - (g) Check APU oil system tank is full. Service as required. (Dip stick on oil tank cap.)
  - (h) Check APU module assembly is secure on its mountings and that all connected system ducts and lines are in place and secure.
  - (j) Check all electrical connections are in place and secure at the electrical control boxes on left hand side of aft face of bulkhead 960 and electrical connector panel on inboard side of APU module.
  - (k) Remove bolts securing top half of module housing and accessory end cover. Remove associated cooling air ducts and lift cover sections away from module assembly
  - (l) Disconnect 28 VDC supply connector from igniter unit.
  - (m) Disconnect fuel line from atomizer and place end of fuel line into suitable two gallon container.
  - (n) Close all APU control circuit breakers on starter control box. Leave generator circuit breakers open.

C Motoring the APU Prior to Initial Start-up

- (1) Turn on battery switch on APU cockpit control panel. Check minimum 22 volts dc available
- (2) Test APU indicating lights on APU cockpit control panel
- (3) Carry out APU fire extinguisher circuit test
- (4) Depress momentarily APU master switch to ON
- (5) Motor the APU engine by depressing the Start switch lite momentarily

CAUTION HIGH ENERGY ELECTRICAL STARTERS ARE EASILY DAMAGED. TO PREVENT DAMAGE, DO NOT EXCEED STARTER DUTY CYCLE OF ONE MINUTE "ON", FOUR MINUTES "OFF"

- (6) Continue motoring the engine, until fuel free of air bubbles is discharged into container

NOTE Clear fuel should normally appear within three motoring cycles

- (7) During cycling, ensure that oil is circulating to the engine by removing the oil line "return to tank" hose at the tank connection and placing the free end into a suitable two gallon container
- (8) Reconnect oil line "return to tank" hose when proper oil circulation has been established during the motoring over of the engine

NOTE Approximately two cups of oil is all that is necessary to be released from the oil system to establish circulation

- (9) Terminate motoring run by momentarily depressing the APU Master switch lite
- (10) Reconnect fuel line to atomizer
- (11) Reconnect oil return to tank line hose
- (12) Replenish oil system with new oil to full mark on dipstick
- (13) Open all APU control circuit breakers
- (14) Reconnect 28 volts dc supply electrical connector to igniter unit



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- (15) Close Hour Meter circuit breaker
  - (16) Re-install both the top half section and the accessory end cover, install attaching bolts and complete module assembly housing
  - (17) Re-install module cooling air duct system to accessory end cover and bulkhead 960
  - (18) Close all APU control and generator circuit breakers
- D Operation - APU - Limitations, Starting, Loading, Stopping and Emergency Procedure

WARNING · DURING OPERATION OF APU, PERSONNEL SHALL STAND CLEAR OF COMPRESSOR AIR INTAKE, HIGH TEMPERATURE EXHAUST AND PLANE OF ROTATION OF HIGH SPEED COMPRESSOR AND TURBINE.

NOTE. Switch off air bleed on APU cockpit control panel once the first main engine start has been accomplished and engine cross starts are to be initiated.

(1) Limitations - Observe the following operating limitations, see also Table 501, Chapter 49-20-01, Page 509/510

- (a) Shut down the APU if its RPM exceeds 103% for a period of more than ten seconds
- (b) Shut down the APU immediately if its RPM exceeds 108%
- (c) Exhaust temperature

Continuous operation - 620°C maximum  
Never exceed - 660°C maximum

NOTE 1 · The never exceed temperature may be exceeded during engine (APU) starting and acceleration, provided the starting provided the starting time does not exceed 30 seconds

NOTE 2 If the exhaust gas temperature (EGT) exceeds 710° during the start/acceleration cycle, shut down the APU and perform a "hot start" inspection.

NOTE 3 Maximum field altitude operation is limited to 14,000 feet

(2) Starting

NOTE 1 The following items should be checked prior to the initial APU start of the day in conjunction with the APU installation - Inspection/Check List (Ref Chapter 49-00-2, Page 601 through 605 and Table 601)

NOTE 2 If starting a new installation

All items per Para "B" 49-00-2, Page 202 and Para "C" Page 203 through item 18 Page 204, and accomplish requirements of Para E Chapter 49-00-2, Page 20

NOTE 3. If a previously run installation

Para "3" 49-00-2, Page 202 items (a) through (j).

- (a) Place the APU BATTERY switch to ON position DOOR CLOSED light illuminates (Green)
- (b) Press and hold the TEST INDIC LIGHTS switch-lite Check that all APU cockpit control panel indicator lights illuminate (Chapter 49-60-0, Figure 2) Release the switch-lite, the DOOR CLOSED light remains illuminated
- (c) Place PANEL LTS switch to ON position Check that the EDGE LIT front panel illuminates (Leave on, if required)
- (d) Press and release the TEST FIRE CIRCUIT switch-lite The TEST FIRE CIRCUIT and FIRE/HORN CUTOFF switch-lites will illuminate and the APU Fire Warning Horns (Flight Deck and Right Hand Main Undercarriage Wheel Bay) will sound After 20 seconds, the FIRE/HORN CUTOFF switch-lite will extinguish, the APU Fire Warning Horns will silence and the PUSH TO EXTING FIRE will illuminate After an additional ten seconds the PUSH TO EXTING FIRE and TEST FIRE CIRCUIT switch lites will extinguish signalling the successful completion of the test

NOTE Pressing the FIRE/HORN CUTOFF switch-lite momentarily will silence the APU Fire Warning Horns in the Flight Deck and Right Hand Main Undercarriage Wheel Bay

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(e) Press and Release the MASTER switch-lite The MASTER switch-lite will illuminate, the Exhaust Door will open, the DOOR OPEN light will illuminate on the APU Control Panel, (The APU DOOR OPEN light on the first officer's Door Annunciator panel will also illuminate when the APU Exhaust Door opens), the Fuel Supply Valve will open and the APU Fuel Boost Pump will start running

(f) Press and Release the START switch-lite

1) The START switch-lite will illuminate when the start relay is energized and will remain illuminated when the switch is released if the start relay has actuated (The start relay will not actuate until the APU Exhaust Door is fully open )

2) The START switch-lite will extinguish when the engine speed has reached approximately 35% RPM If the START switch-lite does not extinguish within 60 seconds, depress the MASTER switch-lite to de-energize the system (MASTER and START switch-lites will extinguish.)

NOTE The starter duty cycle is ONE MINUTE ON and FOUR MINUTES OFF  
A cooling period of 30 MINUTES is required after four duty cycles

(g) Monitor the PERCENT RPM indicator (tachometer) and EGT (exhaust gas temperature) until the APU reaches governed, no load, steady state speed

1) Percent RPM

Shutdown the APU if its RPM exceeds 103% for a period of more than ten seconds.

NOTE The maximum allowable momentary overshoot is 108%

2) Exhaust Temperature

Continuous Operation - 565°C maximum  
Never Exceed - 621°C maximum

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NOTE 1 The Never Exceed temperature may be exceeded during engine start and acceleration, provided the start time does not exceed 30 seconds

NOTE 2 If Exhaust Gas Temperature exceeds 710°C during the start/acceleration cycle, shutdown the APU and carry out a HOT START inspection

NOTE 3 The APU is ready to load after a one minute warm-up period

(3) APU Loading

(a) To pressurize the Aircraft Pneumatic System from the APU

1) Press and release the BLEED AIR switch-lite. The switch-lite will illuminate and the DUCT PRESSURE gauge on the Flight Engineer's upper panel will indicate a rise in duct pressure

(b) To power the Aircraft Electrical System from the APU, accomplish the following

- 1) Position the voltmeter essential power source selector (upper center Flight Engineers panel) to the APU position
- 2) Place the APU CONTACTOR switch in the CLOSE position momentarily, the GEN ON BUS light will illuminate, the switch toggle will return to center locked position, and the AMPS AC meter will indicate electrical load on the APU

NOTE To eliminate the possibility of a hung start during main engine starting with the APU, reduce the APU Electrical Load to 75 AMPS AC or LESS

If the 75 AMPS AC Load Limit is exceeded while running in air mode - (AIR BLEED ON) the APU generator will automatically trip OFF and the GEN TRIPPED switch-lite will illuminate

(4) APU Stopping

(a) Normal Procedure

- 1) Remove the Electrical and Pneumatic load from the APU and allow the APU to run at no load for at least three minutes to cool down the gas turbine engine
- 2) Depress the OVERSPEED TEST button momentarily. This will simulate an APU overspeed condition, causing the APU to shut down

CAUTION DO NOT ACTUATE THE MASTER SWITCH-LITE UNTIL THE APU HAS STOPPED ROTATING. THIS ACTION WOULD CLOSE THE APU EXHAUST DOOR AND STOP COOLING AIRFLOW THROUGH THE ENGINE AND APU HOUSING DURING ENGINE SPIN-DOWN

- 3) When the APU has stopped rotating, press and release the MASTER switch-lite to close the APU Exhaust Door and shut down the APU fuel supply system
- 4) After the APU MASTER switch-lite has been actuated (pressed) to the open position (MASTER switch-lite - extinguished) APU door closed (APU EXHAUST DOOR CLOSED LIGHT ILLUMINATED) place the APU battery switch to the OFF position

(b) Emergency Procedure

- 1) Placing the APU BATTERY switch in the OFF position will shut down the APU immediately

NOTE This emergency stopping procedure will not close the APU Exhaust Door. Therefore, when the emergency has passed, place the APU BATTERY switch in the ON position. The still latched MASTER switch-lite will illuminate again. Depress the MASTER switch lite. This will close the Exhaust Door and shut down the APU Fuel System and the MASTER switch lite will extinguish (APU Exhaust DOOR CLOSED light illuminates)

- 2) Place the APU BATTERY switch to the OFF position

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(5) Start Procedure Observations

(a) General

- 1) If light-off does not occur after 15 seconds of cranking, depress MASTER switch-lite to terminate start. Light-off is indicated by EGT rise.
- 2) If light-off occurs, but unit does not accelerate to 100 percent governed speed in 30 seconds, turn off battery switch to terminate start.
- 3) If start is aborted, observe a minimum of two minutes delay before attempting another start.
- 4) If a satisfactory start is not obtained on a second attempt, maintenance action is recommended.
- 5) If torching light off occurs, shut down per step 2) and render APU inoperative pending corrective action. For corrective action, refer to paragraph 7, Maintenance After Torching Light Off.

(b) New/Completely Overhauled APU

- 1) Perform steps (a) through (g) of Para D(2)
- 2) Allow unit to run at governed speed for five minutes under no load conditions.
- 3) Shut down APU (Ref Para D.(4)(a)2) Normal Procedure Para D(4)(b)1) Emergency Procedure )
- 4) Replace Fuel Filter element (Refer to 49-32-31, Fuel Pump and Control Unit - Servicing).
- 5) Replace Oil Filter element (Refer to 49-90-01 Oil Pump Maintenance Practices)
- 6) Adjust unit (Refer to Auxiliary Power Unit - Adjustment/ Test)

(6) Automatic Fire Shutdown

(a) General

- 1) If a false fire warning or malfunction of the automatic shutdown circuit stops the unit, the cause must be located and corrected before the unit can be restarted.

- (b) If an automatic fire shutdown occurs, the FIRE/HORN CUTOUT switch-lite will extinguish when the fire detectors cool down to a temperature below their actuating point

CAUTION REPLACEMENT APU SYSTEM AND OR COMPONENTS ENSURE THAT THE FIRE DETECTOR CIRCUIT BREAKER FDI ON STA 960 STARTER RELAY BOX HAS BEEN CYCLED OPEN/CLOSED TO DE-ACTIVATE THE SELF-LOCKING CIRCUIT OF THE FIRE LOCK OUT RELAY (FLO) BEFORE ATTEMPTING TO INSTALL REPLACEMENT UNITS AND LEAVE OPEN UNTIL ALL WORK HAS BEEN ACCOMPLISHED

(7) Maintenance After Torching Light-Off

(a) General

- 1) A torching light-off is indicated by flames emitting from the APU exhaust duct. Primary causes for torching light-off are delayed ignition and excessive fuel. Delayed ignition results in fuel-air mixture being conducted through exhaust system. When ignition finally occurs, the fuel-air mixture is ignited causing flame emission from exhaust. Excessive amount of fuel can be caused by an improperly operating fuel atomizer, fuel pump and control unit acceleration limited valve opening pressure set higher than specified, or accumulation of fuel in turbine assembly which has not had time to drain a previously unsuccessful start attempt

(b) Check ignition system.

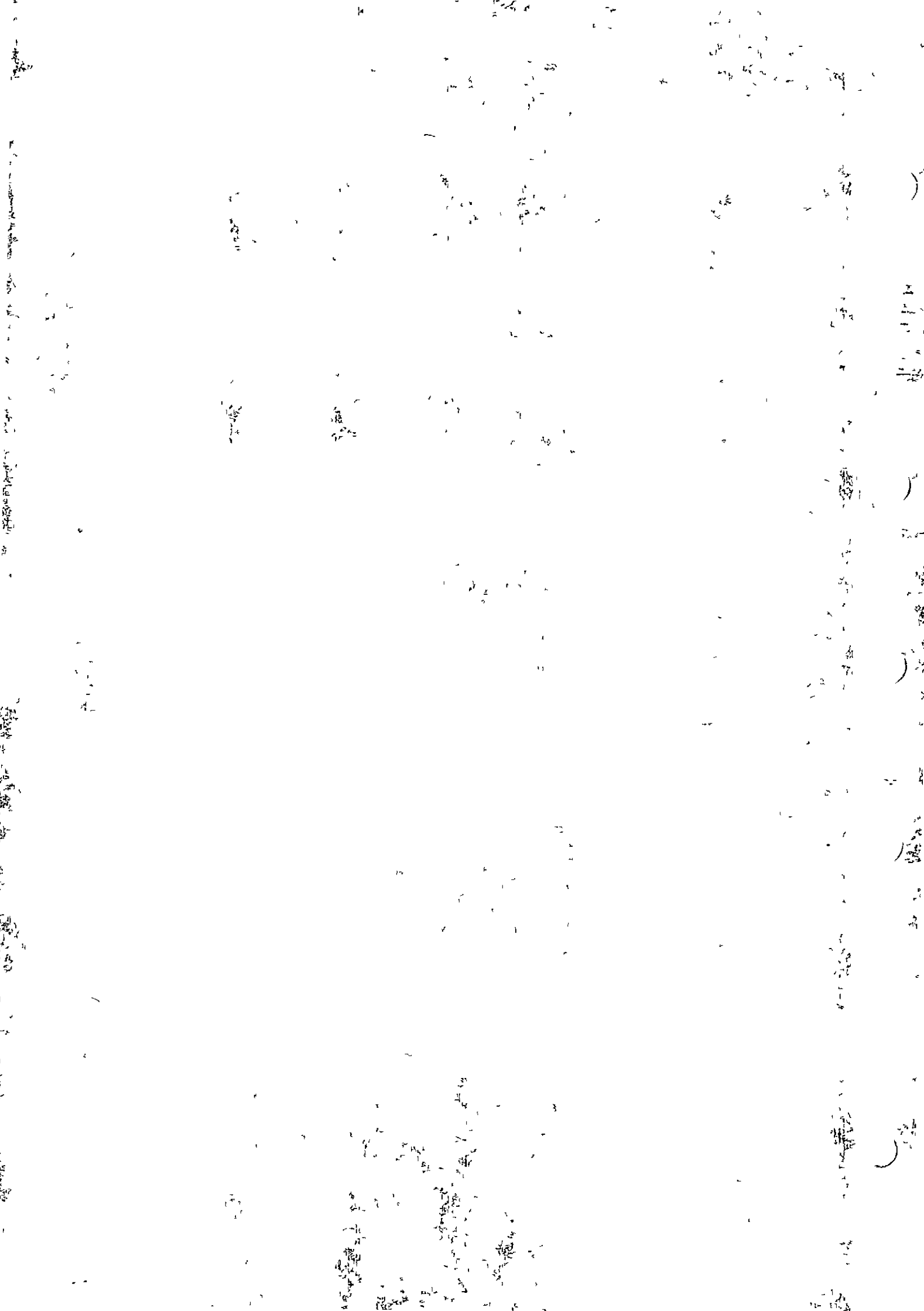
- 1) Check ignition unit power supply wiring
- 2) Check high voltage lead for serviceability.
- 3) Test igniter plug Refer to 49-40-21, Igniter Plug - Adjustment/Test.
- 4) If igniter plug test reveals improper ignition system operation, replace ignition unit

(c) Check combustion chamber liner for excessive carbon build-up Refer to 49-20-11, Combustion Chamber Liner - Inspection/Check

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(d) Test fuel system

- 1) Test fuel pump and control unit acceleration limiter valve opening pressure Refer to 49-32-31, Fuel Pump and Control Unit - Adjustment/Test.
- 2) Replace fuel atomizer, Refer to 49-32-31, Fuel Atomizer - Removal/Installation



APU INSTALLATION - INSPECTION/CHECK

1. GENERAL

A general inspection for leakage at fittings, security of component part attachment, chafing of wiring harness and obstructions at inlet and exhaust areas shall be made at each inspection interval. Inspect all tubes for chafing, cracks, signs of corrosion, or other damage

2. PERIODIC INSPECTION

A. Accomplish Inspections on Installed Engine (APU)

- (1) Components listed in Table 601 shall be checked periodically at specified intervals. The periodic inspection interval should not be increased unless a program consisting of an incremental increase (100 to 150 APU hour increments) on a sampling basis is undertaken by the individual operator to substantiate that an increase in time between inspection intervals would not adversely affect the APU.

NOTE: Oil system drain/refill and oil filter removal/replacement shall not exceed 700 APU hours maximum unless specific approval has been granted in writing by A1Research. This limit is not an absolute maximum and may be increased on an individual airline basis when justified by A1Research oil sampling program and operational experience.

- (2) Components listed in Table 601 and marked by an asterisk may be inspected by observation through the combustion chamber liner assembly opening in the turbine plenum assembly (combustor unit removed) and up the exhaust pipe, to the extent that the parts are visible. Inspect components to the inspection criteria outlined in 49-20-04, COMBUSTION AND EXHAUST SECTION, as applicable. If distress is observed, the engine shall be removed from the installation and a detailed inspection of all hot end section components (Table 601) accomplished (Refer to Paragraph B.)

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Table 601. Periodic Inspection Requirements

Components	Interval (APU Hrs)	Nature of Inspection
<u>Engine (hot) Section</u>		
<p><b>NOTE</b> Manufacturer recommends that the combustor unit consisting of a liner assembly, combustor cap, fuel atomizer assembly and igniter plug, be removed and re-installed as a unit.</p>		
Combustor Unit	250	Remove and replace (Refer to 49-20-11).
Containment Ring	250	Check containment ring attaching washers for fretting. Replace attaching nuts and washers if fretting of washers exceed 50 percent of the washer thickness. (Refer to Heavy Maintenance Section of AIRsearch Engine Overhaul Manual, Report No. 49-20-37 for replacement of nuts and washers.)
*Exhaust Pipe Assembly	800	Check for cracks. (Refer to 49-20-04.)
Exhaust Flange Assembly	800	Check for cracks. (Refer to 49-20-04.)
Oil Tank Vent Tube Assembly and Fitting	250	Check that tube assembly and fitting are not obstructed. (Refer to 49-20-04.)
Turbine Plenum Gasket	250	Check for evidence of deterioration or leakage.
Turbine Plenum Assembly	250	Check for cracks. (Refer to 49-20-04.)
*Turbine Nozzle	250	Check for cracks, wear, deformation or erosion. (Refer to 49-20-04.)
*Turbine Wheel	250	Inspect for cracks, erosion, and blade tip rubbing. (Refer to 49-20-04.)

\*These components may be inspected by observation through combustor unit opening and up exhaust flange assembly. If distress is observed, remove engine from installation and perform detailed hot section inspection. (Refer to Paragraph B.)

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Table 601 Periodic Inspection Requirements (cont)

Component	Interval (APU Hrs)	Nature of Inspection
<u>Engine Fuel and Control Section</u>		
Fuel Control Unit	800	Check cracking pressure. Refer to ADJUSTMENT/TEST.)
	250	Check that acceleration limiter valve orifice is not obstructed. (Refer to 49-32-31)
	2500	Lubricate drive shaft. (Refer to 49-32-31.)
Fuel Filter Element	250	Remove and replace. (Refer to 49-32-31 )
Turbine Plenum Drain	250	Clean and Inspect
<u>Ignition/Starting Section</u>		
Electrical Engine Starter	1000- 1250	Remove and replace. Send removed starter to authorized overhaul facility for brush change, clutch check and run-in or complete overhaul. (Refer to 49-40-52 )
<u>Air Section</u>		
Air Pressure Regulator	250	Remove and clean. (Refer to Air-Research Maintenance Manual, Report No. 49-20-36, Sect. 49-50-07.)
Orificed Tee Assembly	1000- 1250	Clean. (Refer to CLEANING/PAINTING.)
<u>Control Section</u>		
Pneumatic (Load Control) Thermostat	250	Check calibration. Refer to ADJUSTMENT/TEST.)
<u>Oil Section</u>		
Lubrication Oil System	700	Drain and refill. (Refer to SERVICING.)
Oil Filter Element	250	Remove, clean and inspect. (Refer to 49-90-01)

2. B. Inspection of Removed Engine (APU)

- (1) A detailed inspection of the hot section components (Table 601) should be accomplished during a convenience removal of the APU at a time approximating the midpoint of the established TBO, but not to exceed 2500 APU hours. The 2500 APU Hours inspection time requirement should not be increased unless a program consisting of an incremental increase (500 to 750 APU hour increments) on a sampling basis is undertaken by the individual operator to substantiate that an increase in time would not adversely affect the APU.
- (2) During this inspection, the removal (except turbine wheel and exducer) and detailed inspection of hot section components (Table 601) is recommended. Refer to Heavy Maintenance Section of Overhaul Manual for inspection of hot section components
- (3) Hot section components not meeting inspection requirements shall be repaired or replaced prior to reuse.

3. HOT START INSPECTION

A Perform Hot Start Inspection

- (1) Remove Combustor Unit. (Refer to 49-20-11.)
- (2) Visually inspect the following hot section components to the extent that the components are visible through the combustor unit opening in the turbine plenum assembly. Use normally available equipment, i.e., light, mirror, fiber optics, etc., for the inspection. Inspect for evidence of distress per Air-Research Engine Overhaul Manual Report No. 49-20-37 as delineated in the Heavy Maintenance Section. If no distress is indicated, the APU may continue in service; if distress is indicated, the APU should be removed for overhaul.
  - (a) Turbine Wheel blade tips for erosion/burning.
  - (b) Turbine Wheel blades for erosion/rubbing.
  - (c) Turbine nozzle guide vanes for erosion.
  - (d) Turbine torus assembly for erosion.
- (3) Install replacement combustor unit. (Refer to 49-20-11.)
- (4) Replace fuel control unit. (Refer to 49-32-31.)



## MAINTENANCE MANUAL

- (5) Check calibration of pneumatic thermostat. (Refer to ADJUSTMENT/TEST.)
- (6) Check turbine plenum drain for obstructions.
- (7) Check APU battery voltage (22 volts DC minimum, 26 volts DC minimum with charger connected).



## AUXILIARY POWER UNIT INSTALLATION

### DESCRIPTION AND OPERATION

EFFECTIVITY RTCA LX-N1997 LX-N20000

#### 1 GENERAL

- A. The Auxiliary Power Unit (APU) installation provides pneumatic and AC electric power to the airplane systems during ground operations and makes the airplane independent of ground support equipment. The installation is certified for ground use only and the APU must be shut down prior to the start of takeoff. The installation consists of an APU powerplant module, inlet air and exhaust ducting, fuel supply system, battery charging system (see Chapter 24), a fire protection system (see 49-00-27), transport system for moving the module into or out of the cargo compartment, plus the necessary components to connect the APU output to the airplane pneumatic and AC electrical distribution systems. An individual control panel at the flight engineer's station provides for the start, stop, and loading of the APU.
- B. The APU powerplant module is located in the forward section of the aft baggage compartment, right of the airplane centerline. The APU powerplant module consists of a gas turbine and a turbine-driven AC generator, together with controls and mountings enclosed within an insulated stainless steel housing for safe and continuous ground operation. The gas turbine compressor bleed system is connected to the airplane pneumatic system and supplies pneumatic power for main engine starting and airplane airconditioning. Refer to 49-00-37, APU Pneumatic Interface. The AC generator supplies electrical power to energize the aircraft's electrical system. (Refer to Chapter 24-00-00) Engine compressor Inlet and Accessory cooling air is drawn from the right hand Main Landing Gear well through the bulkhead Sta 960 and ducted separately to the module housing. The inlets are screened to prevent the ingestion of possibly damaging material by the engine turbine and accessory cooling blower. With the main landing gear door closed the wheelwell serves as a muffler to subdue external noises associated with the gas turbine engine and cooling inlets.
- C. APU turbine exhaust gases are ducted overboard through the right wing-to-body fairing. The exhaust duct assembly consists of an inner and outer duct. The hot turbine exhaust gases pass through the inner section of the duct assembly and through an eductor prior to exhausting overboard. The eductor draws accessory cooling air from the module housing through the annular section between the outer and inner duct. The cooler air from the module housing passing through the annular section serves as insulation to reduce the temperature of the exhaust duct surface and when mixed with the turbine gases downstream of the eductor, and serves to reduce the total temperature of the exhaust gases. An exhaust gas door provides an aerodynamically clean closure over the exhaust exit and prevents the entry of foreign material into the APU engine when it is not operating.



## AUXILIARY POWER UNIT INSTALLATION

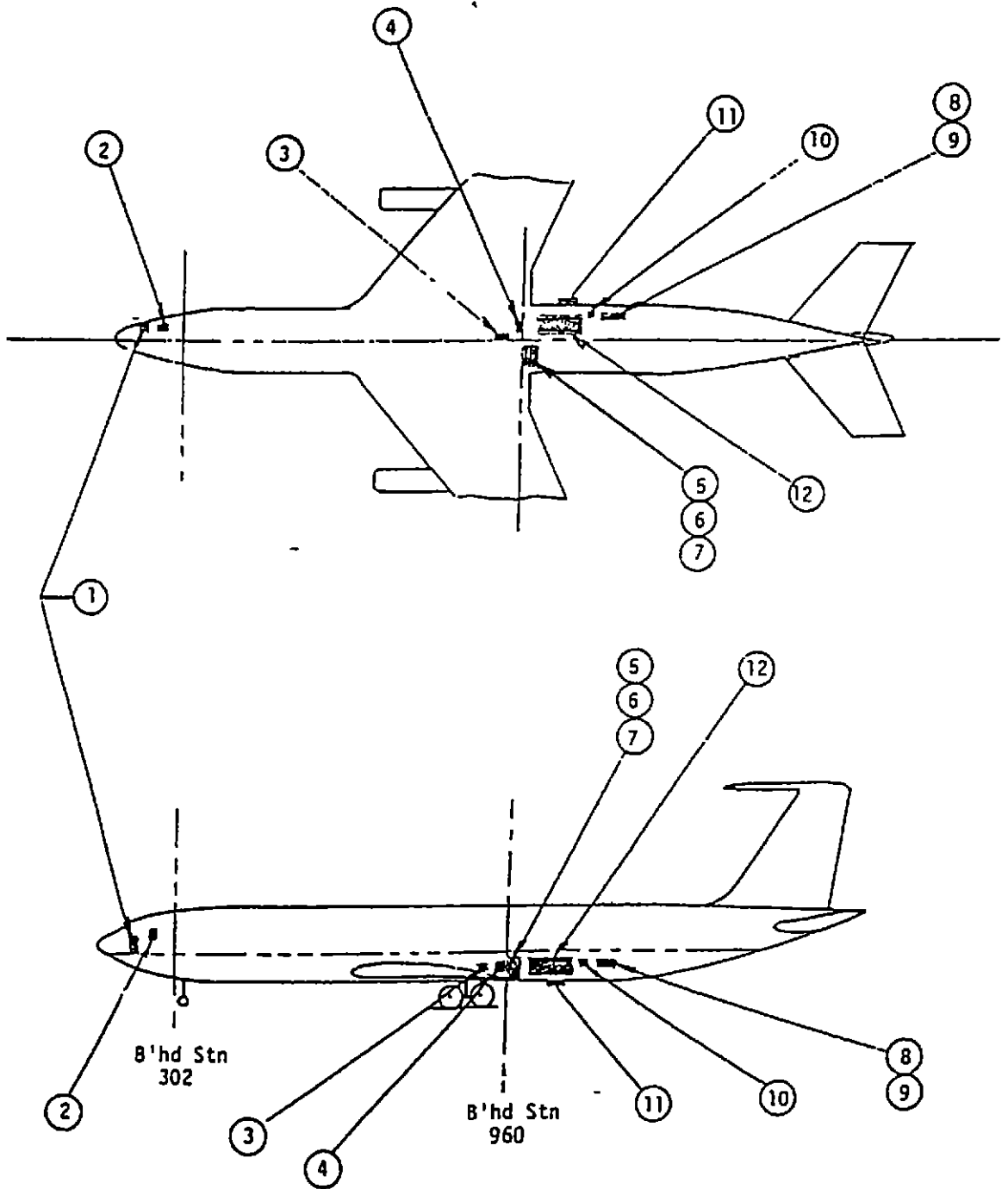
### DESCRIPTION AND OPERATION (CONTINUED)

- D Operation and control of the APU is completely automatic through the ignition/starting and engine fuel and control systems provided in the gas turbine engine installation. With the APU battery switch in the ON position and the APU master switch in the ON position, depressing the START switch-lite momentarily will initiate a series of automatically controlled operations to start the APU engine quickly and safely. After running at governed, no load, speed for one minute, pneumatic or electrical power may be obtained by actuating the appropriate controls. If electrical power is being used in conjunction with pneumatic power, the amount of shaft horsepower available driving the generator will be governed automatically to maintain a safe exhaust gas temperature. Therefore, if maximum pneumatic power is required, such as for a main engine start, the electrical load must be reduced to provide a priority to the pneumatic load (Refer to Chapter 49-00-3, Sub-chapter D Operation - APU Loading, Item (3) (b) and notes Page 207). After the electrical and pneumatic loads have been removed for three minutes, the APU is shut down by depressing the OVERSPEED TEST switch momentarily and opening the master relay by depressing the MASTER SWITCH-LITE.
- E The APU battery charging circuit is self-regulating and connected directly to the aircraft synchronizing bus. The APU battery will be on charge, as required, at all times that power is available at the synchronizing bus.
- F The transport system provides a means for moving the APU module from the cargo door to the installed position in the forward section of the aft cargo compartment. The system consists of a track section attached to the compartment ceiling and a trolley assembly for lifting and moving the module to and from the door.

#### 2 APU MODULE

- A The APU module consists of a gas turbine engine, AC generator, engine mounted accessories, and necessary wiring and plumbing enclosed in a pressure-tight housing.
- B The APU gas turbine engine provides mechanical shaft power for driving the generator and provides pneumatic bleed-air power for starting the main engines and for cabin airconditioning during airplane ground operations. The AC generator mounts on an engine accessory pad and is directly driven through the accessory gear train.
- C The APU module housing consists of four sections to provide access to the turbine engine and its accessories for normal line maintenance procedures. The housing is insulated to muffle the APU operating noise, to reduce the heat load imposed on the airplane airconditioning system when the APU is operating, and to protect the airplane and equipment if an APU fire should occur. The housing provides quick-disconnects for all fluid lines, air and exhaust ducts, electrical cables and wiring to expedite the removal and installation of the module.

Ref. MM STEWARD-DAVIS



**FIGURE 1**  
**APU COMPONENT LOCATION**



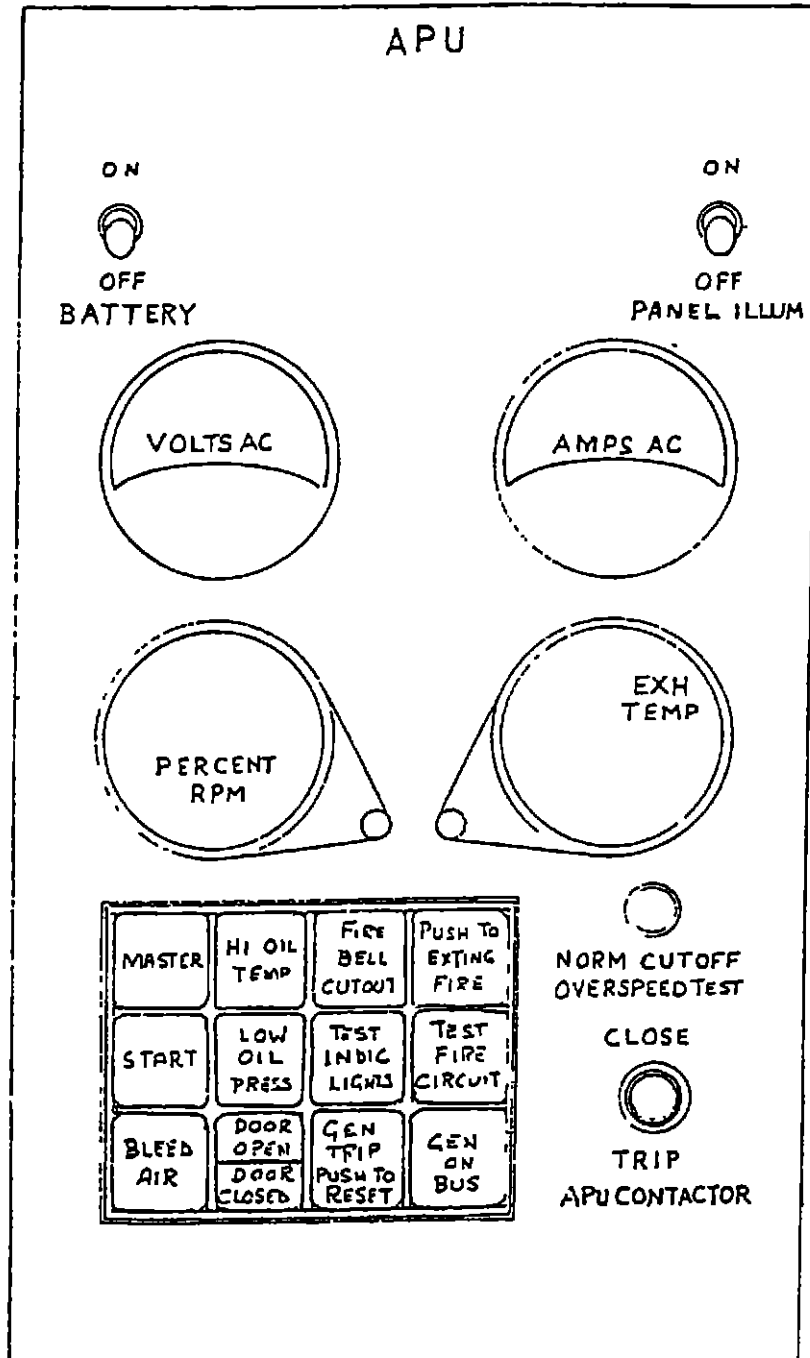
MAINTENANCE MANUAL

KEY TO FIGURE 1

- 1 AUX A C POWER SHIELD (AUX J6) STN 240
- 2 APU COCKPIT CONTROL PANEL
- 3 APU FUEL PANEL
- 4 APU BATTERY
- 5 STARTER RELAY BOX
- 6 CONTROL RELAY BOX
- 7 CURRENT XFMR BOX
- 8 GENERATOR PROTECTION PANEL
- 9 VOLTAGE REGULATOR
- 10 BATTERY CHARGER
- 11 EXTERNAL DC POWER CONNECTOR
- 12 APU INSTALLATION

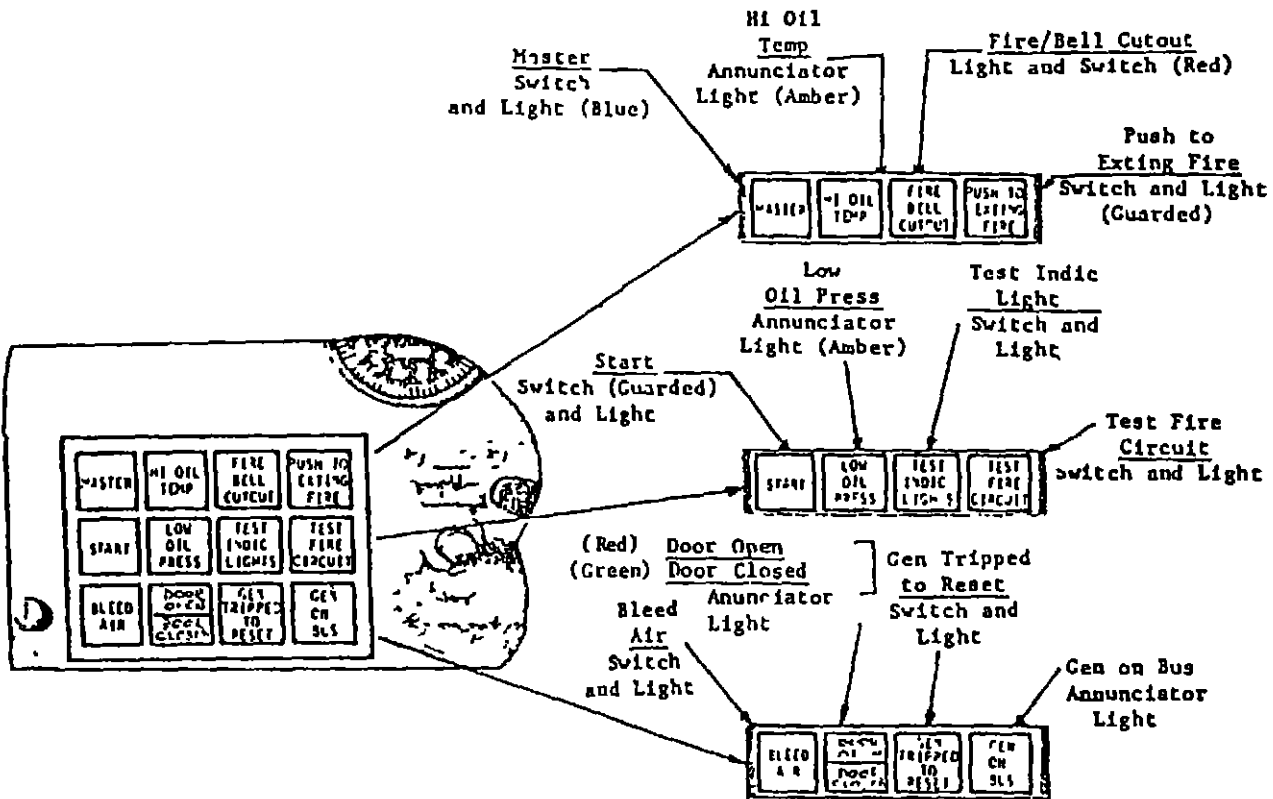
Ref MM STEWARD-DAVIS

EFFECTIVITY



APU COCKPIT CONTROL PANEL

FIGURE 2



APU CONTROL MODULE

FIGURE 3

Ref MM STEWARD-DAVIS



## MAINTENANCE MANUAL

### 3. APU ENGINE

- A The APU engine is a gas turbine basically composed of a two-stage centrifugal compressor directly coupled to a single-stage inward flow turbine. The turbine shaft is coupled to the accessory drive section to provide power for driving the engine accessories and the generator.

### 4. APU FUEL SUPPLY AND ENGINE FUEL CONTROL SYSTEMS

- A The APU fuel supply and engine fuel control system delivers clean, metered fuel under pressure to the turbine engine combustion chamber as required to accelerate the engine during starting and to maintain a constant engine speed under all load conditions.
- B The APU fuel supply system filters and pressurizes fuel from the airplane main tank No 3 and delivers it to the engine fuel control system. The fuel supply system consists of a fuel tap at the wing rear spar, a manual shutoff valve, a solenoid actuated fuel supply shutoff valve, a thermal relief valve, a fuel filter and fuel boost pump, plus appropriate plumbing. The solenoid actuated fuel supply shutoff valve and the fuel boost pump are both energized when the APU master relay is closed.
- C The engine fuel control system consists of a fuel control unit mounted on the front of the turbine engine accessory section, a fuel solenoid valve, a fuel atomizer, a control thermostat and a turbine plenum drain. The system is fully automatic in operation and does not require external controls.

### 5. APU IGNITION AND STARTING

- A. The APU ignition and starting systems provides a means of cranking the engine and a predetermined RPM and igniting the fuel-air mixture in the combustion chamber. Automatic controls de-energize the starter motor and ignition circuits when the engine is rotating at approximately 35% and 95% speed respectively.

### 6. APU AIR

- A. The APU air system consists of pneumatic and electromechanical components, which function automatically, to regulate the maximum amount of bleed air that may be drawn from the APU for use in the airplane pneumatic systems. Accessory cooling is accomplished by drawing ambient air into the housing, circulating it around the accessories and exhausting it overboard.
- B The engine bleed-air control system is fully automatic in operation. The system consists of a pneumatic thermostat, a three-way solenoid valve and a pneumatic shutoff (load control) valve. Bleed air is not available until the engine reaches governed speed. When engine speed reaches approximately 95% RPM, the three-way solenoid valve is actuated to direct the thermostat output to the load control valve to modulate the valve position and maintain safe exhaust gas temperature.

6 APU AIR (CONTINUED)

C Bleed air from the APU is carried forward in the bleed-air duct to the airplane across-over ducting. A flapper type check valve is installed downstream from the load control valve prior to the manifold. The check valve prevents reverse flow through the compressor section of the APU when main engine turbo-compressors are operating.

7 APU ENGINE CONTROL

- A The APU engine control system provides for the selection, control and monitoring of the operations and loading of the APU engine.
- B Instrumentation and annunciator lights on the control panel provides for monitoring the operation and loading configuration of the APU engine.
- C The APU control system receives 28 VDC power from the APU DC bus through its master relay when the MASTER switch-lite is activated and the APU BATTERY switch is in the ON position.

8 APU INDICATING

A The APU indicating system consists of an hourmeter, mounted on the APU, for recording the number of hours the APU has been operated, and exhaust gas temperature and RPM indicators on the APU control panel.

9 APU EXHAUST

A The APU exhaust is an aspirated (to induce cooling air flow for the APU components), sound reducing, system of ducting that directs the APU exhaust gases overboard through a door in the right wing-to-body fairing aft of the wing flap fence.

10 APU OIL

A The APU oil system is a self-contained, positive pressure, dry-sump system that provides pressurized and splash lubrication for all gears and bearings within the unit. The oil supply tank is located at the inboard aft end of the APU module mounted outside of the housing for easy access.

11 OPERATION

A. Operation of the APU consists of preparing to start, starting, loading and shutdown. Each step is manually initiated through selector switches on the APU control panel. However, the engine control circuits monitor the conditions required for safe operation of the APU engine before power is applied to actuate start and loading control components.

## 11 OPERATION (CONTINUED)

### B Preparing to Start APU

- (1) Placing the APU BATTERY switch to the ON position actuates the APU battery relay and connects the battery bus, through a 15 ampere circuit breaker, to two dc busses.
- (2) Actuating the MASTER switch-lite to the ON position applies power to the control circuit of the master relay, the APU generator control relay, and to the MASTER switch-lite.

NOTE The MASTER switch-lite indicates that the contacts of the master switch and the NC contacts of the firelockout relay are closed and that power from the APU dc busses is available to the relay. The light does not indicate the position of the master relay.

- (a) The master relay will actuate when control power is applied if an electrical ground is available to its coil through contacts of the squat relay. (The electrical ground is only available when the airplane is on the ground.) When the master relay actuates, control power from the APU dc bus is applied to open the APU exhaust gas door, to actuate the fuel boost relay and to energize the engine and generator control circuits.
  - 1) When the fuel boost relay actuates, control power is applied to open the fuel supply shutoff valve and to run the fuel supply boost pump.
- (3) In summary, with the airplane on the ground, the APU BATTERY switch in the ON position and MASTER switch-lite on, the APU exhaust gas door will open, pressurized fuel will be available to the engine fuel and control system, the engine and generator control circuits will be energized and the APU will be ready to start.

### C APU Starting

- (1) Momentarily pressing the START switch will apply power from the master relay to the starter relay and start light circuits.
  - (a) The START light will illuminate if power is available to the starter relay through the contacts of the start switch, the oil pressure sequence switch, and the 35% switch.



## MAINTENANCE MANUAL

- (b) The starter relay (SR) will actuate if an electrical ground is available to its coil through the exhaust door switch No. 1. When the SR actuates, power from the APU battery bus is applied to the starter motor and power from the master relay is applied to a self-locking circuit to retain power on SR and on the START light after the start switch is released. At the same time power is applied to terminal 6 of the battery charger control. This prevents the APU battery charger from carrying the heavy electrical load required during the start cycle.
- (2) When the sequencing oil pressure switch closes, power is applied to the fuel solenoid valve and to the ignition unit. This provides fuel and ignition to initiate combustion. When combustion starts, the gases generated assist the starter motor in accelerating the engine.
- (3) When the 35% switch actuates, power is interrupted to the starter relay and start light circuit.
  - (a) The START switch-lite will go out.
  - (b) The starter motor will stop.
  - (c) The APU battery charger will be re-activated.
- (4) When the 95% switch actuates, power is removed from the ignition unit and applied to the three-way solenoid valve, the speed relay, the auxiliary underspeed relay, and to the hourmeter.
  - (a) When the three-way solenoid valve actuates, the pneumatic thermostat control output is transferred from the acceleration limiter valve to the load control valve to control the pneumatic loading of the engine when bleed air is selected.
  - (b) When the speed relay actuates, its contacts close in the low oil pressure fault and bleed air valve (close) control circuits to allow a pneumatic load and low oil pressure protection to be applied to the engine.
  - (c) When the auxiliary underspeed relay actuates the generator control panel underspeed lockout circuitry is de-activated.
  - (d) The hourmeter is energized to time and totalize the hours that the engine operates.

### D APU Loading

**NOTE:** After a warm-up period of one minute at governed speed the APU engine is ready for loading electrically and/or pneumatically.

**D APU Loading (Continued)**

APU loading is accomplished through the controls provided on the APU control panel. After the APU has warmed up, electrical and/or pneumatic power can be obtained through the positioning of controls as outlined below

**(1) Electrical Power only**

- (a) This configuration provides shaft horsepower exceeding normal generator requirement and no pneumatic power. The turbine engine is not loaded to rated capacity. (Generator protective devices would function before the engine is overloaded.)
- (b) Control Selection and Indication
  - 1) GEN TRIPPED - Push to rest.
  - 2) Essential power selector - Position selector to APU (on flight engineer's upper center panel)
  - 3) APU CONTACTOR SW - Momentarily select the CLOSE position. Green GEN ON BUS annunciator light illuminates
  - 4) BLEED AIR - Off, light out. Press switch-lite to close bleed air valve, if blue, light is illuminated

**(2) Electrical and Pneumatic Power**

- (a) This configuration provides electrical power limited to 75 amps per phase and pneumatic power to load turbine engine to rated capacity

**NOTE** Adequate pneumatic power for starting an airplane engine is assured when the APU is in the pneumatic and electrical load condition. However, electrical loading must be carefully monitored on the generator of the APU because its entire electric load will be dropped if the 75 ampere limit is reached in any phase of the electrical power generated

**(b) Control Selection and Indication**

As in (1-b) above except the following

**BLEED AIR - ON** - Depress switch-lite momentarily to open bleed air valve. Blue cover plate will illuminate

**(4) Pneumatic Power only**

- (a) This configuration provides pneumatic power only and not electrical power. The turbine engine is not loaded to rated capacity

(4) Pneumatic Power only (Continued) ,

(b) Control Selection and Indication

1) GEN TRIPPED - Reset

NOTE: The generator field control relay should be closed, generator tripped light out, during all APU operations

2) APU CONTACTOR SW - Momentarily select the TRIP position, green GEN ON BUS annunciator will extinguish

3) BLEED AIR - On, blue light illuminated

E APU Shutdown

NOTE Electrical and pneumatic loads should be removed from the APU three minutes prior to engine shutdown

(1) Momentarily pressing the OVERSPEED test switch will apply power from the master relay to the pneumatic solenoid valve and cause the 110% switch of the centrifugal switch assembly to actuate. Actuation of the 110% switch removes power from the fuel solenoid valve, causing the valve to close, and from the hold relay, removing all operating power from the engine

(a) When the fuel solenoid valve closes, the engine shuts down due to fuel starvation

(b) When the hold relay relaxes, the power circuits to the fuel solenoid valve, ignition unit and starter relay are interrupted until the engine rotational speed falls below 7% RPM. This prevents the fuel solenoid valve from opening and the ignition unit from being energized when the 110% and 95% switches relax as the engine spins down and it prevents the starter relay from energizing the starter when the 35% switch relaxes if a re-start were attempted before full spindown of the engine

CAUTION: OPENING THE MASTER SWITCH PRIOR TO COMPLETE SPINDOWN OF THE ENGINE CAUSES EXCESSIVE HEAD BUILD-UP IN THE APU MODULE AND EXHAUST SYSTEM DUE TO THE RESTRICTION OF AIRFLOW THROUGH THE ENGINE AND EXHAUST DUCTS WHEN THE APU EXHAUST DOOR CLOSES

- (2) When engine spindown is completed, actuating the MASTER switchlite to the open position (MASTER switch-lite out) will remove power from the control coil of the master relay. When the master relay opens, the following events occurs:
  - (a) Control power is applied to the APU exhaust door actuator to close the exhaust gas door
  - (b) Power is removed from the engine control circuits.
  - (c) Power is removed from the fuel boost relay to de-activate the APU fuel supply system
  - (d) Power is removed from the generator control relay to disconnect power from the generator control unit.
- (3) Placing the APU BATTERY switch to the OFF position completes the shutdown of the APU engine



(BLANK)

**APU BATTERY**

**1. GENERAL**

- A The 24 volt, 36 ampere-hour lead acid storage battery is located in the main landing gear wheelwell cavity. The battery support is mounted on the forward side of the aft cargo compartment (Sta 960) to the right of the keel. The battery is connected to its fire protection circuits through a circuit breaker, and to its control circuits by the common APU battery switch and individual relay. The battery is charged by its single phase charger which is energized by the essential bus through a relay controlled by the APU battery switch.
- B The service required to maintain the APU battery is dependent on the rate and length of charge, ambient temperature and relative humidity. Chemically approved water should be added to the battery cells whenever necessary. A periodic check for electrolyte level should be made after each flight, depending on battery use and rate of charge.
- C Both hydrogen and oxygen are generated during the charging cycle of the lead acid storage battery. Air containing 4 to 8 percent hydrogen will burn if ignited. Air mixtures containing more than 8 percent hydrogen will explode.

**CAUTION** KEEP ALL OPEN FLAMES, SPARKS FROM ELECTRIC DEVICES, AND ANYONE WHO MAY BE SMOKING, AWAY FROM BATTERY, PARTICULARLY DURING AND FOLLOWING A CHARGING CYCLE

**NOTE** Allow a charged battery to stand disconnected in a well ventilated area until gas bubbling stops, before using a torch or flame near the battery.

**2. UNIT SERVICING - STORAGE BATTERY - 24 VOLT 36 AMPERE-HOUR**

- A Addition of Water - See Para 3, Ch 24-49-31, Page 102- Inspection/Check of APU Storage Batteries
- B APU Battery Charging - See Para 2B, Ch 24-49-31, Page 102 - APU Battery Charging
- C Cleaning and Painting-- See Para C (1) through (6), Ch 24-49-31, Page 102
- D Battery Ventilation Hoses - See Para D (1) through (4), Ch 24-49-31, Page 103



## APU CONTROL COMPONENTS

### TROUBLESHOOTING

EFFECTIVITY RTCA LX-N19997 LX-N20000

#### 1 GENERAL

- A The APU control component troubleshooting section consists of troubleshooting procedures and wire trace diagrams, plus identification and location tables for circuit breakers, relays, and connectors
- B Troubleshooting procedures are outlined in Table 101
  - (1) Malfunctions are listed in Table 101 as they would appear in normal APU precheck, start-up, loading and shutdown sequence. The latter procedures do not include checkout of components whose malfunction would have been identified and corrected in earlier procedures
  - (2) The troubleshooting procedures assume that the contacts of a relay act in unison, all tripped or all actuated. Thus, establishing that one set of relay contacts are correctly positioned is sufficient evidence to accept it as functioning properly
  - (3) Checkpoints, diodes, circuit breakers, etc., are identified for the APU circuits in the troubleshooting procedures and the wire trace diagrams
- C The Wire Trace Diagrams, Figures 101 through 118, are presented to simplify the tracing of wire runs from the power source through the component to ground. The diagrams are not intended for use as functional schematics
- D Tables 102 through 105 at the end of the troubleshooting section, identify and locate the components as abbreviated in the troubleshooting procedures and wire trace diagrams

APU CONTROL COMPONENTS

TROUBLE SHOOTING

TABLE 101

1 FIRE TEST

- A Test does not actuate when TEST FIRE CIRCUIT switch-lite is pressed (Test Fire Circuit and Fire/BellCutout lights do not come on, fire bells do not ring ) WTD, Figure 102
- (1) Check for 24 VDC at circuit breakers Fire Det 1 and Fire Det 2, Starter Relay Box.
    - (a) Not OK
      - 1) Check battery condition and replace/recharge if required
      - 2) Correct wiring, battery to FD1 and FD2, Figure 101
    - (b) OK -- Step (2)
  - (2) Check for 24 VDC at FLO-A2 and FT-8, Control Relay Box, Figure 102
    - (a) Not OK -- Correct wiring, FD1 to FLO-A2, FD2 to FT-8
    - (b) OK -- Step (3)
  - (3) With Fire Test Switch depressed, check for 24 VDC at FT-2 and 6, Control Relay Box, Figure 102
    - (a) Not OK
      - 1) Check for continuity through Fire Test Switch when depressed (terminals 17 to 7 and 16 to 6), Figure 102
      - 2) If not OK, replace switch
      - 3) If OK, correct wiring, FLO-A2 to Fire Test switch and Fire Test Switch to FT-2 and 6
    - (b) OK -- Step (4)
  - (4) With Fire Test switch depressed, check for 24 VDC at FT-1 and FTD-2, Control Relay Box, Figure 102.

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- (a) Not OK
  - 1) Check for open diodes CR8 and CR11.
  - 2) If not OK, replace.
  - 3) If OK, correct wiring FT-6 to FT-1 and FTD-2.
- (b) OK -- Step (5)
- (5) With Fire Test switch depressed, check for 24 VDC at FT-3
  - (a) If not OK --
    - 1) Check for ground at FT-7
    - 2) If not OK, correct wiring, FT-7 to ground
    - 3) If OK, replace Fire Test Relay
  - (b) OK -- Step (6)
- (6) With Fire Test switch depressed, check for 24 VDC at BS-A3, Control Relay Box, Figure 103 (Note Be sure (4) (a) 3 is OK )
  - (a) Not OK -- Replace Bell Silence relay
  - (b) OK -- Step (7)
- (7) With Fire Test switch depressed, check for 24 VDC at plus terminal of Fire Warning horn, cockpit, Figure 103.
  - (a) Not OK -- Correct wiring BS-A3 to Fire Warning horn
  - (b) OK --
    - 1) Check for ground at minus terminal of horn
    - 2) If not OK, correct wiring to ground, Figure 103.
    - 3) If OK and horn does not sound, replace horn
- (8) Repeat (7) for Fire Warning horn in wheel well, Figure 103
- (9) With Fire Test switch depressed, check for 24 VDC at Cathode (-) terminal of CR7, Control Relay Box, Figure 103 (Note. Be sure (4) (a) 3 is OK )

- (a) Not OK – Replace CR7
  - (b) OK -- Step (10).
- (10) With Fire Test switch depressed, check for 24 VDC at cathode (-) terminal of CR30, Control Panel
- (a) Not OK – Correct wiring (CR7 to CR30)
  - (b) OK -- Check Fire/Bell Cutout indicator light circuit per Figure 107.
- B Fire Warning system (Fire/Bell Cutout indicator light and Fire Warning horns) turns on when Fire Test switch is depressed, but does not remain on when released
- (1) Check that circuit breaker, FD2, Starter Relay Box, Figure 102, is closed
- (a) Not OK - Close FD2
  - (b) OK -- Step (2)
- (2) Check for 24 VDC at FT-8, Control Relay Box, Figure 102
- (a) Not OK -- Correct wiring, FD2 to FT-8
  - (b) OK -- Replace Fire Test relay
- C Fire Exting light does not come on  $20 \pm 1$  seconds after Fire Test switch is depressed and released (fire warning system activates normally)
- (1) With Fire Test circuit activated, Figure 102, check for 24 VDC at FTD-11, Control Relay Box
- (a) Not OK --
    - 1) Check per A(4) and (5)
    - 2) Correct wiring FT-3 to FTD-11
  - (b) OK -- Step (2)
- (2) Depress and release Fire Test switch After  $20 \pm 1$  seconds, check for 24 VDC at FTD-9, Control Relay Box, Figure 102.
- (a) Not OK --
    - 1) Check for ground at FTD-10

- 2) Not OK -- Correct wiring.
  - 3) OK -- Check resistor across FTD-5 and 7 (301 K ohms).
  - 4) Not OK -- Replace resistor
  - 5) OK -- Replace Fire Time Delay relay.
- (b) OK -- Step (3)
- (3) Depress and release Fire Test switch After  $20 \pm 1$  seconds, check for 24 VDC at cathode terminals of CR21 and CR22, Control Panel, Figure 102
- (a) Not OK -- Correct wiring FTD-9 to CR21/22
  - (b) OK -- Check Push to Exting Fire indicator light per Figure 107
- D Exting Fire light remains on beyond  $30 \pm$  seconds after the Fire Test switch was depressed and released ( $10 \pm 1$  seconds after the Fire/Bell Cutout light and the warning horns turned off)
- (1) Check that Fire Test switch terminals, Control Panel, Figure 102, open when switch is released
    - (a) Not OK -- Replace Fire Test switch
    - (b) OK -- Replace Fire Test relay
- E Bell Cutout switch does not silence Fire Warning horns during Fire Test cycle
- (1) With Fire Test Circuit actuated and Bell Cutout switch depressed, check for 24 VDC at BS-A1 and X1, Control Relay Box, Figure 103 (Note. Be sure A(10) is OK )
    - (1) With Fire Test circuit actuated and Bell Cutout switch depressed, check for 24 VDC at BS-A1 and X1, Control Relay Box, Figure 103 (Note. Be sure A(10) is OK )
      - (a) Not OK --
        - 1) Check continuity through Bell Cutout switch terminals 16 and 6 with Bell Cutout switch depressed.
        - 2) Not OK -- Replace Bell Cutout switch
        - 3) OK -- Correct wiring Bell Cutout switch -6 to BS A1 and X1

(b) OK --

- 1) Check for ground at BS-X2
- 2) Not OK -- Correct wiring, Figure 102.  
OK -- Replace Bell Silence relay

## 2 PANEL ILLUMINATION

A With Battery and Panel Illum switches closed, APU Control Panel edge lights do not turn on

(1) Check for 24 VDC at circuit breakers, APU Bus Feed, and Batt SW, Starter Relay Box, Figure 105

(a) Not OK -- Follow procedure 1 A

(b) OK --

(2) Check for 24 VDC at circuit breaker, Indio Lights, Starter Relay Box, Figure 105

(a) Not OK --

1) Check for 24 VDC at TB-17, Control Relay Box, Figure 105

a) Not OK -- Correct wiring, Batt SW circuit breaker to TB-17

b) OK --

2) Check for 24 VDC at TB-16, Control Relay Box, Figure 105

a) Not OK -- Correct wiring, TB-17 to TB-16 and/or replace Battery switch

b) OK --

3) Check for 24 VDC at B-X1, Starter Relay Box, Figure 105

a) Not OK -- Correct wiring, TB-16 to B-X1

b) OK --

4) Check for 24 VDC at B-B2

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- a) Not OK -- Correct wiring, APU Bus Feed circuit breaker to BR-B2.
  - b) OK --
- 5) Check for 24 VDC at BR-B1
- a) Not OK -- Check for ground at BR-X2.
    - 1 Not OK -- Correct wiring BR-X2 to ground
    - 2 OK - Replace Battery Relay
  - b) OK -- Correct wiring, BR-B1 to Indic. Lights circuit breaker
- (b) OK --
- (3) Check for 24 VDC at TB-12, Control Relay Box, Figure 106
- (a) Not OK -- Correct wiring, Indic Light circuit breaker to TB-12
  - (b) OK --
- (4) Check for 24 VDC at anode (plus) terminal of CR36, Control Panel, Figure 106
- (a) Not OK -- Correct wiring, TB-12 to CR36
- (5) Check for 24 VDC at cathode (minus) terminal of CR36
- (a) Not OK -- replace CR36
  - (b) OK --
- (6) Check for 24 VDC at Panel Illum switch -2
- (a) Not OK -- correct wiring, CR36 to Panel Illum switch
  - (b) OK --
- (7) Check for 24 VDC at Panel Illum switch -1 (switch closed)
- (a) Not OK -- replace switch
  - (b) OK --

(8) Check for 24 VDC at edge light circuit board connector, Control Panel, Figure 106.

(a) Not OK -- correct wiring, Panel Illum switch to connector.

(b) OK -- replace edge light circuit board.

### 3 APU INDICATOR LIGHT TEST

A Indicator lights do not turn on when Test Indic Lights switch is depressed

(1) With Battery switch closed, check for 24 VDC at Panel Illum switch, terminal 2, Control Panel, Figure 106

(a) Not OK -- follow procedure 2 A (1) through (6)

(b) OK -- Trace circuitry for fault per Wire Trace Diagram, Figure 107 Replace light bulbs, switch-lite units, and diodes as necessary

### 4 APU MASTER SWITCH

A Master Light does not turn on when Master switch is depressed. (Battery switch closed and Indicator Light Test, Figure 107, OK )

(1) Check for 24 VDC at circuit breaker, Control Feed 1, Starter Relay Box, Figure 105

(a) Not OK -- Follow procedure 2 A (1) through (2) (a) substituting circuit breaker Control Feed 1 for circuit breaker Indicator Lights, and BR-A2/A1 for BR-B2/B1

(b) OK --

(2) Check for 24 VDC at TB-8, Control Relay Box, Figure 109

(a) Not OK -- Correct wiring CF1 to TB-8

(b) OK --

(3) Check for 24 VDC at FLO-82, Control Relay Box, Figure 109

(a) Not OK -- Correct wiring, TB-8 to FLO-B2 (replace Master switch-lite unit, if required)

(b) OK --

(4) Check for 24 VDC at FLO-B3

(a) Not OK --

1) Check for 24 VDC at FLO-X1, Control Relay Box, Figure 104

a) Not OK -- replace Fire Lockout Relay

b) OK -- Open and close circuit breaker Fire Det 1, Starter Relay Box, Figure 101

NOTE The Fire Lockout relay should only be energized (24 VDC at X1 and normally closed B2/B3 open) if one or more of the fire detectors (APU Module, Figures 102 and 103) have closed. For trouble shooting, See Figures 102, 103, and 104

(b) OK --

(5) Check for 24 VDC at cathode (minus) terminal of CR 28, Control Panel, Figure 109

(a) Not OK -- Correct wiring, FLO-B3 to CR28 Replace diode CR4, Control Relay Box, Figure 109, if necessary

**B Exhaust door does not open (battery and Master switches closed, Master light on)**

(1) Check for 24 VDC at circuit breaker Door Motor, Starter Relay Box, Figure 105 (Door Motor circuit breaker closed).

(a) Not OK -- Follow procedure 2.A. (1) through (2) (a)

(b) OK --

(2) Check for 24 VDC at MR-B2, Control Relay Box, Figure 110

(a) Not OK -- Correct wiring, Door Motor circuit breaker to MR-B2

(b) OK --

(3) Check for 24 VDC at MR-B1.

(a) Not OK --

- 1) Check for 24 VDC at MR-X1, Control Relay Box, Figure 109.
  - a) Not OK -- Correct wiring, FLO-B3 to MR-X1
  - b) OK --
- 2) Check for ground at MR-X2
  - a) Not OK --
    - 1 Wiring from insulated terminal to R54-D2, Anti-Skid relay is faulty
    - 2 Wiring from R54-D3 to ground is faulty.
    - 3 R54 is faulty

NOTE The specific safety (Squat") relay required may vary with aircraft Refer to manufacturer's diagram

- b) OK -- Replace Master Relay, Control Relay Box, Figure 109
  - (b) OK -- Refer to Figure 110
    - 1) Wiring, MR-B1 to P23, Door Actuator connector, is faulty.
    - 2) Wiring, P23 to ground, is faulty
    - 3) Door Actuator internal sequence switches are incorrectly adjusted and/or faulty
    - 4) Door Actuator is faulty
- C Boost Pump does not operate (Battery and Master switches closed, Master Light on)
- (1) Check for 24 VDC at circuit breaker Boost Pump, Starter Relay Box, Figure 105 (Boost Pump circuit breaker closed)
    - (a) Not OK -- Follow procedure 4 A. (1) (a)
    - (b) OK --
  - (2) Check for 24 VDC at BP-A1, Starter Relay Box, Figure 111

- (a) Not OK – Correct wiring, Boost Pump circuit breaker to BP-A1.
  - (b) OK –
- (3) Check for 24 VDC at BP-A2.
- (a) Not OK –
    - 1) Check for 24 VDC at circuit breaker Control Feed 2, Starter Relay Box, Figure 105
      - a) Not OK – Follow procedure 2 A (1) through (2)
        - (a)
        - b) OK –
    - 2) Check for 24 VDC at MR-A2, Control Relay Box, Figure 111
      - a) Not OK – Correct wiring, Control Feed 2 circuit breaker to MR-A2
      - b) OK --
    - 3) Check for 24 VDC at MR-A1
      - a) Not OK -- Follow procedure 4 B (3) (a)
      - b) OK --
    - 4) Check for 24 VDC at TB-33
      - a) Not OK -- Correct wiring, MR-A1 to TB-33
      - b) OK --
    - 5) Check for 24 VDC at BP-X1, Starter Relay Box, Figure 111
      - a) Not OK -- Correct wiring, TB-33 to BP-X1
      - b) OK --
    - 6) Check for ground at BP-X2.
      - a) Not OK -- Correct wiring, BP-X2 to ground
      - b) OK -- Replace Boost Pump relay.

- (b) OK --
  - (4) Check for 24 VDC at TB-35, Control Relay Box, Figure 111
    - (a) Not OK -- Correct wiring, BP-A2 to TB-35.
    - (b) OK --
  - (5) Check for 24 VDC at P12, Boost Pump Connector, wheel well, Figure 111.
    - (a) Not OK -- correct wiring, TB-35 to P12
    - (b) OK --
      - (1) Check for ground at Boost Pump housing (Boost Pump housing must be bonded to airframe and wired to TB-21, Control Relay Box, Figure 111).
        - a) Not OK -- Correct ground of Boost Pump housing
        - b) OK -- Replace Boost Pump
- D Fuel Valve does not open (Battery and Master switches closed, Master Light on, Boost Pump running.
- NOTE To avoid running boost pump with fuel system dry, disconnect P12, boost pump connector, from boost pump
- (1) Check for 24 VDC at P13-A Fuel Valve connector, wheel well, Figure 111
    - (a) Not OK -- Correct wiring, TB-35 to P13-A
    - (b) OK --
  - (2) Check for ground at P13-B.
    - (a) Not OK -- Correct wiring, P13-B to TB-21
    - (b) OK -- Replace Fuel Valve
- 5 DOOR POSITION INDICATOR LIGHTS
- A Door Closed light does not turn on (Battery switch closed, Master switch open, Exhaust Door closed, and indicator Light Test, Figure 107, OK)

- (1) Check for ground at TB-3, Control Relay Box, Figure 108
  - (a) Not OK --
    - 1) Correct wiring, TB-3 through Exhaust Door Switch 2 normally open contacts to ground.
    - 2) Correct adjustment of Exhaust Door Switch 2.  
NOTE Exhaust Door Switch 2 normally open contacts are closed when the exhaust door is fully closed
    - 3) Replace Exhaust Door Switch 2
  - (b) OK -- Correct wiring, Door Closed light, Terminal 23 to TB-3
- B APU Exhaust Door Annunciator light, in A/C Door Annunciator Warning Lights panel, does not turn on when APU Exhaust Door begins to open (A/C Door Annunciator Warning lights powered by A/C DC power system)
  - (1) Check APU Exhaust Door annunciator warning light with Door Annunciator Warning Lights test switch
    - (a) Not OK --
      - 1) Replace bulb(s)
      - 2) Correct wiring, Figure 108 (refer to A/C manufacturer's wiring diagrams)
    - (b) OK --
  - (2) Check for ground at TB-4, Control Relay Box, Figure 108 (APU Exhaust Door "less than" fully closed)
    - (a) Not OK --
      - 1) Correct wiring, TB-4 through Exhaust Door Switch 2 normally closed contacts to ground.
      - 2) Correct adjustment of Exhaust Door Switch 2  
NOTE. Exhaust Door Switch 2 normally closed contacts close when the APU Exhaust Door moves from the fully closed position

- 3) Replace Exhaust Door Switch 2.
  - (b) OK -- Correct wiring D349-N, Door Annunciator Warning Lights connector, to TB-4
- C Door Open light does not turn on (Battery and Master switches closed, Master light on, APU Exhaust Door fully open, and Indicator Light test, Figure 107, OK)
- (1) Check for ground at TB-5, Control Relay Box, Figure 108
    - (a) Not OK --
      - 1) Correct wiring, TB-5 through Exhaust Door Switch 1 normally open contacts to ground
      - 2) Correct adjustment of Exhaust Door Switch 1

NOTE Exhaust Door Switch 1 normally open contacts close when APU Exhaust Door reaches fully open position

      - 3) Replace Exhaust Door Switch 1
    - (b) OK --
  - (2) Check for ground at TB-2, Control Relay Box, Figure 108
    - (a) Not OK --
      - 1) Check continuity of CR17, Control Relay Box, Figure 108
        - a) Not OK -- Replace CR17
        - b) OK -- Correct wiring, TB-2 to TB-5
    - (b) OK -- Correct wiring, Door Open light, terminal 3 to TB-2

## 6 APU START CIRCUIT

- a Start light does not come on when Start switch is depressed (Battery and Master switches closed, Bleed Air switch open (Bleed Air Light off) APU Exhaust Door fully open, fuel system (Boost Pump and fuel valve) operating, and indicator light test, Figure 107, OK).

NOTE Before trouble shooting the start circuit, it is advisable to disconnect P/J 19 at the APU Module, Figure 113 and P12 at the Boost Pump in the wheel well, Figure 111, in order to avoid unnecessarily operating the starter and boost pump during procedure.



## MAINTENANCE MANUAL

- (1) With the Battery and Master switches closed (Master light on) and the Bleed Air switch open (Bleed Air light off), check for 24 VDC at TB-31, 32, and 33, Control Relay Box, Figure 112 (NOTE TB-31, 32, and 33 are bussed together.)
  - (a) Not OK --
    - 1) Check for 24 VDC at P12, wheel well, Figure 111
      - a) Not OK -- Follow procedure 3 C (3) (a) 3 through 4)
      - b) OK -- Repair or replace bus bar, TB-31, 32 and 33
    - (b) OK --
  - (2) With start switch held closed and conditions for (1) above maintained, check for 24 VDC at TB-27, Control Relay Box, Figure 112
    - (a) Not OK
      - 1) Check for 24 VDC at Start switch, terminal 16, Control Panel, Figure 112
        - a) Not OK -- Correct wiring, TB-31, Control Relay Box, to Start switch
        - b) OK --
      - 2) Check for 24 VDC at Start switch terminal 6 (Start switch held closed)
        - a) Not OK -- Replace Start switch lite unit
        - b) OK -- Correct wiring, Start switch to TB-27
      - (b) OK --
    - (3) With Start switch held closed and conditions for (1) still maintained, check for 24 VDC at TB-36, Control Relay Box, Figure 112
      - (a) Not OK --
        - 1) Disconnect P/J 18 at APU module and, with Start switch held closed, check for 24 VDC at P18-S, Figure 112

- a) Not OK -- Correct wiring, TB-27 to P18-S.
- b) OK --
- 2) Check continuity through J18-S to P
  - a) Not OK --
    - 1 Wiring J18-S/P to AiResearch engine harness connector plug -S/P, is open -- correct wiring.
    - 2 Wiring, AiResearch engine harness connector receptacle - S/P to Oil Pressure Sequence switch connector plug is open -- correct wiring
    - 3 Oil Pressure Sequence switch (AiResearch engine component) is open -- replace Oil Pressure Sequence switch
  - b) OK -- correct wiring, P18-P to TB-36, Figure 112
- (b) OK --
- (4) With Start switch held closed (conditions for (1) maintained), check for 24 VDC at TB-39, Control Relay Box, Figure 112
  - (a) Not OK --
    - 1) Disconnect P/J18 at APU module and, with Start switch held closed, check for 24 VDC at P18-E, Figure 112
      - a) Not OK -- Correct wiring, TB-36 to P18-E
      - b) OK
    - 2) Check continuity through J18-E to H
      - a) Not OK --
        - 1 Wiring, J18-E/H to AiResearch engine harness connector plug - I/H is open -- correct wiring.
        - 2 Wiring, AiResearch engine harness connector receptacle - I/H to centrifugal switch connector plug - D/C is open -- correct wiring.
        - 3 35% switch (Centrifugal switch connector receptacle - DC) is open -- replace centrifugal switch (AiResearch component)

- b) OK -- Correct wiring, P18-H to TB-39, Figure 112
- (b) OK --
- (5) With Start switch held closed, check for 24 VDC at cathode (Minus terminal of CR 2, Control Relay Box, Figure 112)
  - (a) Not OK --
    - 1) Check for 24 VDC at anode (plus) terminal of CR2
      - a) Not OK -- Correct wiring, TB-39 to CR 2
      - b) OK -- Replace diode, CR 2
    - (b) OK -- Correct wiring, CR2 to CR26, Control Panel, Figure 112
- B Starter does not rotate when Start switch is depressed (Start light comes on and conditions for A above maintained) (See note in A above)
  - (1) With Start switch held closed, check for 24 VDC at SR-X1, Starter Relay Box, Figure 112
    - (a) Not OK -- Correct wiring, TB-39, Control Relay Box to SR-X1
    - (b) OK --
  - (2) Check for ground at SR-X2
    - (a) Not OK --
      - 1) Check for ground at TB-5, Control Relay Box, Figure 112
        - a) Not OK -- Follow procedure 5 C (1) (a)
        - b) OK --
      - 2) Check for ground at TB-1
        - a) Not OK -- Replace diode, CR18
        - b) OK -- Correct wiring, SR-X2 to TB-1

- (b) OK --
- (3) With Start switch held closed, check for 24 VDC at SR-A1, Starter Relay Box, Figure 113
  - (a) Not OK -- Replace Starter Relay
  - (b) OK --
- (4) With Start switch held closed, check for 24 VDC at P19-D, APU module, Figure 113
  - (a) Not OK -- Correct wiring, SR-A1 to P19-D
  - (b) OK --
- (5) Check for ground at P19-B
  - (a) Not OK -- Correct wiring, P19-B to ground stud, Starter Relay Box, Figure 113
  - (b) OK --
- (6) Check continuity, J19-B through D
  - (a) Not OK --
    - 1) Wiring, J19 to Starter is open -- correct wiring
    - 2) Wiring, Starter to ground is open -- correct wiring
    - 3) Starter is faulty -- replace starter
- C Start circuit does not hold when Start switch is released (starter rotates and Start light comes on when Start switch is depressed but both discontinue when Start switch is released)
  - (1) With Battery and Master switches closed (Master light on), check for 24 VDC at HR-B2, Control Relay Box, Figure 112
    - (a) Not OK -- Correct wiring, TB-32 to HR-B2.
    - (b) OK --
  - (2) Remove wire from HR-B1 (CAUTION Wire will be "HOT" during following procedure). Hold Start switch closed and check for 24 VDC at HR-B1.
    - (a) Not OK

- 1) With Start switch held closed, check for 24 VDC at HR-X1, Control Relay Box, Figure 114
  - a) Not OK --
    - 1 Wiring, P18-G (APU module to HR-X1, is open -- correct wiring.
    - 2 Wiring, J18-G to A1Research engine harness connector plug - G, is open -- correct wiring
    - 3 Wiring, A1Research engine harness connector receptacle - G to centrifugal switch connector plug - B, is open -- correct wiring
    - 4 110% switch, centrifugal switch connector receptacle - D through B, is open -- replace centrifugal switch
  - b) OK --
- 2) Check for ground at HR-X2
  - a) Not OK -- Correct wiring, HR- to ground.
  - b) OK -- Replace Hold Relay, Control Relay Box, Figure 114
- (b) OK --
- (3) Hold Start switch closed and check for 24 VDC at terminal of wire previously removed from HR-B1, Control Relay Box, Figure 112.
  - (a) Not OK --
    - 1) Check wiring, TB-36 to HOT-A3, HOT-A3, HOT-A2 to LOP-A3, LOP-A2 to HR-B1 end of wire
      - (a) Not OK -- Correct wiring
      - (b) OK --
    - 2) Check continuity, HOT -A3 to A2
      - a) Not OK --



## MAINTENANCE MANUAL

- 1 HOT relay, Control Relay Box, Figure 116, is energized (High Oil Temp light, Control Panel, Figure 116, is on). HOT relay is normally energized through the normally open contacts of the High Oil Temp switch, in oil line adjacent to APU module, Figure 116. The High Oil Temp switch contacts are set to close at 275°F
  - a Open and close Master switch -- HOT relay should de-energize, High Oil Temp light should turn off, normally closed contacts, HOT-A3 to A2, should close (Fig 112)

If not -- correct wiring, Figure 116. Replace High Oil Temp switch, if necessary.
- 2 HOT relay is not energized (High Oil Temp light is not on)
  - a Normally closed contacts, HOT-A3/A2 (Fig 112) are open -- replace High Oil Temp relay, Control relay box, Figure 116
  - b) OK --
- 3) Check continuity, LOP-A3 to A2 (Fig 112)
  - a) Not OK --
    - 1 LOP relay is energized (Low Oil Press light, Control Panel, Figure 116 is on) LOP relay is normally energized through the normally closed contacts of the Low Oil Pressure switch, mounted in the oil line inside the APU module, in series with normally open contacts 95%-B2 to B1, Control Relay Box, Figure 116. The 95% relay is normally energized through the normally open contacts of the 95% switch, Centrifugal switch -E to A, AiResearch component, APU module, Figure 114, which transfers at 95% engine RPM, at which point the Low Oil Pressure switch contacts should be open.

Ref MM STEWARD-DAVIS



## MAINTENANCE MANUAL

- a. Open and close Master switch-- LOP relay should de-energize, Low Oil Press light should turn off, normally closed contacts LOP-A3 to A2 should close

If not -- correct wiring, Figure 116 Replace Low Oil Press and/or Centrifugal switches, if necessary

- 2 LOP relay is not energized (Low Oil Press light not on)

- a Normally closed contacts LOP-A3/A2 are open -- replace Low Oil Press relay Control Relay Box, Figure 116

NOTE On completion of C (3), reconnect wire previously removed to HR-B1

### D Engine light off does not occur

- (1) Check APU fuel boost pump operation, procedure 4 C
  - (a) Not OK -- Correct per procedure 4 C.
  - (b) OK --
- (2) Check operation of APU fuel supply solenoid valve procedure 4 D
  - (a) Not OK -- Correct per procedure 4 D
  - (b) OK --
- (3) Using appropriate container (two or more gallons) to collect fuel, remove bowl of water separator (fuel filter)
  - (a) Fuel flow stops after line drainage -- Check position of manual fuel supply valve Replace fuel supply solenoid valve if manual valve is open
  - (b) Fuel flow continues, in excess of line drainage -- See (c)
  - (c) Replace water separator bowl - See (d)

**BOEING**  **Intercontinental**   
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- (d) Continue troubleshooting per AirResearch Maintenance Manual
- E Starter operates, but cranks engine too slowly
  - (1) Check battery condition
    - (a) Not OK -- Replace/recharge battery
    - (b) OK --
  - (2) Check for adequate continuity of wiring, Battery to Starter Motor, Figures 101 and 113
    - (a) Not OK -- Correct wiring

(Continued on next page)

(b) OK -- Proceed per AiResearch Maintenance Manual

F. Other start malfunctions -- refer to AiResearch Maintenance Manual.

#### 6A EXHAUST GAS TEMPERATURE INDICATION

A Gage does not indicate properly

(1) Check wiring, Figure 118

(a) Not OK -- Correct wiring

(b) OK --

(2) Check resistance of total circuit -- disconnect 1 lead from EGT Gage and measure 8 ohms resistance from disconnected lead through thermocouple circuit to lead still connected to EGT gage

(a) Not OK -- Adjust resistance by adding or subtracting wire at resistor spool Control Panel, Figure 118

(b) Not OK -- Replace gage

(3) Refer to AiResearch Maintenance Manual

#### 6B TACHOMETER (% RPM) INDICATION

A Gage does not indicate properly

(1) Check wiring, Figure 118

(a) Not OK -- Correct wiring

(b) Not OK -- Replace gage and/or tach generator -- refer to AiResearch Maintenance Manual.

#### 7 BLEED AIR - PNEUMATIC LOADING

A. Bleed Air light does not come on when Bleed Air switch is depressed (Indicator Light Test, Figure 107, OK)

(1) With Battery, Master, and Bleed Air switches closed (Master light on), check for 24 VDC at 95% -A2, Control Relay Box, Figure 115.

(a) Not OK --

1) Check for 24 VDC at TB-31, Control Relay Box, Figure 112

- a) Not OK -- Follow procedure 4 C (3) (a) 2)
- b) OK --
- 2) Check for 24 VDC at Bleed Air switch, terminal 16, Control Panel, Figure 112.
  - a) Not OK -- Correct wiring, TB-31 to Bleed Air switch
  - b) OK --
- 3) Check for 24 VDC at Bleed Air switch, terminal 6 (Bleed Air switch closed)
  - a) Not OK -- Replace Bleed Air switch-lite unit
  - b) OK -- Correct wiring, Bleed Air switch to 95%-A2, Figure 115
- (b) OK --
- (2) Check for 24 VDC at cathode (minus) terminal of CR23, Control Panel, Figure 115
  - (a) Not OK --
    - 1) Check continuity of CR1, Control Relay Box, Figure 115
      - a) Not OK -- Replace diode, CR1
      - b) OK -- Correct wiring, 95% - A2 to CR23
- B Pneumatic duct pressure does not increase when Bleed Air switch is closed (engine at governed speed and Bleed Air light on)
  - (1) Check for 24 VDC at 95% -A1, Control Relay Box, Figure 115
    - (a) Not OK --
      - 1) Check for 24 VDC at 95% -X1, Control Relay Box, Figure 114
        - a) Not OK --
          - 1 Correct wiring, Centrifugal Switch Assembly -A to 95% -X1
          - 2 Replace Centrifugal Switch, AiResearch component, APU module, Figure 114

- b) OK --
- 2) Check for ground at 95%-X2.
  - a) Not OK -- Correct wiring, 95%-X2 to ground.
  - b) OK -- Replace 95% relay, Control Relay Box, Figure 114
- (b) OK --
- (2) Check for 24 VDC at P17-A, Bleed Valve connector plug, Figure 115
  - (a) Not OK -- Correct wiring, 95%-A1 to P17-A
  - (b) OK --
- (3) Check for ground at P17-B
  - (a) Not OK -- Correct wiring, P17-B to ground
  - (b) OK -- Replace bleed valve

## 9 ELECTRICAL LOADING

-- Refer to Chapter 24-49-01 Troubleshooting

## 10 SHUTDOWN

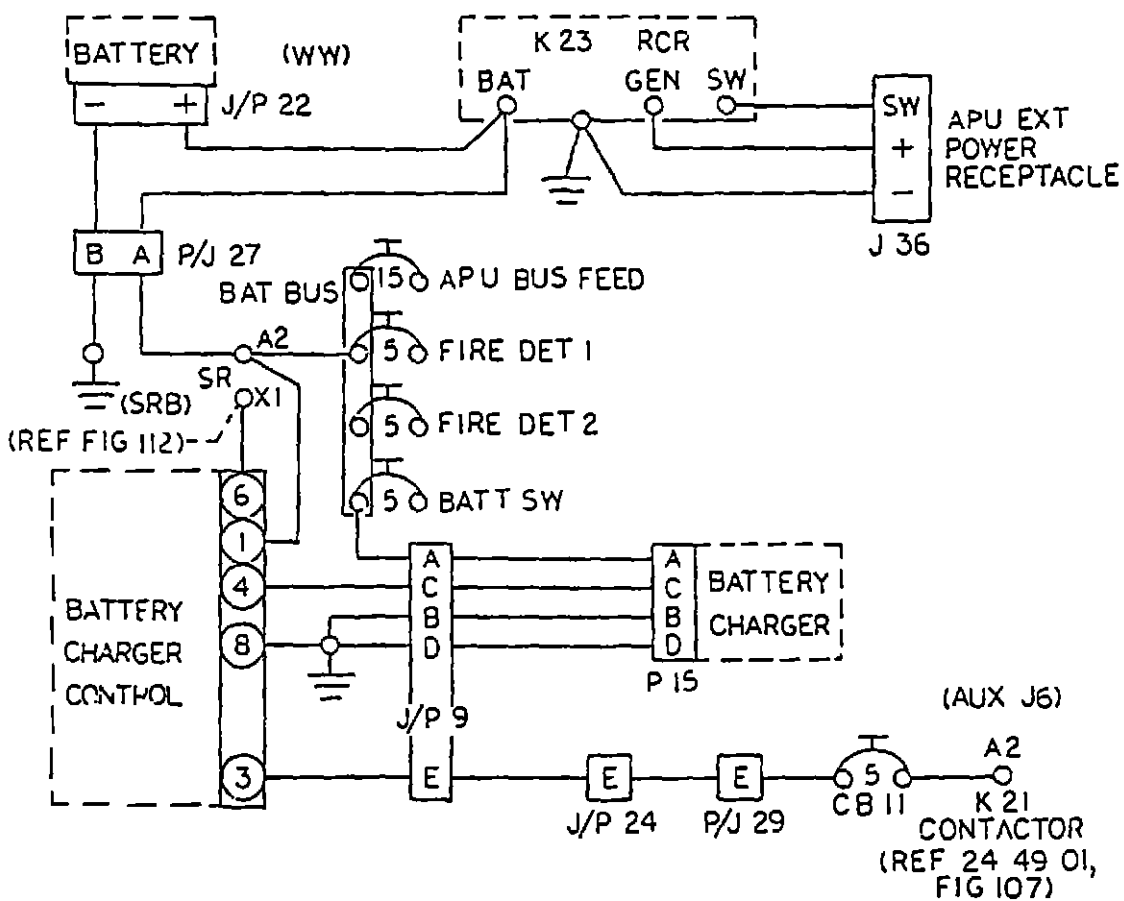
### A Overspeed Test Switch does not shut down engine

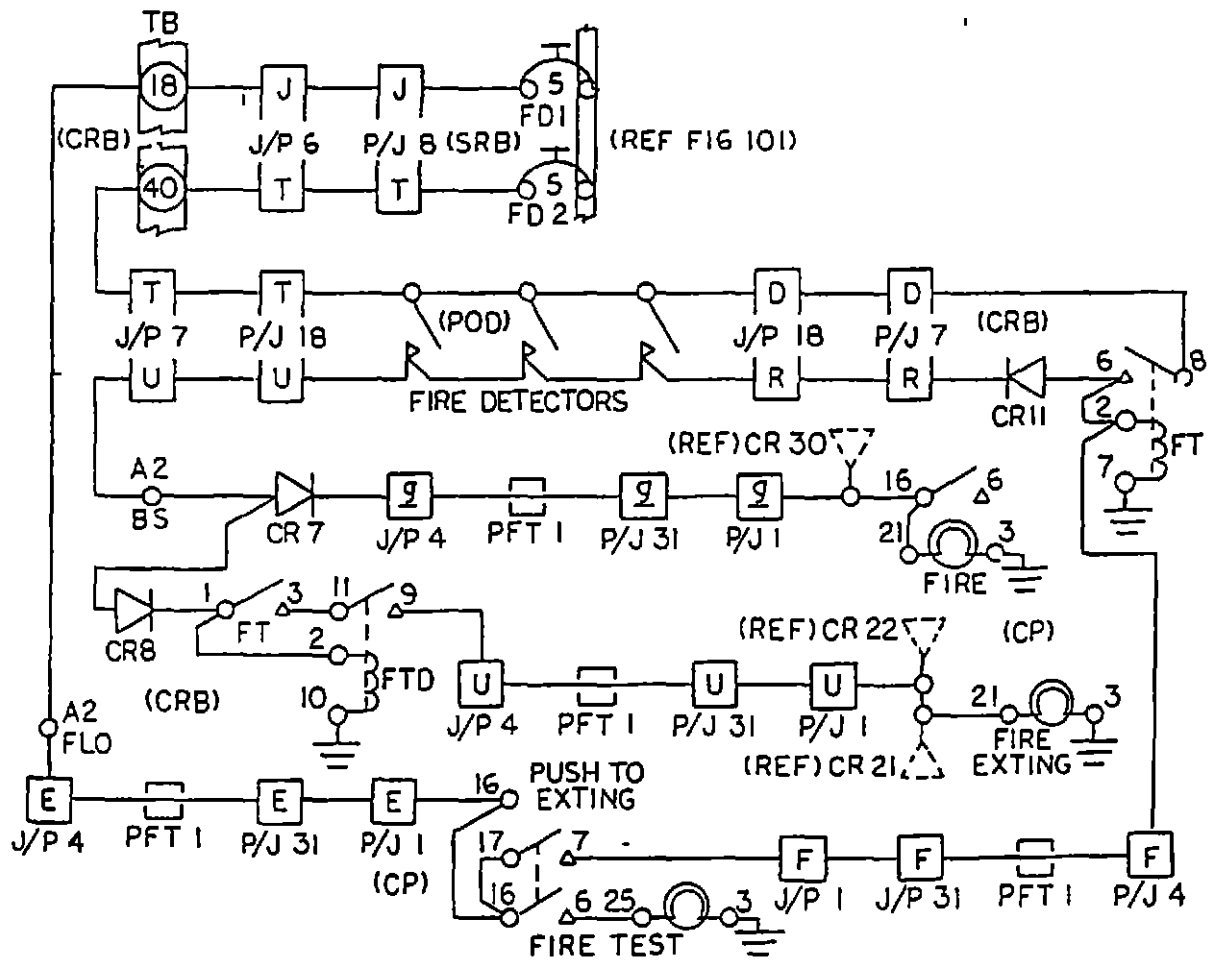
- (1) With Battery and Master switches closed (Master Light on), hold Overspeed Test switch closed and check for 24 VDC at TB-34, Control Relay Box, Figure 117.
  - (a) Not OK --
    - 1) Check for 24 VDC at Overspeed Test switch -C
      - a) Not OK -- Correct wiring, TB-31, Control Relay Box, to Overspeed Test switch, Figure 112
      - b) OK --
    - 2) Hold Overspeed Test switch closed and check for 24 VDC at NO terminal, Figure 117
      - a) Not OK -- Replace Overspeed Test switch

- b) OK -- Correct wiring, Overspeed Test switch to TB-34.
- (b) OK --
- (2) Hold Overspeed Test switch closed and check for 24 VDC at pneumatic solenoid valve connector plug -A, AirResearch component, APU module, Figure 117
  - (a) Not OK - Correct wiring, TB-34 to connector plug
  - (b) OK --
    - 1) Check for ground at connector plug -B
      - a) Not OK -- Correct wiring, connector plug -B to ground.
      - b) OK -- Replace pneumatic solenoid valve
- B High oil temperature does not shut engine down
  - (1) With Battery and Master switches closed (Master light on), check for 24 VDC at TB-31, Control Relay box, Figure 116
    - (a) Not OK -- Follow procedure 4 C(3)(a)2
    - (b) OK --
  - (2) Jumper TB-29 and 31 and check for 24 VDC at HOT-X1, Control Relay box, Figure 116
    - (a) Not OK -- Correct wiring, TB-29 to HOT-X1
    - (b) OK --
  - (3) Check for Open contacts, HOT-A2 to A3, Figure 112.
    - (a) Not OK
      - 1) Check for ground at HOT X2
        - a) Not OK -- Correct wiring, HOT-X2 to ground
        - b) OK -- Replace High Oil Temp relay, Control Relay box, Figure 116

- (b) OK -- Remove jumper TB-29 to 31
  - 1) Wiring TB-29/31 is open - correct wiring.
  - 2) High Oil Temp switch is not closing at temperature set point. (Refer to 6.C.(3)(a)2)a1 ) Replace High Oil Temp switch.
- C High Oil Temp light does not come on (B, above, is OK and Indicator Light Test, Figure 107, is OK)
  - (1) Check continuity of diode, CR6, Control Relay box, Figure 116
    - (a) Not OK -- Replace CR6
    - (b) OK -- Correct wiring, CR6 to CR29, Control Panel, Figure 116
- D Low Oil Pressure does not shut engine down
  - (1) With Battery and Master switches closed (Master light on) check for 24 VDC at TB-31, Control Relay box, Figure 116
    - (a) Not OK -- Follow procedure 4.C(3)(a)2
    - (b) OK --
  - (2) Jumper TB-28 and 31 and check for 24 VDC at TB-30
    - (a) Not OK --
      - 1) Wiring TB-28/30 to Low Oil Press switch connector plug, APU module, Figure 116, is open - correct wiring
      - 2) Normally closed contacts, Low Oil Press switch, are open (refer to 6.C (3)(a) 3)a1 ) - replace Low Oil Press switch
    - (b) OK --
  - (3) Check for 24 VDC at LOP-X1, Control Relay box, Figure 116
    - a) Not OK -- Correct wiring, TB-30 to LOP-X1
    - b) OK --

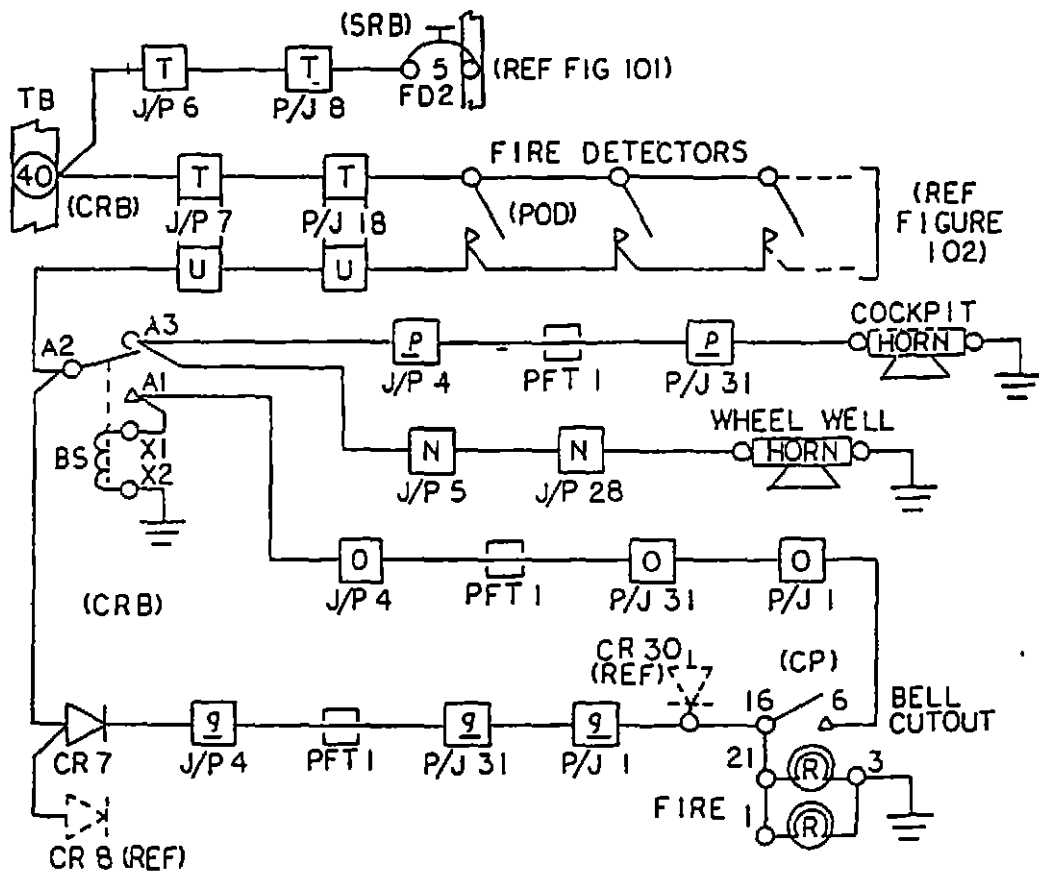
- (4) Check for open contacts, LOP-A2 to A3, Figure 112
- (a) Not OK --
    - 1) Check for ground at LOP-X2.
      - a) Not OK -- Correct wiring, LOP-X2 to ground.
      - b) OK -- Replace Low Oil Press relay, Control Relay box, Figure 116
    - (b) OK --
      - 1) Wiring, 95% -B1, Control Relay box, Figure 116, to TB-28 is open - correct wiring
      - 2) Wiring, TB-31 to 95% - B2, is open - correct wiring
      - 3) Normally open contacts, 95% - B2/B1, are not closing when engine RPM reaches 95% - check 95% relay operation, refer to function 7 B
- E Los Oil Press does not come on (D, above, and Indicator Light Test, Figure 107, is OK)
- (1) Check continuity of diode, CR5, Control Relay box, Figure 116
    - (a) Not OK -- Replace CR6
    - (b) OK -- Correct wiring, CR5 to CR27, Control Panel, Figure 116





**WIRE TRACE DIAGRAM**  
**APU FIRE TEST**  
**FIGURE 102**

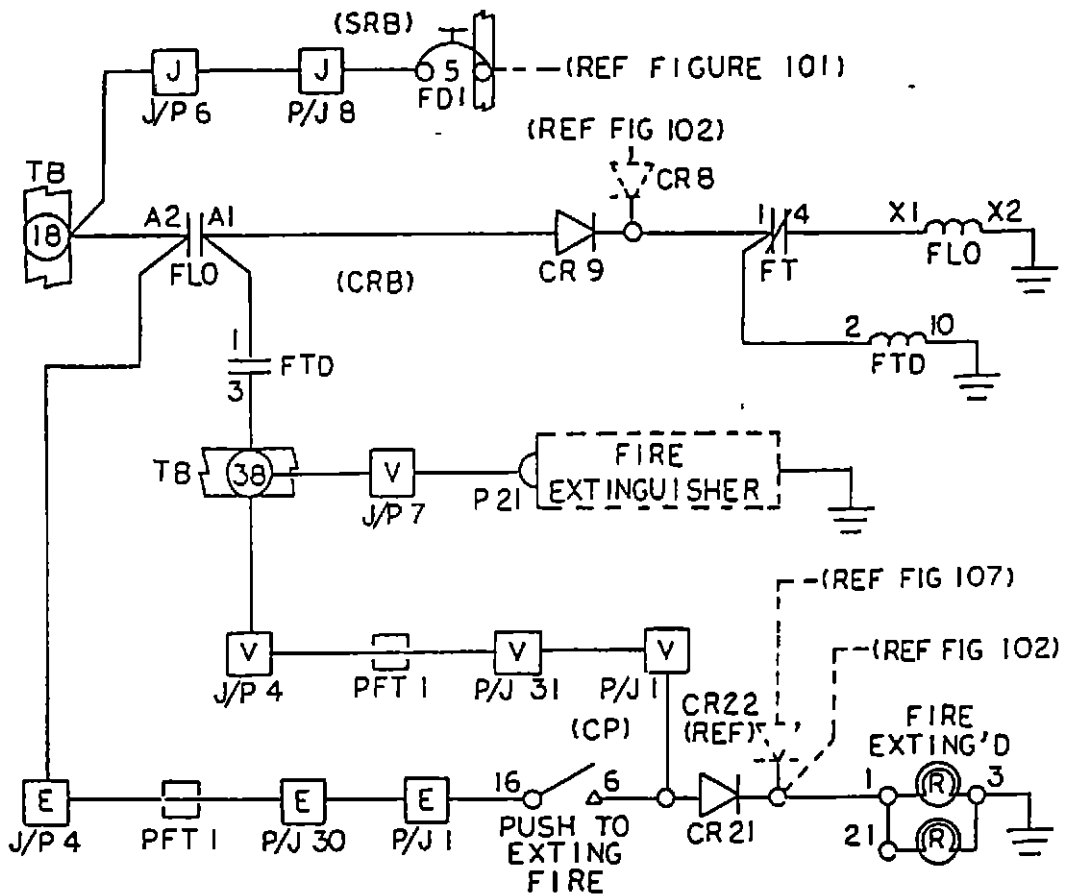
Ref.. MM STEWARD-DAVIS



**WIRE TRACE DIAGRAM**

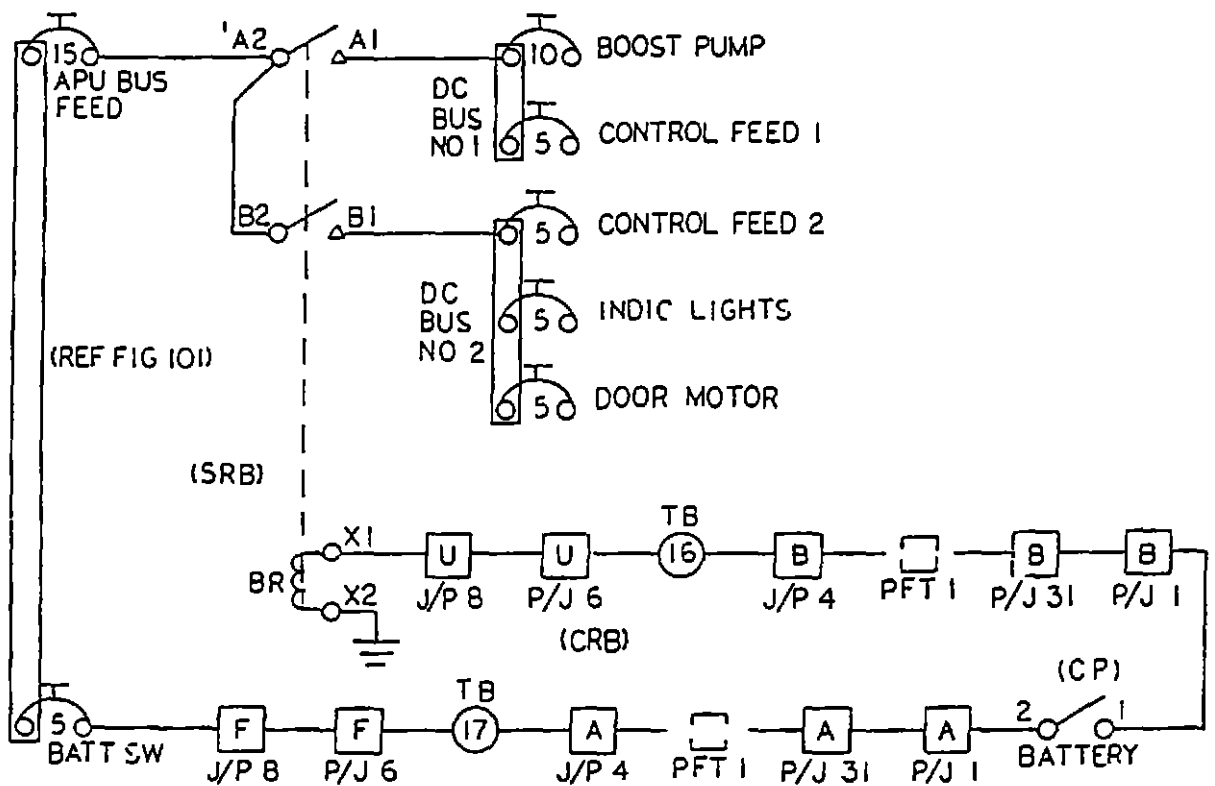
**APU FIRE WARNING**

**FIGURE 103**

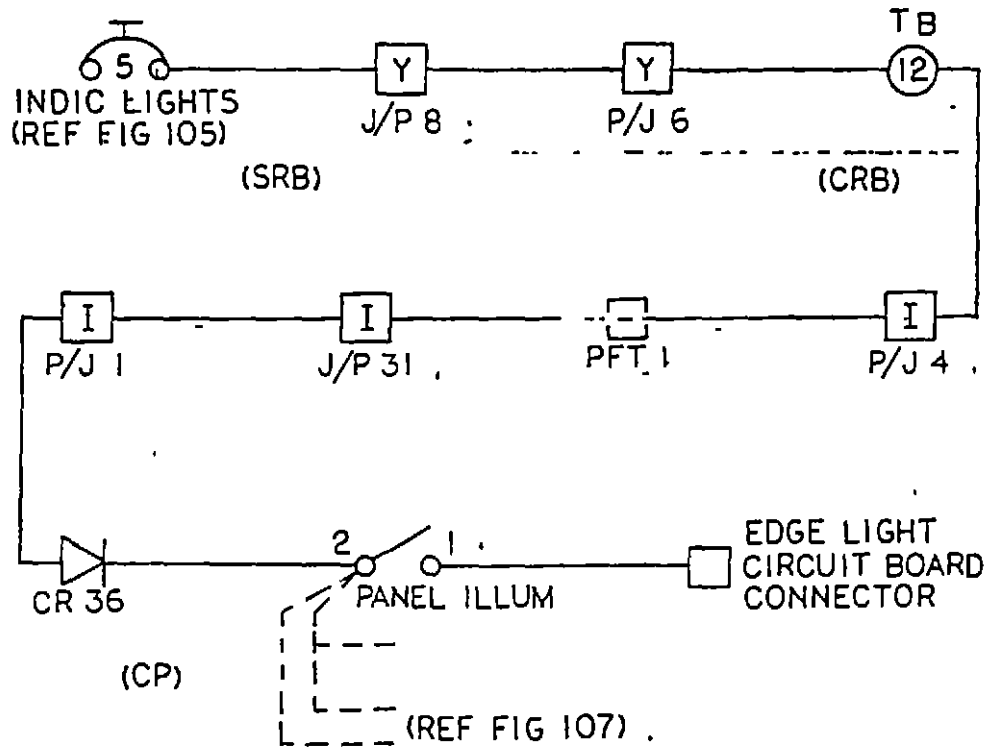


WIRE TRACE DIAGRAM  
 APU FIRE EXTINGUISHER ACTUATION  
 FIGURE 104

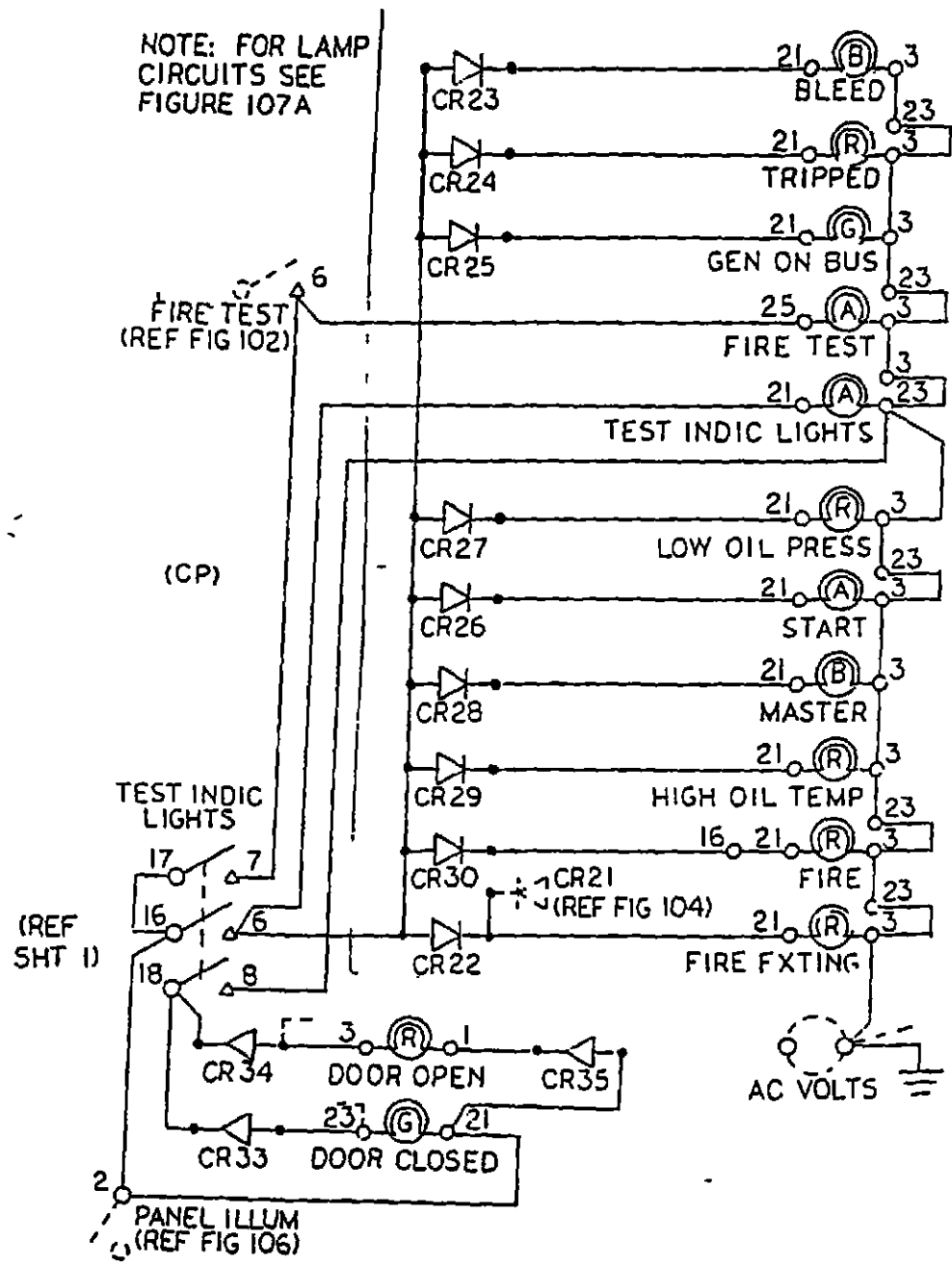
Ref. MM STEWARD-DAVIS



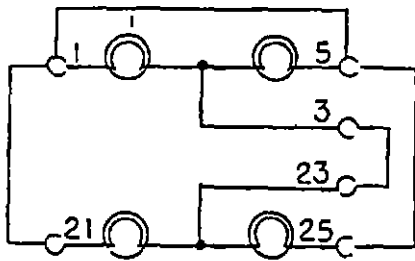
WIRE TRACE DIAGRAM  
 APU BATTERY RELAY  
 FIGURE 105



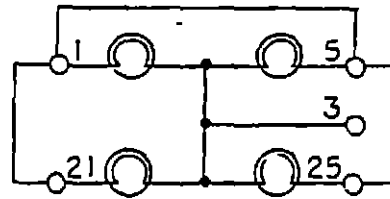
Ref . MM STEWARD-DAVIS



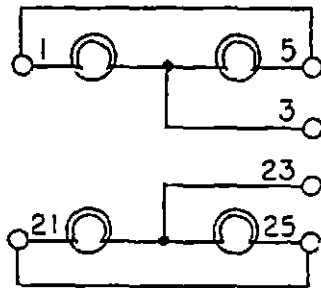
**WIRE TRACE DIAGRAM**  
**APU-INDIC LIGHT TEST**  
**FIGURE 107**



A



B

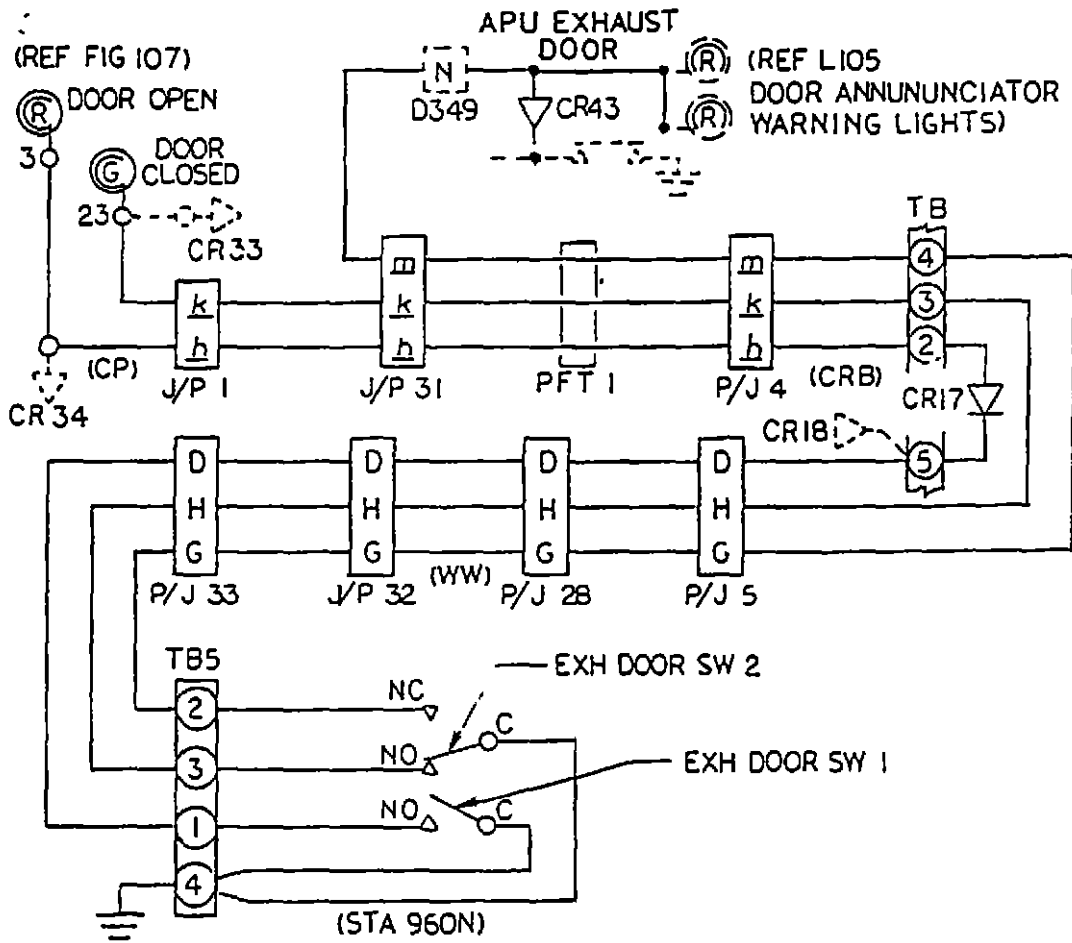


C

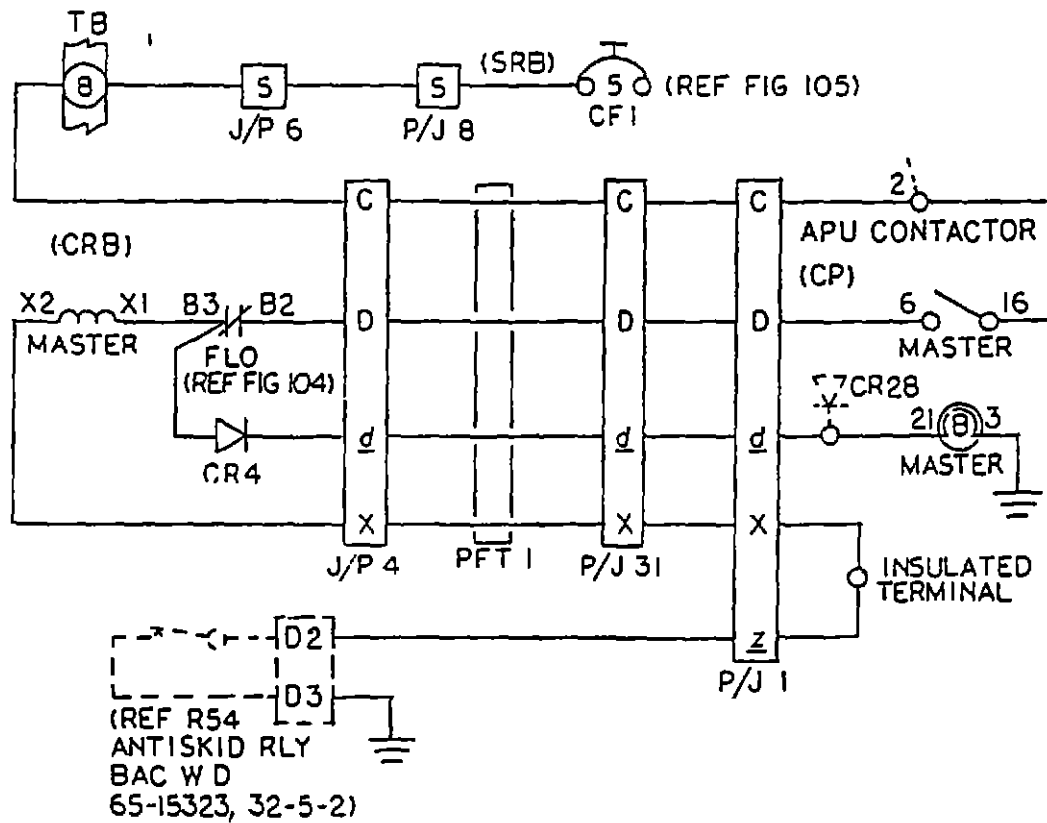
APPLICATION	
CIRCUIT	INDIC LIGHT
A	EXTING FIRE FIRE START TEST FIRE CIRCUIT TEST INDIC LIGHTS GEN TRIPPED
B	BLEED AIR GEN ON BUS HI OIL TEMP LOW OIL PRESS MASTER
C	DOOR OPEN /CLOSED

**WIRE TRACE DIAGRAM**  
**INDICATOR LAMP CIRCUITS**  
**FIGURE 107A**

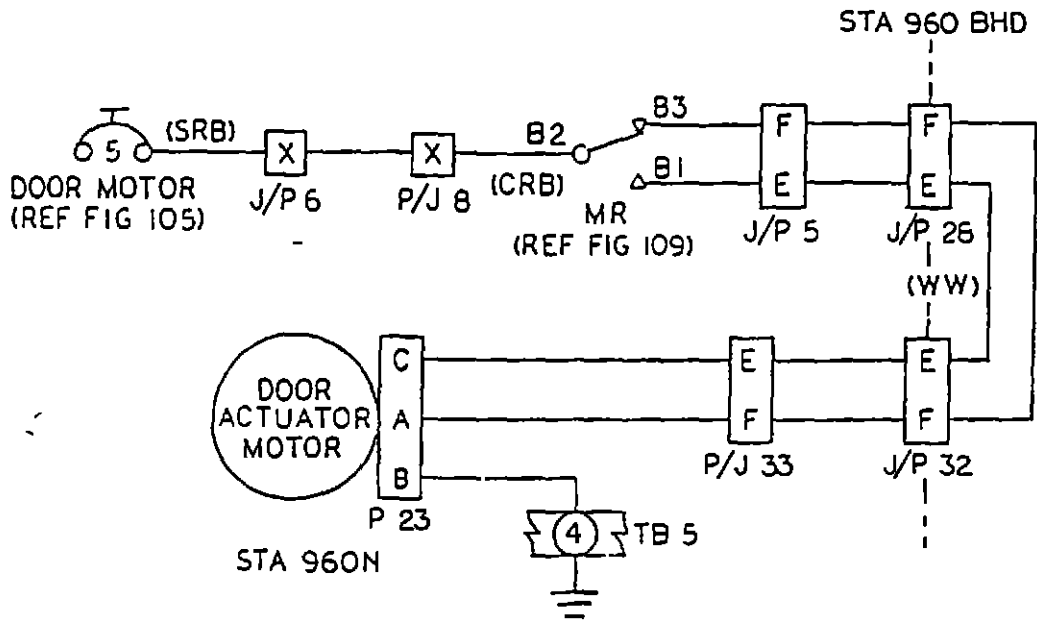
Ref. MM STEWARD-DAVIS



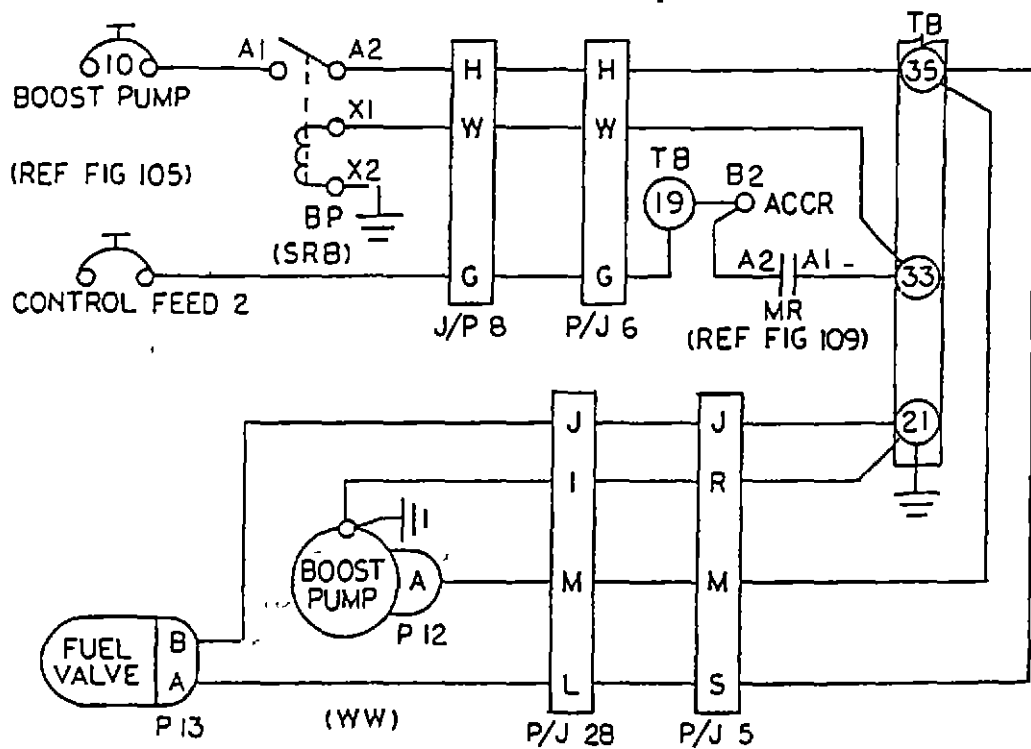
**WIRE TRACE DIAGRAM**  
**APU DOOR POSITION INDICATION**  
**FIGURE 108**



Ref . MM STEWARD-DAVIS



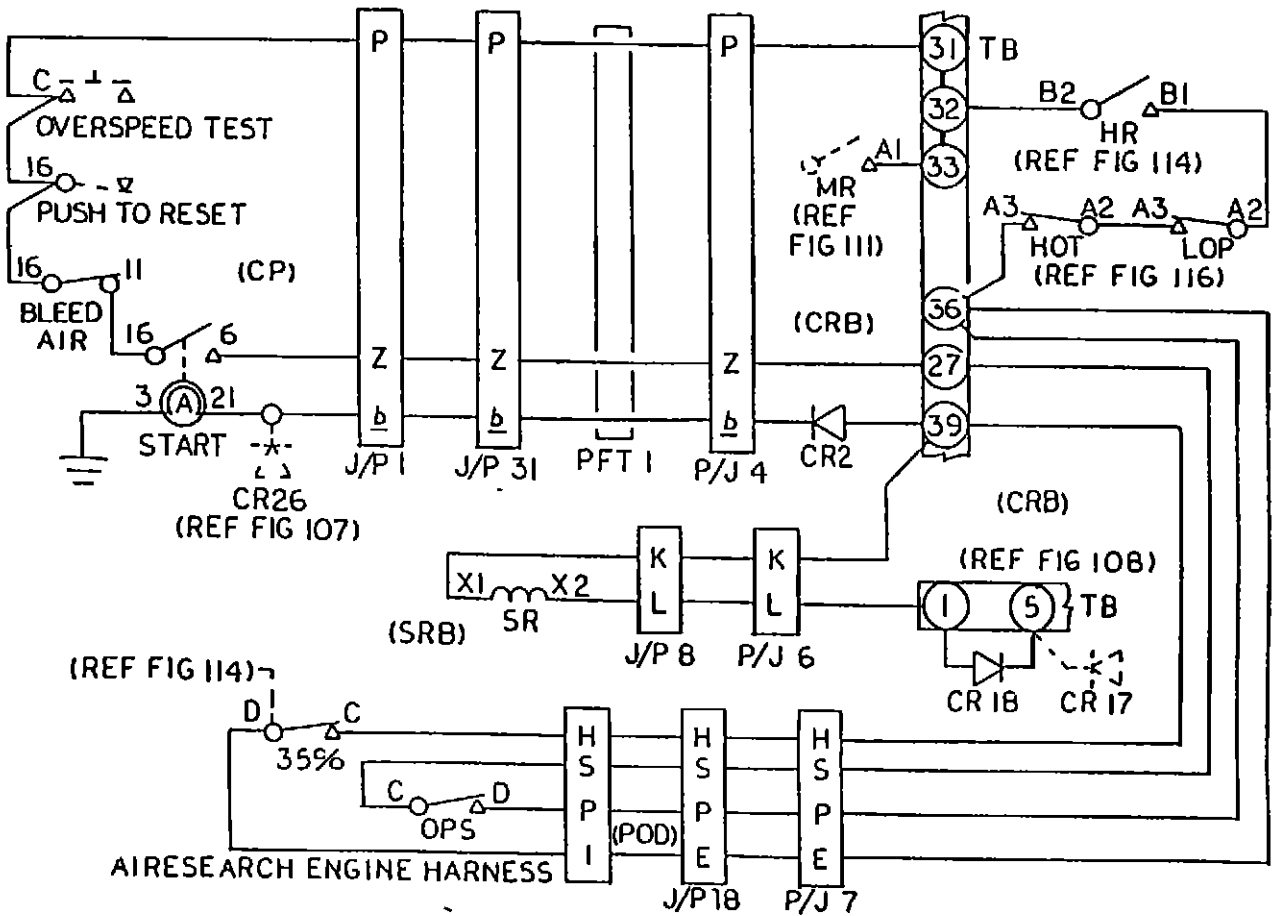
**WIRE TRACE DIAGRAM**  
**APU EXHAUST DOOR ACTUATOR**  
**FIGURE 110**

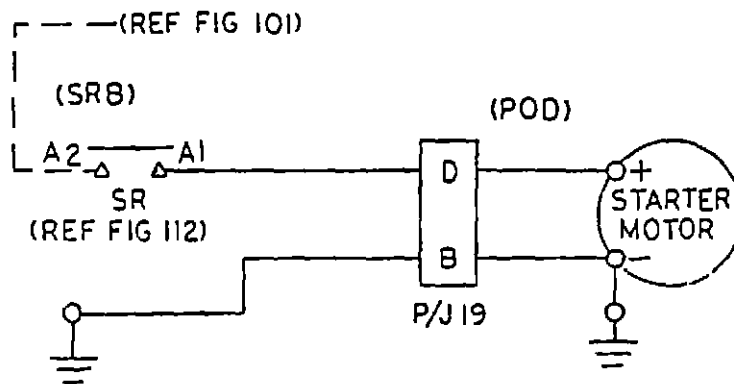


**WIRE TRACE DIAGRAM**  
**APU FUEL SUPPLY**  
**FIGURE 111**

Ref . MM STEWARD-DAVIS

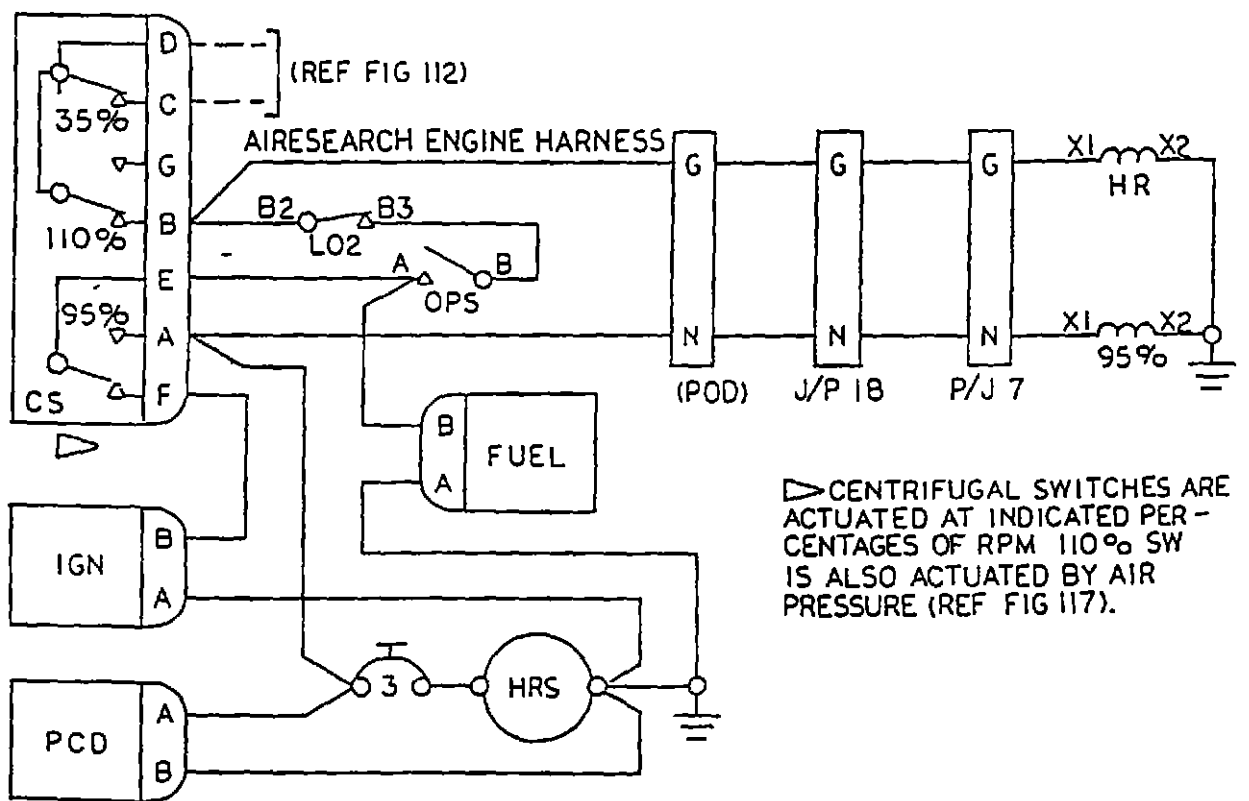
WIRE TRACE DIAGRAM  
APU STARTER  
FIGURE 112



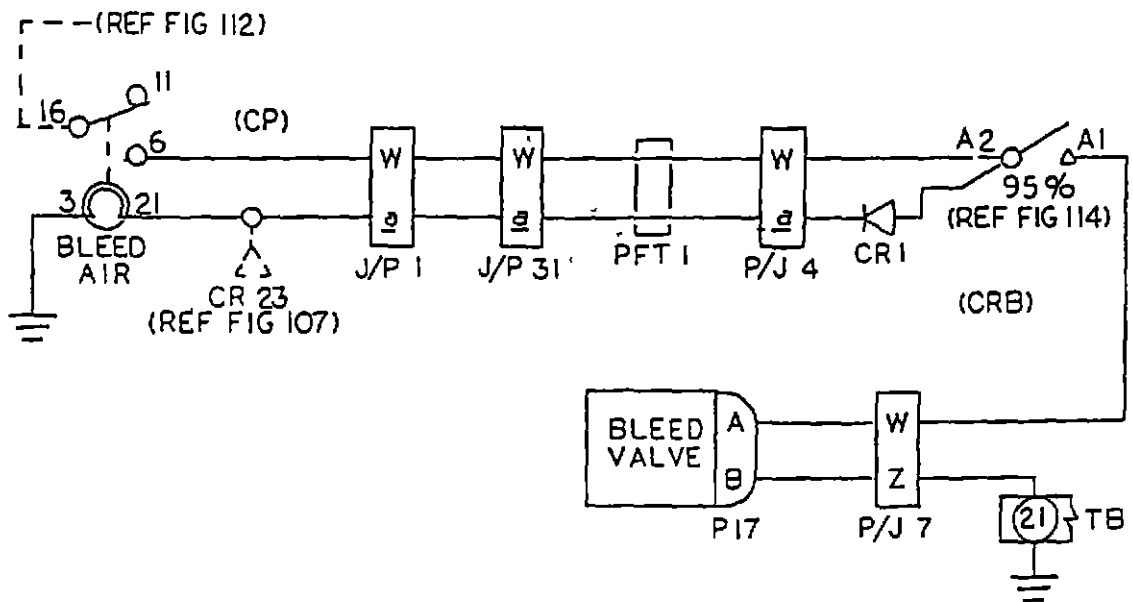


WIRE TRACE DIAGRAM  
 APU STARTER  
 FIGURE 113

Ref. MM STEWARD-DAVIS

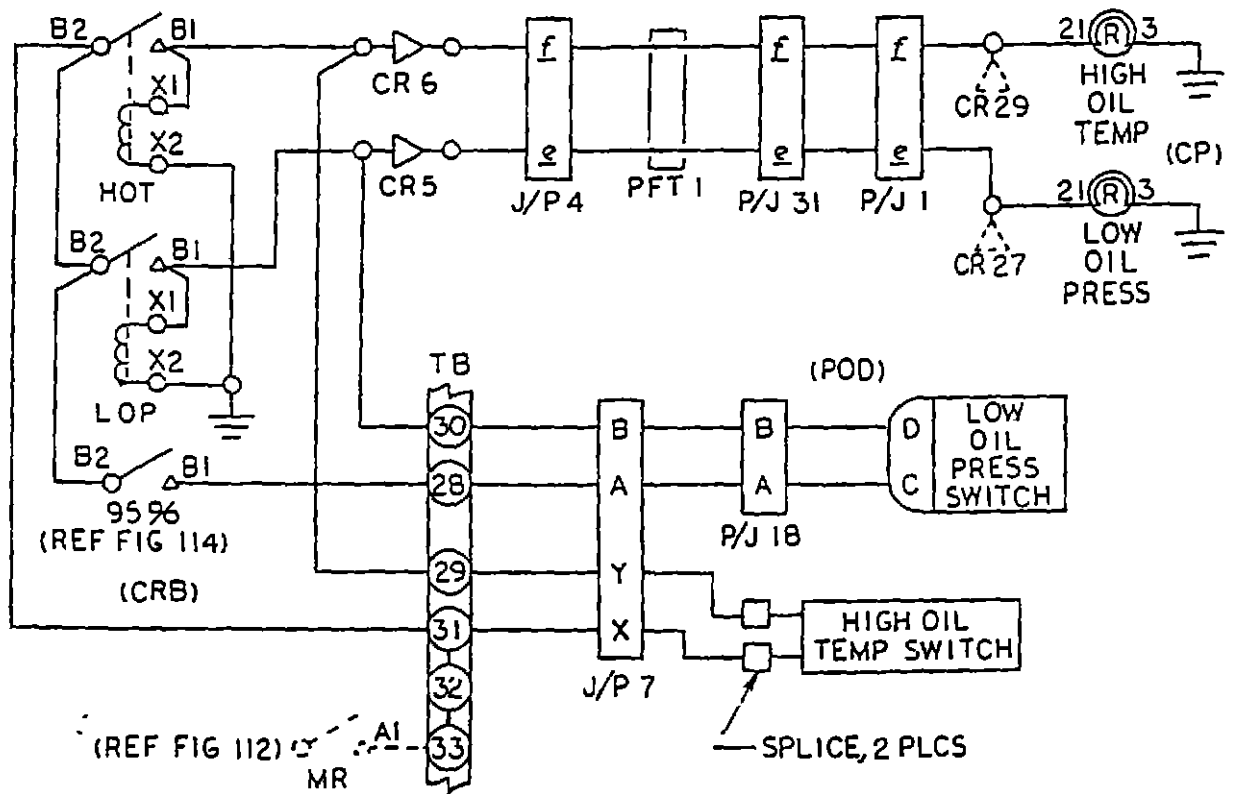


WIRE TRACE DIAGRAM  
 APU SEQUENCING SWITCHES  
 FIGURE 114



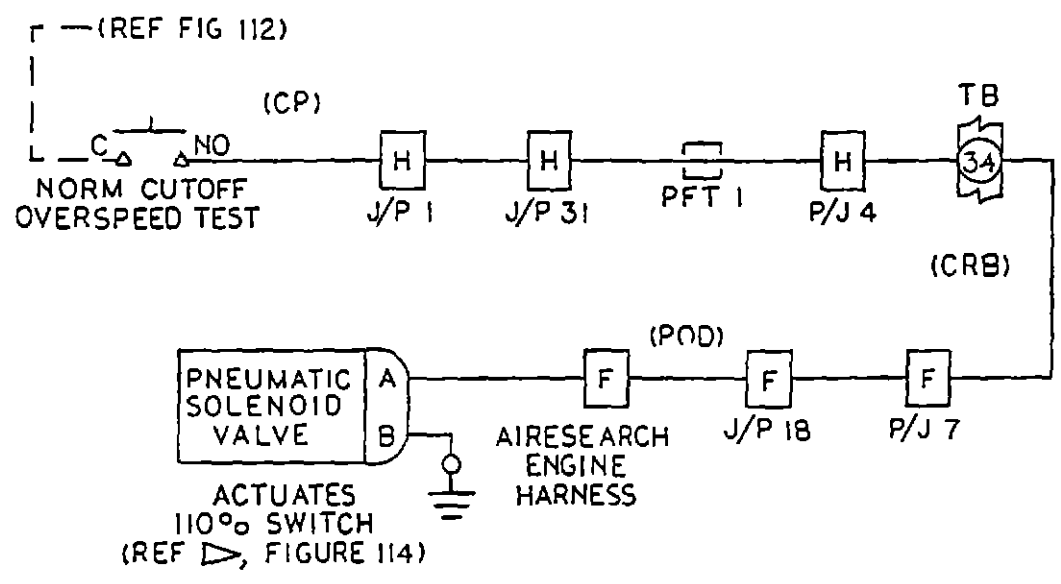
**WIRE TRACE DIAGRAM**  
**APU BLEED VALVE**  
**FIGURE 115**

Ref MM STEWARD-DAVIS



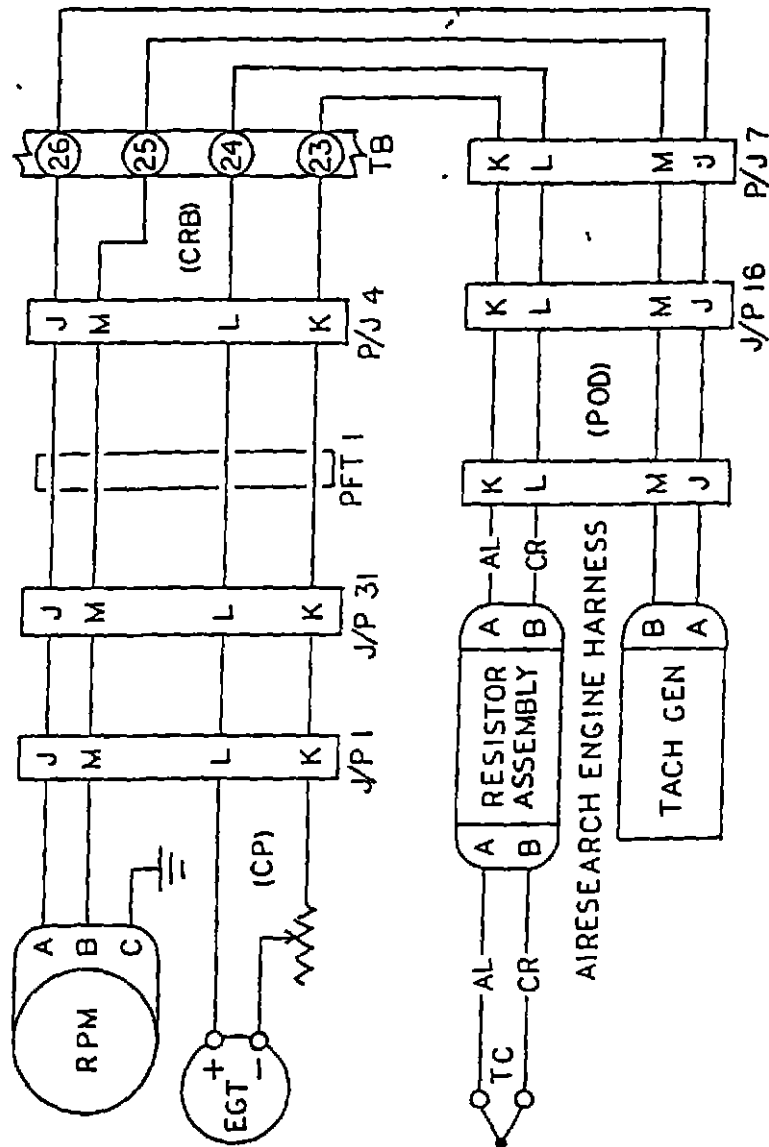
**WIRE TRACE DIAGRAM**  
**APU OIL TEMP/PRESS FAULT INDICATION**

**FIGURE 116**



**WIRE TRACE DIAGRAM**  
**APU SHUTDOWN**  
**FIGURE 117**

Ref MM STEWARD-DAVIS



**WIRE TRACE DIAGRAM**  
**APU EXHAUST GAS TEMPERATURE AND TACHOMETER INDICATION**  
**FIGURE 118**

  
**MAINTENANCE MANUAL**

TABLE 102  
 ENCLOSURES  
 IDENTIFICATION/LOCATION

<u>Abbr</u>	<u>Identification</u>	<u>Location</u>	<u>Drawing</u>	<u>Wiring Diagram</u>
AUX J6	Auxiliary Main AC Power Shield	Sta 271R		
CP	APU Control Panel	Sta 294R	90065	90065
CRB	Control Relay Box	Sta 960L	84501	84501
CXB	Current Transformer Box	Sta 960L	90516	90512
POD	APU Module	Sta 960R	84100	84504
SRB	Starter Relay Box	Sta 960L	90513	90501

TABLE 103  
 CIRCUIT BREAKERS  
 IDENTIFICATION/LOCATION

<u>Abbr /No.</u>	<u>Rating (Amps)</u>	<u>Circuit</u>	<u>Location</u>
BF	15	APU Bus Feed	SRB
BP	10	Boost Pump	SRB
BS	5	Battery Switch	SRB
CB 10	5	APU AC Voltmeter	AUX J6
CB 11	5	APU Battery Charger	AUX J6
CB 12	50	APU Essential Bus Feed, ØA	AUX J6
CB 13	50	APU Essential Bus Feed, ØB	AUX J6
CB 14	50	APU Essential Bus Feed, ØC	AUX J6
CF 1	5	Control Feed 1	SRB
CF 2	5	Control Feed 2	SRB
DM	5	Door Motor	SRB
FD 1	5	Fire Detector 1	SRB
FD 2	5	Fire Detector 2	SRB
IL	5	Indicator Lights	SRB
ØA	160	APU Generator Output, ØA	CXB
ØB	160	APU Generator Output, ØB	CXB
ØC	160	APU Generator Output, ØC	CXB

Ref. MM STEWARD-DAVIS



TABLE 104  
RELAYS  
IDENTIFICATION/LOCATION

<u>Abbr./No.</u>	<u>Identification</u>	<u>Location</u>
ACCR	Auxiliary Contactor Control Relay	CRB
AUS	Auxiliary Underspeed	SRB
BP	Boost Pump	SRB
BR	Battery Relay	SRB
BS	Bell Silence	CRB
CS	Current Sensor	CRB
CST	Current Sensor Transfer	CRB
FLO	Fire Lockout	CRB
FT	Fire Test	CRB
FTD	Fire Time Delay	CRB
HOT	High Oil Temperature	CRB
HR	Hold Relay	CRB
LO2	Lockout Number 2	POD
LOP	Low Oil Pressure	CRB
MR	Master Relay	CRB
95%	Ninety-five Percent	CRB
OC	Overcurrent	CRB
OCTD	Overcurrent Time Delay	CRB
OCTDBP	Overcurrent Time Delay Bypass	CRB
RCR K23	Reverse Current Relay	Sta
SR	Starter Relay	SRB
K20	APU Contactor Control	AUX J6
K21	APU Contactor	AUX J6
K22	APU External Power Interlock	AUX J6
K24	APU Essential Bus	AUX J6

**TABLE 105**  
**CONNECTORS**  
**IDENTIFICATION/LOCATION**

P. Connector Plug  
 J Connector Receptacle

<u>Number</u>	<u>Component</u>	<u>Location</u>
P/J(J/P)		CP
1		
2		
3	Differential Current Transformer	AUX J6
4		CRB
5		CRB
6		CRB
7		CRB
8		SRB
9		SRB
10		SRB
11		SRB
12	Fuel Boost Pump	WW
13	Fuel Valve	RH Fuel Jettison Mast. Compartment
14	Generator Protection Panel	Sta 1000
15	Battery Charger	Sta 1000
16		
17	Bleed Valve	Sta 960M
18		POD
19		POD
20		POD
21	Fire Extinguisher	Sta 960M
22	Battery	Sta 960
23	Door Actuator Motor	Sta 960N
27	Bulkhead	Sta 960R
28	Bulkhead	Sta 960R
29	Wing Fillet (Leading Edge)	Sta 600K
30	Wing Fillet (Leading Edge)	Sta 600K
31	Wing Fillet (Leading Edge)	Sta 600K
32	Bulkhead	Sta 960
33		Sta 960N
34		CXB
35		CXB
36	APU External Power Receptacle	Sta 960NR (Fillet Frg. (T/Edge)
PFT 1(2)	Pressure Feed Through, Bulkhead	Sta 960

Ref.. MM STEWARD-DAVIS



## MAINTENANCE MANUAL

### AUXILIARY POWER UNIT - MAINTENANCE PRACTICES

EFFECTIVITY RTCA LX-N19997 LX-N20000

#### 1 GENERAL

- A. The maintenance practices included in this section (201 through 299 page block) are general maintenance instructions that do not definitely fall within a specific category. Other maintenance instructions, such as Removal/Installation, Adjustment/Test, etc., are provided in the applicable page blocks.

#### 2 EQUIPMENT AND MATERIALS

- A. Two, two gallon containers
- B. Lubrication oil per Mil Specification MIL-L-7808 and MIL-L-23699 in accordance with Air Research Manufacturing Company of Arizona Specification GT-7800-R Rev 6

#### 3 APU OPERATION PROCEDURE

##### A. General

- (1) Before starting the unit, all protective covers must be removed and the air inlet must be clear of all loose objects that could be ingested. Lubricating oil and fuel supply sources must be serviced, and the APU battery must be charged. It is necessary to open the main landing gear doors to perform the prestart check, after completing the check, the doors may be closed since operation of the unit does not require them to be open. Initial start of a new or completely overhauled unit must be made in accordance with procedure outlined in paragraph 3 F.
- (2) The aircraft main fuel tank No. 3 must contain a minimum of 5,000 pounds of fuel for the parked airplane and a minimum of 11,400 pounds of fuel for airplane taxiing conditions. For extended usage, plan an additional 275 pounds of fuel for each hour of operation.

**CAUTION DO NOT OPERATE THE APU WHEN FLAMMABLE FLUID SUCH AS A CLEANING AGENT, IS BEING USED WITHIN THE VICINITY OF THE APU. IN PARTICULAR, THIS REFERS TO THE AREA NEAR THE APU COOLING AIR INLET, APU MAIN AIR INLET, AND APU EXHAUST DUCT.**

**DO NOT, AT ANY TIME, SPRAY FLUID INTO THE APU MAIN AIR INLET OR APU COOLING AIR INLETS.**

- (3) This section covers normal starting of the APU, starting of a new or overhauled unit, normal shutdown, manual fire alarm shutdown and automatic fire alarm shutdown

**B Depreservation of APU Fuel and Oil System**

- (1) Preparing APU installation for motoring over and initial start-up
- (a) Open right hand main landing gear door and
  - (b) Check battery is serviceable and is secure
  - (c) Check that main APU air intake and cooling air intake are clear and free from foreign objects
  - (d) Check all electrical connections on bulkhead 960 and fuel boost pump are secure
  - (e) Check that overboard drains in lower surface of right hand trailing edge wing root fairing are open and free from obstruction
  - (f) Check that aircraft fuel tank No 3 contains minimum fuel contents Service if necessary (Ref 3 A(2) above)
  - (g) Check APU oil system tank is full Service as required (Dip stick on oil tank cap )
  - (h) Check APU module assembly is secure on its mountings and that all connected system ducts and lines are in place and secure
  - (j) Check all electrical connections are in place and secure at the electrical control boxes on left hand side of aft face of bulkhead 960 and electrical connector panel on inboard side of APU module.
  - (k) Remove bolts securing top half of module housing and accessory end cover Remove associated cooling air ducts and lift cover sections away from module assembly
  - (l) Disconnect 28 VDC supply connector from igniter unit
  - (m) Disconnect fuel line from atomizer and place end of fuel line into suitable two gallon container
  - (n) Close all APU control circuit breakers on starter control box Leave generator circuit breakers open

**C Motoring the APU Prior to Initial Start-up**

- (1) Turn on battery switch on APU cockpit control panel. Check minimum 22 volts dc available.
- (2) Test APU indicating lights on APU cockpit control panel
- (3) Carry out APU fire extinguisher circuit test
- (4) Depress momentarily APU master switch to ON
- (5) Motor the APU engine by depressing the Start switch lite momentarily

**CAUTION** HIGH ENERGY ELECTRICAL STARTERS ARE EASILY DAMAGED TO PREVENT DAMAGE, DO NOT EXCEED STARTER DUTY CYCLE OF ONE MINUTE "ON", FOUR MINUTES "OFF"

- (6) Continue motoring the engine, until fuel free of air bubbles is discharged into container

**NOTE** Clear fuel should normally appear within three motoring cycles

- (7) During cycling, ensure that oil is circulating to the engine by removing the oil line "return to tank" hose at the tank connection and placing the free end into a suitable two gallon container
- (8) Reconnect oil line "return to tank" hose when proper oil circulation has been established during the motoring over of the engine

**NOTE** Approximately two cups of oil is all that is necessary to be released from the oil system to establish circulation.

- (9) Terminate motoring run by momentarily depressing the APU Master Switch lite
- (10) Reconnect fuel line to a atomizer.
- (11) Reconnect oil return to tank line hose.
- (12) Replenish oil system with new oil to full mark on dipstick
- (13) Open all APU control circuit breakers.
- (14) Reconnect 28 volts dc supply electrical connector to igniter unit

- (15) Close Hour Meter circuit breaker.
  - (16) Re-install both the top half section and the accessory end cover, install attaching bolts and complete module assembly housing.
  - (17) Re-install module cooling air duct system to accessory end cover and bulkhead 960
  - (18) Close all APU control and generator circuit breakers
- D Operation - APU - Limitations, Starting, Loading, Stopping and Emergency Procedure

**WARNING** DURING OPERATION OF APU, PERSONNEL SHALL STAND CLEAR OF COMPRESSOR AIR INTAKE, HIGH TEMPERATURE EXHAUST AND PLANE OF ROTATION OF HIGH SPEED COMPRESSOR AND TURBINE

**NOTE** Switch off air bleed on APU cockpit control panel once the first main engine start has been accomplished and engine cross starts are to be initiated

- (1) Limitations - Observe the following operating limitations, see also Table 501, Chapter 49-20-02 Page 509/510
  - (a) Shut down the APU if its RPM exceeds 103% for a period of more than ten seconds
  - (b) Shut down the APU immediately if its RPM exceeds 108%
  - (c) Exhaust temperature

Continuous operation - 620°C maximum  
Never exceed - 660°C maximum

**NOTE 1** The never exceed temperature may be exceeded during engine (APU) starting and acceleration, provided the starting time does not exceed 30 seconds

**NOTE 2.** If the exhaust gas temperature (EGT) exceeds 710° during the start/acceleration cycle, shut down the APU and perform a "hot start" inspection.

NOTE 3 Maximum field altitude operation is limited to 14,000 feet

(2) Starting

NOTE 1 The following items should be checked prior to the initial APU start of the day in conjunction with the APU installation - Inspection/Check List (Ref Chapter 49-00-3, Page 601 through 605 and Table 601)

NOTE 2 If starting a new installation

All items per Para "B" 49-00-3, Page 202 and Para "C" Page 203 through Item 18 Page 204 and accomplish requirements of Para E Chapter 49-00-3, Page 20

NOTE 3 If a previously run installation.

Para "3" 49-00-3, Page 202 items (a) through (j)

- (a) Place the APU BATTERY switch to ON position DOOR CLOSED light illuminates (Green).
- (b) Press and hold the TEST INDIC LIGHTS switch-lite Check that all APU cockpit control panel indicator lights illuminate (Chapter 49-60-1, Figure 2) Release the switch-lite, the DOOR CLOSED light remains illuminated
- (c) Place PANEL LTS switch to ON position Check that the EDGE LIT front panel illuminates (Leave on, if required )
- (d) Press and release the TEST FIRE CIRCUIT switch-lite The TEST FIRE CIRCUIT and FIRE/HORN CUTOOUT switch-lites will illuminate and the APU Fire Warning Horns (Flight Deck and Right Hand Main Undercarriage Wheel Bay) will sound After 20 seconds, the FIRE/HORN CUTOOUT switch-lite will extinguish, the APU Fire Warning Horns will silence and the PUSH TO EXTING FIRE will illuminate. After an additional ten seconds the PUSH TO EXTING FIRE and TEST FIRE CIRCUIT switch lites will extinguish signalling the successful completion of the test

NOTE: Pressing the FIRE/HORN CUTOOUT switch-lite momentarily will silence the APU Fire Warning Horns in the Flight Deck and Right Hand Main Undercarriage Wheel Bay

- (e) Press and Release the MASTER switch-lite. The MASTER switch-lite will illuminate, the Exhaust Door will open, the DOOR OPEN light will illuminate on the APU Control Panel, (The APU DOOR OPEN light on the first officer's Door Annunciator panel will also illuminate when the APU Exhaust Door opens), the Fuel Supply Valve will open and the APU Fuel Boost Pump will start running.
- (f) Press and Release the START switch-lite
- 1) The START switch-lite will illuminate when the start relay is energized and will remain illuminated when the switch is released if the start relay has actuated (The start relay will not actuate until the APU Exhaust Door is fully open )
  - 2) The START switch-lite will extinguish when the engine speed has reached approximately 35% RPM. If the START switch-lite does not extinguish within 60 seconds, depress the MASTER switch-lite to de-energize the system (MASTER and START switch-lites will extinguish )
- NOTE The starter duty cycle is ONE MINUTE ON and FOUR MINUTES OFF. A cooling period of 30 MINUTES is required after four duty cycles
- (g) Monitor the PERCENT RPM indicator (tachometer) and EGT (exhaust gas temperature) until the APU reaches governed, no load, steady state speed.
- 1) Percent RPM  
Shutdown the APU if its RPM exceeds 103% for a period of more than ten seconds.  
NOTE: The maximum allowable momentary overshoot is 108%
  - 2) Exhaust Temperature  
Continuous Operation - 620°C maximum  
Never Exceed - 660°C maximum



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NOTE 1 The Never Exceed temperature may be exceeded during engine start and acceleration, provided the start time does not exceed 30 seconds.

NOTE 2. If Exhaust Gas Temperature exceeds 710°C during the start/acceleration cycle, shutdown the APU and carry out a HOT START inspection

NOTE 3 The APU is ready to load after a one minute warm-up period

### (3) APU Loading

(a) To pressurize the Aircraft Pneumatic System from the APU

- 1) Press and release the BLEED AIR switch-lite. The switch-lite will illuminate and the DUCT PRESSURE gauge on the Flight Engineer's upper panel will indicate a rise in duct pressure

(b) To power the Aircraft Electrical System from the APU, accomplish the following

- 1) Position the voltmeter essential power source selector (upper center Flight Engineers panel) to the APU position
- 2) Place the APU CONTACTOR switch in the CLOSE position momentarily, the GEN ON BUS light will illuminate, the switch toggle will return to center locked position, and the AMPS AC meter will indicate electrical load on the APU

NOTE To eliminate the possibility of a hung start during main engine starting with the APU, reduce the APU Electrical Load to 75 AMPS AC or LESS

If the 75 AMPS AC Load Limit is exceeded while running in air mode - (AIR BLEED ON) the APU generator will automatically trip OFF and the GEN TRIPPED switch-lite will illuminate



## MAINTENANCE MANUAL

### (4) APU Stopping

#### (a) Normal Procedure

- 1) Remove the Electrical and Pneumatic load from the APU and allow the APU to run at no load for at least three minutes to cool down the gas turbine engine
- 2) Depress the OVERSPEED TEST button momentarily. This will simulate an APU overspeed condition, causing the APU to shut down

**CAUTION** DO NOT ACTUATE THE MASTER SWITCH-LITE UNTIL THE APU HAS STOPPED ROTATING THIS ACTION WOULD CLOSE THE APU EXHAUST DOOR AND STOP COOLING AIRFLOW THROUGH THE ENGINE AND APU HOUSING DURING ENGINE SPINDOWN

- 3) When the APU has stopped rotating, press and release the MASTER switch-lite to close the APU Exhaust Door and shut down the APU fuel supply system
- 4) After the APU MASTER switch-lite has been actuated (pressed) to the open position (MASTER switch-lite extinguished) APU door closed (APU EXHAUST DOOR CLOSED LIGHT ILLUMINATED) place the APU battery switch to the OFF position.

#### (b) Emergency Procedure

- 1) Placing the APU BATTERY switch in the OFF position will shut down the APU immediately.

**NOTE:** This emergency stopping procedure will not close the APU Exhaust Door. Therefore, when the emergency has passed, place the APU BATTERY switch in the ON position. The still latched MASTER switch-lite will illuminate again. Depress the MASTER switch lite. This will close the Exhaust Door and shut down the APU Fuel System and the MASTER switch lite will extinguish. (APU Exhaust DOOR CLOSED light illuminates )

Ref MM STEWARD-DAVIS

- 2) Place the APU BATTERY switch to the OFF position.
- (5) Start Procedure Observations
- (a) General
    - 1) If light-off does not occur after 15 seconds of cranking, depress MASTER switch-lite to terminate start. Light-off is indicated by EGT rise
    - 2) If light-off occurs, but unit does not accelerate to 100 percent governed speed in 30 seconds, turn off battery switch to terminate start
    - 3) If start is aborted, observe a minimum of two minutes delay before attempting another start
    - 4) If a satisfactory start is not obtained on a second attempt, maintenance action is recommended
    - 5) If torching light off occurs, shut down per step 2) and render APU inoperative pending corrective action For corrective action, refer to Paragraph 7, Maintenance After Torching Light Off
  - (b) New/Completely Overhauled APU
    - 1) Perform steps (a) through (g) of Para D (2)
    - 2) Allow unit to run at governed speed for five minutes under no load conditions
    - 3) Shut down APU (Ref Para D (4)(a)2) Normal Procedure Para D(4)(b)1) Emergency Procedure )
    - 4) Replace Fuel Filter element (Refer to 49-32-32, Fuel Pump and Control Unit - Servicing)
    - 5) Replace Oil Filter element (Refer to 49-90-02 Oil Pump Maintenance Practices)
    - 6) Adjust unit (Refer to Auxiliary Power Unit - Adjustment/Test)
- (6) Automatic Fire Shutdown
- (a) General
    - 1) If a false fire warning or malfunction of the automatic shutdown circuit stops the unit, the cause must be located and corrected before the unit can be restarted.

- (b) If an automatic fire shutdown occurs, the FIRE/HORN CUTOFF switch-lite will extinguish when the fire detectors cool down to a temperature below their actuating point

**CAUTION**· REPLACEMENT APU SYSTEM AND OR COMPONENTS ENSURE THAT THE FIRE DETECTOR CIRCUIT BREAKER FD1 ON STA 960 STARTER RELAY BOX HAS BEEN CYCLED OPEN/CLOSED TO DEACTIVATE THE SELF-LOCKING CIRCUIT OF THE FIRE LOCK OUT RELAY (FLO) BEFORE ATTEMPTING TO INSTALL REPLACEMENT UNITS AND LEAVE OPEN UNTIL ALL WORK HAS BEEN ACCOMPLISHED

(7) Maintenance After Torching Light-Off

(a) General

- 1) A torching light-off is indicated by flames emitting from the APU exhaust duct. Primary causes for torching light-off are delayed ignition and excessive fuel. Delayed ignition results in fuel-air mixture being conducted through exhaust system. When ignition finally occurs, the fuel-air mixture is ignited causing flame emission from exhaust. Excessive amount of fuel can be caused by an improperly operating fuel atomizer, fuel pump and control unit acceleration limited valve opening pressure set higher than specified, or accumulation of fuel in turbine assembly which has not had time to drain a previously unsuccessful start attempt.

(b) Check ignition system

- 1) Check ignition unit power supply wiring.
- 2) Check high voltage lead for serviceability.
- 3) Test igniter plug. Refer to 49-40-22, Igniter Plug - Adjustment/Test
- 4) If igniter plug test reveals improper ignition system operation, replace ignition unit

- (c) Check combustion chamber liner for excessive carbon build-up. Refer to 49-20-12, Combustion Chamber Liner - Inspection/Check.

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(d) Test fuel system

- 1) Test fuel pump and control unit acceleration limiter valve opening pressure. Refer to 49-32 32, Fuel Pump and Control Unit - Adjustment/Test
- 2) Replace fuel atomizer, Refer to 49-32 32, Fuel Atomizer - Removal/Installation

EFFECTIVITY RTCA LX-N19997 LX-N20000

**APU INSTALLATION - INSPECTION/CHECK**

**1 GENERAL**

A general inspection for leakage at fittings, security of component part attachment, chafing of wiring harness and obstructions at inlet and exhaust areas shall be made at each inspection interval. Inspect all tubes for chafing, cracks, signs of corrosion, or other damage.

**2 PERIODIC INSPECTION**

**A Accomplish Inspections on Installed Engine (APU)**

- (1) Components listed in Table 601 shall be checked periodically at specified intervals. The periodic inspection interval should not be increased unless a program consisting of an incremental increase (100 to 150 APU hour increments) on a sampling basis is undertaken by the individual operator to substantiate that an increase in time between inspection intervals would not adversely affect the APU.

**NOTE** Oil system drain/refill and oil filter removal/replacement shall not exceed 700 APU hours maximum unless specific approval has been granted in writing by AiResearch. This limit is not an absolute maximum and may be increased on an individual airline basis when justified by AiResearch oil sampling program and operational experience.

- (2) Components listed in Table 601 and marked by an asterisk may be inspected by observation through the combustion chamber liner assembly opening in the turbine plenum assembly (combustor unit removed) and up the exhaust pipe, to the extent that the parts are visible. Inspect components to the inspection criteria outlined in 49-20-05, COMBUSTION AND EXHAUST SECTION, as applicable. If distress is observed, the engine shall be removed from the installation and a detailed inspection of all hot end section components (Table 601) accomplished. (Refer to Paragraph B.)

**TABLE 601. PERIODIC INSPECTION REQUIREMENTS**

Components	Interval (APU Hrs)	Nature of Inspection
<u>Engine (hot) Section</u>		
<p><b>NOTE:</b> Manufacturer recommends that the combustor unit consisting of a liner assembly, combustor cap, fuel atomizer assembly and igniter plug, be removed and re-installed as a unit</p>		
Combustor Unit	250	Remove and replace (Refer to 49-20-12).
Containment Ring	250	Check containment ring attaching washers for fretting. Replace attaching nuts and washers if fretting of washers exceed 50 percent of the washer thickness. (Refer to Heavy Maintenance Section of AIResearch Engine Overhaul Manual, Report No. 49-20-37 for replacement of nuts and washers.)
*Exhaust Pipe Assembly	800	Check for cracks. (Refer to 49-20-05.)
Exhaust Flange Assembly	800	Check for cracks. (Refer to 49-20-05.)
Oil Tank Vent Tube Assembly and Fitting	250	Check that tube assembly and fitting are not obstructed. (Refer to 49-20-05)
Turbine Plenum Gasket	250	Check for evidence of deterioration or leakage.
Turbine Plenum Assembly	250	Check for cracks. (Refer to 49-20-05.)
*Turbine Nozzle	250	Check for cracks, wear, deformation or erosion. (Refer to 49-20-05)
*Turbine Wheel	250	Inspect for cracks, erosion, and blade tip rubbing. (Refer to 49-20-05.)
<p>*These components may be inspected by observation through combustor unit opening and up exhaust flange assembly. If distress is observed, remove engine from installation and perform detailed hot section inspection. (Refer to Paragraph B)</p>		

TABLE 601. PERIODIC INSPECTION REQUIREMENTS (CONTINUED)

Component	Interval (APU Hrs)	Nature of Inspection
<u>Engine Fuel and Control Section</u>		
Fuel Control Unit	800	Check cracking pressure Refer to ADJUSTMENT/TEST.)
	250	Check that acceleration limiter valve orifice is not obstructed. (Refer to 49-32-32)
	2500	Lubricate drive shaft (Refer to 49-32-32)
Fuel Filter Element	250	Remove and replace (Refer to 49-32-32)
Turbine Plenum Drain	250	Clean and Inspect.
<u>Ignition/Starting Section</u>		
Electrical Engine Starter	1000- 1250	Remove and replace Send removed starter to authorized overhaul facility for brush change, clutch check and run-in or complete overhaul. (Refer to 49-40-53)
<u>Air Section</u>		
Air Pressure Regulator	250	Remove and clean. (Refer to AI-Research Maintenance Manual, Report No. 49-20-36, Sect. 49-50-07)
Orificed Tee Assembly	1000- 1250	Clean (Refer to CLEANING/PAINTING.)
<u>Control Section</u>		
Pneumatic (Load Control) Thermostat	250	Check calibration. Refer to ADJUSTMENT/TEST.)
<u>Oil Section</u>		
Lubrication Oil System	700	Drain and refill. (Refer to SERVICING.)
Oil Filter Element	250	Remove, clean and inspect. (Refer to 49-90-02)

APU FIRE DETECTION AND EXTINGUISHING SYSTEM

DESCRIPTION AND OPERATION

EFFECTIVITY TCA LX-N20198 LX-N20199

1. GENERAL

- A. The APU fire detection and extinguishing system provides the means to detect and automatically smother a fire within the APU housing with fire extinguishing agent. Fire warning is provided by a light on the APU control panel and by alarm horns located at the flight engineer's station and in the right main gear wheel well.
- B. The system consists of three fire detectors, a fire extinguisher bottle with discharge fittings and tubing, and control circuitry.
- C. The control of the APU fire detection and extinguishing system consists of fire control and fire test circuits, plus TEST FIRE CIRCUIT and PUSH TO EXTING FIRE switch-lites on the APU control panel. When energized by the closure of a fire detector, the fire control circuit activates the FIRE BELL CUTOUT light, the alarm horns, shuts down the APU engine immediately and automatically discharges the fire extinguisher bottle after a delay period which allows the APU exhaust door to close. The fire test circuit provides for testing the fire control circuit at any time by actuating the TEST FIRE CIRCUIT switch. The PUSH TO EXTING FIRE switch-lite provides for manual application of power to the detonator circuit of the fire extinguisher bottle to release the extinguishing agent if automatic discharge should not occur.
- D. The control circuitry of the fire detection and extinguishing system receives power directly from the APU battery bus through the FIRE circuit breaker. This assures power to the control circuits at all times, in flight or on the ground, no matter what position the APU BATTERY switch is in.

APU FIRE DETECTORS

- A. The APU fire detectors are probe type thermal switches that close when they are exposed to excessive temperature. Three detectors are located in the APU housing; one above the engine accessory section, one adjacent to the engine combustion chamber and one adjacent to the right hand side engine mount.

3. APU FIRE EXTINGUISHER BOTTLE AND FITTINGS

- A. A spherical steel bottle of Freon is mounted on the ceiling of the aft baggage compartment adjacent to the APU housing. The bottle is filled with 3.0 pounds of Freon and charged with dry nitrogen at about 600 PSI. A pressure gauge, a discharge plug and a safety discharge connections are provided on the bottle.

- B. The pressure gauge is visible from the baggage compartment only.
- C. The discharge plug is sealed with a frangible disc combined with an explosive charge which is electrically detonated to discharge the fire extinguisher bottle.
- D. Tubing leads from the safety discharge connection on the bottle to the lower body surface where it is capped with a red indicating disc. If the temperature rises above 266 ( $\pm 15$ ) degrees Fahrenheit, the disc will blow out, dumping the gas charge overboard and indicating that the bottle has discharged. The disc should be checked during the preflight walk-around inspection.
- E. When the bottle discharge plug is detonated, gas pressure operates a plunger to knock out a yellow indicator disc, adjacent to the red disc on the lower body, indicating that a discharge has occurred.
- F. The fire extinguisher bottle discharge line is a flexible steel tubing that connects the discharge plug to the APU housing. A baffle within the APU housing directs the Freon gas to all areas of the housing and prevents the gas from impinging directly on the engine control tubing and wiring.

#### 4 CONTROL CIRCUIT COMPONENTS

- A. The control circuit of the fire detection and extinguishing system consists of relays, time delay relays, switches and annunciator lights. The relays and time delay relays provide sequential control of desired functions and are interlocked to obtain necessary protective features.
- B. The relays are standard, single coil, units whose contacts return to the normal (tripped) position when power is removed from the actuating coil.
- C. The time delay relays do not actuate until an electronically timed period has elapsed after actuating power is applied. The contacts of these units return to the normal (tripped) position and the timing circuit resets when power is removed from the actuating coil.
- D. The TEST FIRE CIRCUIT and the (guarded) PUSH TO EXTING FIRE switch-lites are momentary devices which illuminate when activated (The PUSH TO EXTING FIRE switch-lite will illuminate if the fire bottle is detonated automatically or by manual selection.)

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## 5. OPERATION

### A Fire Control Circuit

- (1) The fire control circuit consists of the three fire detectors connected in parallel, a fire lockout relay (FLO), time delay relay (TD) and the fire extinguisher circuit. When a fire detector closes, power from the APU battery bus is applied to the FLO coil, the FIRE warning light and to the alarm horns. This causes the relay to actuate, the warning light to come on and the horns to sound. Actuation of the fire lockout relay performs the following functions:
- (a) One set of FLO contacts open to remove power from the master relay (MR) coil causing it to move to the normal (tripped) position. One set of MR contacts open to remove power from the engine fuel solenoid valve to shut down the engine. One set of normally closed contacts of the MR apply power to the close coil of the APU exhaust door actuator to close the exhaust door. One set of MR contacts open to interrupt power to the fuel boost relay (FBR) causing it to trip. When the FBR trips, power is removed from the fuel supply solenoid shutoff valve and the fuel boost pump causing the valve to close and the boost pump to stop running.
  - (b) One set of the FLO contacts close to apply power to the FLO (self-locking circuit) and time delay relay (TD) coils, and to a set of normally open contacts of the TD. After 20 seconds the TD actuates to apply power from the FLO to the fire extinguisher circuits to detonate the fire bottle discharge plug. This releases the extinguishing agent into the APU housing and causes the PUSH TO EXTING FIRE switch-light to illuminate.

NOTE· The FIRE circuit breaker on the APU battery bus must be opened to interrupt power to the self-locking circuit of the fire-lockout relay (FLO) to reset the fire control circuit after it is actuated by a fire detector.

- (c) One set of FLO contacts apply generator control unit (GCU) power to the trip coil of the generator field control relay to eliminate the APU generator as a possible source of ignition for the fire. This action will also trip the APU generator breaker to disconnect the generator from its load. (The GEN TRIPPED switch-light will come on and the GEN ON BUS light will go off when this action occurs.)
- (d) One set of FLO contacts open to remove power from the TEST FIRE CIRCUIT switch-light to assure that inadvertent actuation of the switch will not open the circuit to the fire extinguisher bottle detonator and prevent the discharge of the fire extinguishing agent.

- (2) To summarize, the following actions occur when a fire detector closes and actuates the fire circuit
- (a) FIRE light comes on
  - (b) Alarm horns sound
    - 1) Flight engineer's station
    - 2) Main landing gear wheel well
  - (c) Fire lockout relay actuates.
    - 1) Control power to master relay is interrupted
      - a) APU engine shuts down
      - b) APU exhaust door closes
      - c) Fuel boost relay trips to remove power from fuel supply solenoid valve and fuel supply boost pump
    - 2) A self-locking circuit to the FLO is completed and power is applied to time delay relay (TD)
      - a) After 20 seconds, the TD applies power to the fire bottle detonator circuit to release the fire extinguishing agent (PUSH TO EXTING FIRE switch-lite illuminates )
    - 3) Control power is applied to the trip circuit of the generator field control relay
      - a) GEN TRIPPED switch-lite comes on
      - b) GEN ON BUS light goes out (if on)
    - 4) Control circuit to TEST FIRE CIRCUIT switch-lite is interrupted

#### B. Fire Test Circuit

- (1) The fire test circuit consists of a test relay (TR), a fire warning test relay (FWT), a test time delay relay (TTD) and a press type momentary action TEST FIRE CIRCUIT switch-lite on the APU control panel. The circuit is energized by power from the APU battery bus through normally closed contacts of the fire-lockout relay when the TEST FIRE CIRCUIT switch-lite is pressed. Momentary closure of the switch-lite applies power to close the TR to perform the following functions

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- (a) One set of NC contacts open to interrupt the circuit to the detonator of the fire extinguisher disc.

NOTE. This action prevents the release of the fire extinguishing agent, automatically and/or manually, and fire protection is lost for the fire circuit test period of approximately 30 seconds duration.

- (b) One set of NO contacts close in the power circuit to the test time delay relay (TTD). Power is not available to the circuit and no action occurs until the time delay relay (TD) actuates.

- (c) One set of NO contacts applies power to two parallel circuits.

- 1) One circuit illuminates the TEST FIRE CIRCUIT switch-lite to indicate that the test has been energized and that the fire extinguisher detonator circuit is de-activated.
- 2) The second circuit, through NC contacts of the time delay relay (TD), applies holding power to the test relay (TR) and actuates the fire warning test relay (FWT).

- (2) Actuation of the fire warning test relay (FWT) simulates the closure of a fire detector and power is applied to the fire warning horns at the F/E station and in the main gear wheel well, to the FIRE horn CUTOUT switch-lite on the APU control panel, and to actuate the fire lockout relay (FLO) because a ground is available through NC contacts of the test time delay relay (TTD).

- (3) Actuation of the fire lock relay actuates the same sequence of events as described in paragraph 5A, Fire Control Circuit.

- (a) FIRE HORN CUTOUT switch-lite comes on.

- (b) Alarm horns sound.

- (c) Master relay trips.

- 1) APU exhaust door closes.

- 2) Fuel boost relay trips.

- a) Fuel supply solenoid valves closes

- b) Fuel supply boost pump stops running.

(d) After 20 seconds

- 1) PUSH TO EXTING FIRE switch-lite comes on
- \*2) FIRE HORN CUTOUT switch-lite goes out
- \*3) Test time delay relay is energized

(e) After 10 seconds (total time 30 seconds)

- 1) PUSH TO EXTING FIRE switch-lite goes out
- 2) TEST FIRE CIRCUIT switch-lite goes out

### C Manual Extinguish Circuit

- (1) The manual extinguish circuit applies power from the APU battery bus to the fire extinguisher detonator circuit by manual actuation of the PUSH TO EXTING FIRE switch-lite. A second set of contacts in the PUSH TO EXTING FIRE switch-lite applies GCU power to trip the APU generator breaker and field control relay. The MASTER switch-lite should be manually actuated to open the master relay and thereby stop the APU and close the APU exhaust door, approximately 20 seconds prior to pressing the PUSH TO EXTING FIRE switch-lite.

\* NOTE These actions only occur during fire circuit test



EFFECTIVITY RTCA LX-N19997 LX-N20000

**APU FIRE DETECTION AND EXTINGUISHING SYSTEM**  
**DESCRIPTION AND OPERATION**

**1 GENERAL**

- A The APU fire detection and extinguishing system provides the means to detect and automatically smother a fire within the APU housing with fire extinguishing agent. Fire warning is provided by a light on the APU control panel and by alarm horns located at the flight engineer's station and in the right main gear wheel well.
- B The system consists of three fire detectors, a fire extinguisher bottle with discharge fittings and tubing, and control circuitry.
- C The control of the APU fire detection and extinguishing system consists of fire control and fire test circuits, plus TEST FIRE CIRCUIT and PUSH TO EXTING FIRE switch-lites on the APU control panel. When energized by the closure of a fire detector, the fire control circuit activates the FIRE BELL CUTOFF light, the alarm horns, shuts down the APU engine immediately and automatically discharges the fire extinguisher bottle after a delay period which allows the APU exhaust door to close. The fire test circuit provides for testing the fire control circuit at any time by actuating the TEST FIRE CIRCUIT switch. The PUSH TO EXTING FIRE switch-lite provides for manual application of power to the detonator circuit of the fire extinguisher bottle to release the extinguishing agent if automatic discharge should not occur.
- D The control circuitry of the fire detection and extinguishing system receives power directly from the APU battery bus through the FIRE circuit breaker. This assures power to the control circuits at all times, in flight or on the ground, no matter what position the APU BATTERY switch is in.

**2 APU FIRE DETECTORS**

- A The APU fire detectors are probe type thermal switches that close when they are exposed to excessive temperature. Three detectors are located in the APU housing, one above the engine accessory section, one adjacent to the engine combustion chamber and one adjacent to the right hand side engine mount.

**3 APU FIRE EXTINGUISHER BOTTLE AND FITTINGS**

- A A spherical steel bottle of Freon is mounted on the ceiling of the aft baggage compartment adjacent to the APU housing. The bottle is filled with 30 pounds of Freon and charged with dry nitrogen at about 600 PSI. A pressure gauge, a discharge plug and a safety discharge connections are provided on the bottle.

- B. The pressure gauge is visible from the baggage compartment only
- C. The discharge plug is sealed with a frangible disc combined with an explosive charge which is electrically detonated to discharge the fire extinguisher bottle
- D. Tubing leads from the safety discharge connection on the bottle to the lower body surface where it is capped with a red indicating disc. If the temperature rises above 266 ( $\pm 15$ ) degrees Fahrenheit, the disc will blow out, dumping the gas charge overboard and indicating that the bottle has discharged. The disc should be checked during the preflight walk-around inspection.
- E. When the bottle discharge plug is detonated, gas pressure operates a plunger to knock out a yellow indicator disc, adjacent to the red disc on the lower body, indicating that a discharge has occurred.
- F. The fire extinguisher bottle discharge line is a flexible steel tubing that connects the discharge plug to the APU housing. A baffle within the APU housing directs the Freon gas to all areas of the housing and prevents the gas from impinging directly on the engine control tubing and wiring.

#### 4 CONTROL CIRCUIT COMPONENTS

- A. The control circuit of the fire detection and extinguishing system consists of relays, time delay relays, switches and annunciator lights. The relays and time delay relays provide sequential control of desired functions and are interlocked to obtain necessary protective features.
- B. The relays are standard, single coil, units whose contacts return to the normal (tripped) position when power is removed from the actuating coil.
- C. The time delay relays do not actuate until an electronically timed period has elapsed after actuating power is applied. The contacts of these units return to the normal (tripped) position and the timing circuit resets when power is removed from the actuating coil.
- D. The TEST FIRE CIRCUIT and the (guarded) PUSH TO EXTING FIRE switch-lites are momentary devices which illuminate when activated (THE PUSH TO EXTING FIRE switch-lite will illuminate if the fire bottle is detonated automatically or by manual selection.)



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## 5 OPERATION

### A Fire Control Circuit

(1) The fire control circuit consists of the three fire detectors connected in parallel, a fire lockout relay (FLO), time delay relay (TD) and the fire extinguisher circuit. When a fire detector closes, power from the APU battery bus is applied to the FLO coil, the FIRE warning light and to the alarm horns. This causes the relay to actuate, the warning light to come on and the horns to sound. Actuation of the fire lockout relay performs the following functions:

- (a) One set of FLO contacts open to remove power from the master relay (MR) coil causing it to move to the normal (tripped) position. One set of MR contacts open to remove power from the engine fuel solenoid valve to shut down the engine. One set of normally closed contacts of the MR contacts open to interrupt power to the fuel boost relay (FAR) causing it to trip. When the FAR trips, power is removed from the fuel supply solenoid shutoff valve and the fuel boost pump causing the valve to close and the boost pump to stop running.
- (b) One set of the FLO contacts close to apply power to the FLO (self-locking circuit) and time delay relay (TD) coils, and to a set of normally open contacts of TD. After 20 seconds the TD actuates to apply power from the FLO to the fire extinguisher circuits to detonate the fire bottle discharge plug. This releases the extinguishing agent into the APU housing and causes the PUSH TO EXTING FIRE switchlight to illuminate.

**NOTE** The FIRE circuit breaker on the APU battery bus must be opened to interrupt power to the self-locking circuit of the fire-lockout relay (FLO) to reset the fire control circuit after it is actuated by a fire detector.

- (c) One set of FLO contacts apply generator control unit (GCU) power to the trip coil of the generator field control relay to eliminate the APU generator as a possible source of ignition for the fire. This action will also trip the APU generator breaker to disconnect the generator from its load. (The GEN TRIPPED switch-light will come on and the GEN ON BUS light will go off when this action occurs.)
- (d) One set of FLO contacts open to remove power from the TEST FIRE CIRCUIT switch-light to assure that inadvertent actuation of the switch will not open the circuit to the fire extinguisher bottle detonator and prevent the discharge of the fire extinguishing agent.

- (2) To summarize, the following actions occur when a fire detector closes and actuates the fire circuit:
- (a) FIRE light comes on
  - (b) Alarm horns sound
    - 1) Flight engineer's station.
    - 2) Main landing gear wheel well
  - (c) Fire lockout relay actuates.
    - 1) Control power to master relay is interrupted
      - a) APU engine shuts down.
      - b) APU exhaust door closes
      - c) Fuel boost relay trips to remove power from fuel supply solenoid valve and fuel supply boost pump
    - 2) A self-locking circuit to the FLO is completed and power is applied to time delay relay (TD)
      - a) After 20 seconds, the TD applies power to the fire bottle detonator circuit to release the fire extinguishing agent (PUSH TO EXTING FIRE switch-lite illuminates )
    - 3) Control power is applied to the trip circuit of the generator field control relay
      - a) GEN TRIPPED switch-lite comes on
      - b) GEN ON BUS light goes out (if on)
    - 4) Control circuit to TEST FIRE CIRCUIT switch-lite is interrupted

#### B Fire Test Circuit

- (1) The fire test circuit consists of a test relay (TR), a fire warning test relay (FWT), a test time delay relay (TTD) and a press type momentary action TEST FIRE CIRCUIT switch-lite on the APU control panel. The circuit is energized by power from the APU battery bus through normally closed contacts of the fire-lockout relay when the TEST FIRE CIRCUIT switch-lite is pressed. Momentary closure of the switch-lite applies power to close the TR to perform the following functions

- (a) One set of NC contacts open to interrupt the circuit to the detonator of the fire extinguisher disc

NOTE: This action prevents the release of the fire extinguishing agent, automatically and/or manually, and fire protection is lost for the fire circuit test period of approximately 30 seconds duration

- (b) One set of NO contacts close in the power circuit to the test time delay relay (TTD) Power is not available to the circuit and no action occurs until the time delay relay (TD) actuates
- (c) One set of NO contacts applies power to two parallel circuits
  - 1) One circuit illuminates the TEST FIRE CIRCUIT switch-lite to indicate that the test has been energized and that the fire extinguisher detonator circuit is de-activated
  - 2) The second circuit, through NC contacts of the time delay relay (TD), applies holding power to the test relay (TR) and actuates the fire warning test relay (FWT)
- (2) Actuation of the fire warning test relay (FWT) simulates the closure of the fire detector and power is applied to the fire warning horns at the F/E station and in the main gear wheel well, to the FIRE horn CUTOUT switch-lite on the APU control panel, and to actuate the fire lockout relay (FLO) because a ground is available through NC contacts of the test time delay relay (TTD)
- (3) Actuation of the fire lock relay actuates the same sequence of events as described in paragraph 5A, Fire Control Circuit.
  - (a) FIRE HORN CUTOUT switch-lite comes on
  - (b) Alarm horns sound
  - (c) Master relay trips
    - 1) APU exhaust door closes
    - 2) Fuel boost relay trips
      - a) Fuel supply solenoid valves closes.
      - b) Fuel supply boost pump stops running.

- (d) After 20 seconds
  - 1) PUSH TO EXTING FIRE switch-lite comes on.
  - \*2) FIRE HORN CUTOUT switch-lite goes out
  - \*3) Test time delay relay is energized
- (e) After 10 seconds (total time 30 seconds)
  - 1) PUSH TO EXTING FIRE switch-lite goes out
  - 2) TEST FIRE CIRCUIT switch-lite goes out

### C Manual Extinguish Circuit

- (1) The manual extinguish circuit applies power from the APU battery bus to the fire extinguisher detonator circuit by manual actuation of the PUSH TO EXTING FIRE switch-lite. A second set of contacts in the PUSH TO EXTING FIRE switch-lite applies GCU power to trip the APU generator breaker and field control relay. The MASTER switch-lite should be manually actuated to open the master relay and thereby stop the APU and close the APU exhaust door, approximately 20 seconds prior to pressing the PUSH TO EXTING FIRE switch-lite.

\*NOTE These actions only occur during fire circuit test



## MAINTENANCE MANUAL

### APU - AIRPLANE PNEUMATIC SYSTEM INTERFACE

EFFECTIVITY TCA LX-N20198 LX-N20199

#### 1. GENERAL

- A. The airplane pneumatic system normally supplies high temperature compressed air for cabin airconditioning, main engine starting and for cabin pressurization in flight.
- B. The airplane pneumatic system consists, in part, of left and right wing manifolds connected across the fuselage by a crossover duct. The APU pneumatic system interfaces with the airplane pneumatic system at the crossover duct, and consists of one flapper-type check valve, bleed air manifold, APU bleed air duct, and transition duct.
- C. The flapper-type check valve prevent the reverse flow of compressed air through the APU from the main engines.
- D. The APU bleed air duct carries the APU output from the Sta. 960 bulkhead to the Sta. 600K pressure bulkhead through the left hand side of the airplane keel beam in a 5-inch diameter, stainless steel, duct. (Warm air to the aft cabin was previously routed through this area of the keel beam in an airconditioning system duct. This warm air is now carried aft in a duct above the cabin ceiling )
- E. The transition duct is a 5-inch stainless steel duct that carries the APU bleed air output from the Sta. 600K bulkhead to connect with the airplane crossover duct.

**APU - AIRPLANE PNEUMATIC SYSTEM INTERFACE**

EFFECTIVITY RTCA LX-N19997 LX-N20000

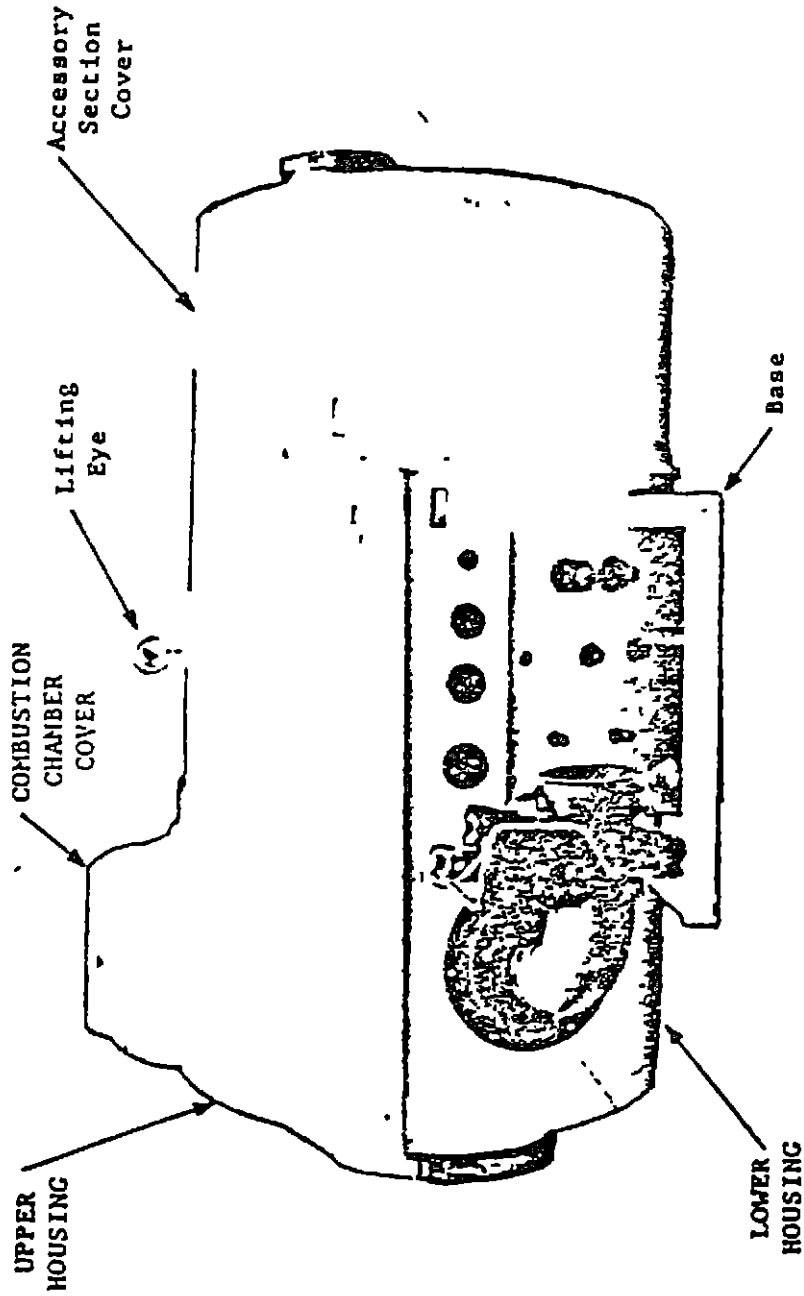
1 **GENERAL**

- A The airplane pneumatic system normally supplies high temperature compressed air for cabin airconditioning, main engine starting and for cabin pressurization in flight.
- B The airplane pneumatic system consists, in parts, of left and right wing manifolds connected across the fuselage by a crossover duct. The APU pneumatic system interfaces with the airplane pneumatic system at the crossover duct, and consists of one flapper-type check valve, bleed air manifold, APU bleed air duct, and transition duct.
- C The flapper-type check valve prevent the reverse flow of compressed air through the APU from the main engines.
- D The APU bleed air duct carries the APU output from the Sta 960 bulkhead to the Sta 600K pressure bulkhead through the left had side of the airplane keel beam in a 5-inch diameter, stainless steel, duct. (Warm air to the aft cabin was previously routed through this area of the keel beam in an airconditioning system duct. This warm air is now carried aft in a duct above the cabin ceiling.)
- E The transition duct is a 5-inch stainless steel duct that carries the APU bleed air output from the Sta 660K bulkhead to connect with the airplane crossover duct.

APU POWERPLANT (MODULE)  
DESCRIPTION AND OPERATION

1' GENERAL

- A. The APU module provides a "quick-change" package containing an APU engine, engine accessories and ac generator, plus necessary plumbing, wiring and control components all enclosed in a pressure-tight, fire-proof, insulated housing.
- B. The APU module housing provides quick-disconnects for all fluid lines and electric cables. Air intake and exhaust ducting are connected to the housing through Marman type clamps to expedite the removal and installation of the module in the cargo compartment. Provisions are made in the upper housing for installing hardware to lift the module and move it to and from the aft cargo door.



APU Module

FIGURE 1



EFFECTIVITY TCA LX-N20198 LX-N20199

AUXILIARY POWER UNIT - REMOVAL/INSTALLATION

1. General

A. The following procedure is applicable to the Removal/Installation of the APU on the airplane in the aft lower cargo compartment.

2. Equipment

A Hoist - P/N 90072-1

B. Rail - P/N 76239-1

C Transporter Dolly

D. Torquemeter

E. Lifting Eye

3 Remove APU from Aft Lower Cargo Compartment

A. On flight deck electrical equipment

(1) Pull out all APU circuit breakers, including GEN CONTROL Panel breaker

(2) Pull out APU MAIN BATTERY circuit breaker, BATTERY CHARGE and VOLTMETER circuit breakers.

(3) Position APU START switch to OFF and place tag "WARNING - DO NOT OPERATE APU".

B Remove cooling air duct

C. Disconnect electrical connectors J16, J18, J19 and J20.

D Disconnect Oil Quantity Indicator wire bundle.

E. Disconnect fire extinguisher hose.

F. Disconnect drain from shroud

G Remove exhaust pipe and support link

H. Remove APU air inlet duct.

- I Disconnect APU breather hose and vent line from oil tank.
- J Remove vent line and oil line to tank.
- K. Remove fuel inlet and vent line.
- L. Remove oil to engine hose.
- M. Drain oil tank and remove oil tank.
- N. Remove air pressure duct, load control valve and pressure sensing line.
- O Install rail, hoist with two spacers and lifting eye.
- P. Remove the four support module attaching bolts, spacers and nuts
- Q. Remove APU from aircraft lower aft cargo compartment.
- R Install APU on transporter dolly

#### 4 Install APU in Aft Lower Cargo Compartment

##### A Prepare APU for installation

- (1) Visually inspect APU prior to installation in housing
- (2) Install APU shock mount supports in lower housing section  
Torque bolts to a value of  $150 \pm 10$  lbs/inch.
- (3) Install and attach all clamps, cooling air inlet duct coupling, all connectors, cooling air exhaust and quick disconnects.
- (4) Check silicone rubber sealant on housing sections for good condition  
Repair or replace if necessary using RTV88 silicone rubber (red) sealant

NOTE Sealant RTV732 may be used as an alternate.

- (5) Visually inspect for cleanliness and forgotten tools
- (6) Close APU engine housings (upper housing section, combustion chamber housing, front and rear housing sections) (See 49-10-0 Description/Operation - Figure 1).
- (7) Tighten bolts and nuts to a torque value of  $55 \pm 5$  lbs/inch

B Install APU in Aft Lower Cargo Compartment

- (1) Install APU module and support on frame
- (2) Install and torque the four attaching bolts, spacers and nuts to a torque value of 200 to 260 lbs/inch
- (3) Remove lifting eye, hoist with two spacers and rail
- (4) Install APU exhaust pipe and support link
- (5) Install APU air inlet duct
- (6) Reconnect drain to shroud
- (7) Reconnect fire extinguisher hose
- (8) Reconnect oil breather hose and vent line to oil tank
- (9) Reconnect oil drain line
- (10) Install fuel inlet and vent line
- (11) Install oil line to engine hose
- (12) Install air pressure duct, load control valve and pressure sensing line
- (13) Install oil tank and fill with oil (MOBIL JET II)
- (14) Install cooling air duct
- (15) Reconnect electrical connectors J16, J18, J19, J20 and install safety wire
- (16) Reconnect oil quantity indicator wire bundle

C On flight deck electrical equipment

- (1) Close all APU circuit breakers including GEN CONTROL Panel circuit breaker
- (2) Close APU MAIN BATTERY circuit breaker, BATTERY CHARGE and VOLTMETER circuit breakers
- (3) Remove warning tag from APU START switch



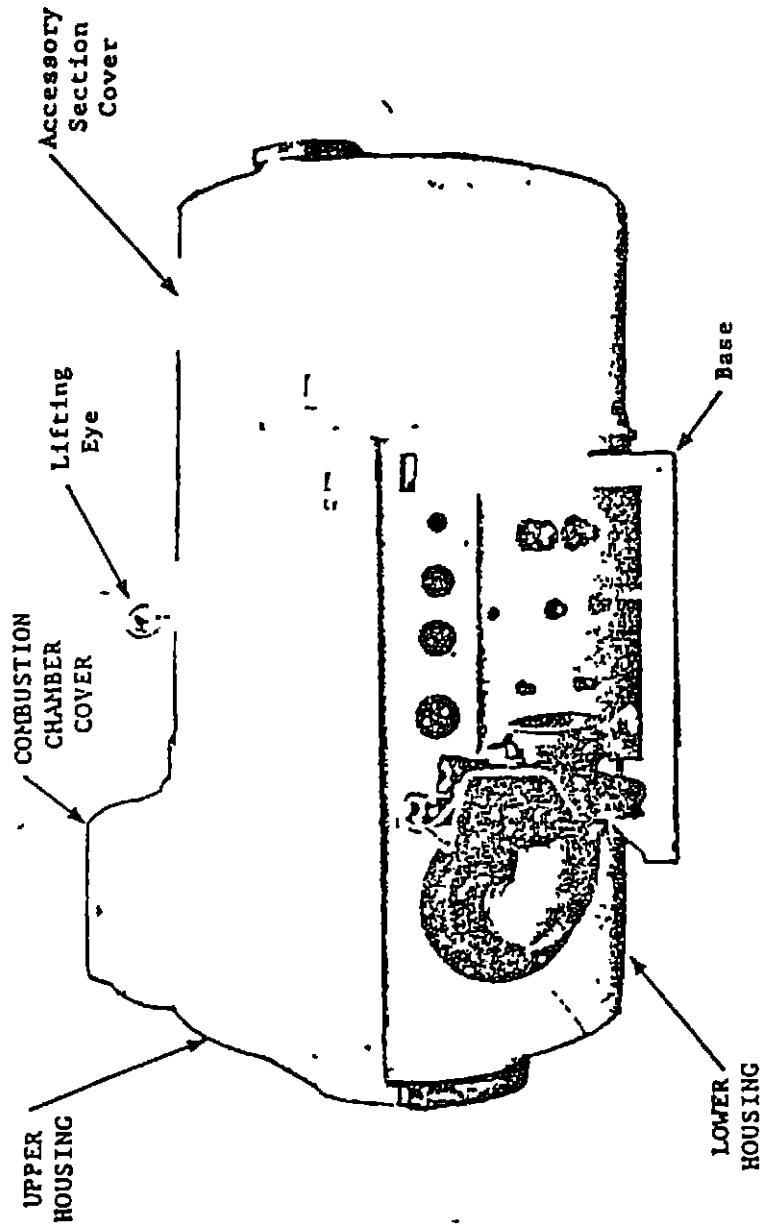
APU POWER PLANT (MODULE)

DESCRIPTION AND OPERATION

EFFECTIVITY RTCA LX-N19997 LX-N20000

1 GENERAL

- A The APU module provides a "quick-change" package containing an APU engine, engine accessories and ac generator, plus necessary plumbing, wiring and control components all enclosed in a pressure-tight, fireproof, insulated housing
- B The APU module housing provides quick-disconnects for all fluid lines and electric cables. Air intake and exhaust ducting are connected to the housing through Marman type clamps to expedite the removal/installation of the module in the cargo compartment. Provisions are made in the upper housing for installing hardware to lift the module and move it to and from the aft cargo door.



APU MODULE  
FIGURE 1

Ref : MM STEWARD-DAVIS



EFFECTIVITY RTCA LX-N19997 LX-N20000  
AUXILIARY POWER UNIT - REMOVAL/INSTALLATION

1 General

A. The following procedure is applicable to the Removal/Installation of the APU on the airplane in the aft lower cargo compartment.

2. Equipment

A. Hoist - P/N 90072-1

B Rail - P/N 76239-1

C. Transporter Dolly

D. Torquemeter

E. Lifting Eye

3. Remove APU from Aft Lower Cargo Compartment

A On flight deck electrical equipment :

(1) Pull out all APU circuit breakers, including GEN CONTROL Panel breaker.

(2) Pull out APU MAIN BATTERY circuit breaker, BATTERY CHARGE and VOLTMETER circuit breakers.

(3) Position APU START switch to OFF and place tag "WARNING - DO NOT OPERATE APU".

B. Remove cooling air duct.

C. Disconnect electrical connectors J16, J18, J19 and J20.

D. Disconnect Oil Quantity Indicator wire bundle.

E. Disconnect fire extinguisher hose.

F. Disconnect drain from shroud.

G. Remove exhaust pipe and support link.

H. Remove APU air inlet duct.

- I. Disconnect APU breather hose and vent line from oil tank.
  - J. Remove vent line and oil line to tank.
  - K. Remove fuel inlet and vent line.
  - L. Remove oil to engine hose
  - M Drain oil tank and remove oil tank
  - N Remove air pressure duct, load control valve and pressure sensing line
  - O. Install rail, hoist with two spacers and lifting eye.
  - P Remove the four support module attaching bolts, spacers and nuts
  - Q Remove APU from aircraft lower aft cargo compartment
  - R. Install APU on transporter dolly
- 4 Install APU in Aft Lower Cargo Compartment
- A Prepare APU for installation
    - (1) Visually inspect APU prior to installation in housing
    - (2) Install APU shock mount supports in lower housing section  
Torque bolts to a value of 150 ±10 lbs/inch.
    - (3) Install and attach all clamps, cooling air inlet duct coupling,  
all connectors, cooling air exhaust and quick disconnects.
    - (4) Check silicone rubber sealant on housing sections for good condition.  
Repair or replace if necessary using RTV88 silicone rubber (red)  
sealant.
- NOTE . Sealant RTV732 may be used as an alternate.
- (5) Visually inspect for cleanliness and forgotten tools.
  - (6) Close APU engine housings (upper housing section, combustion chamber  
housing, front and rear housing sections). (See 49-10-0 Description/  
Operation - Figure 1).
  - (7) Tighten bolts and nuts to a torque value of 55 ±5 lbs/inch.

B. Install APU in Aft Lower Cargo Compartment.

- (1) Install APU module and support on frame.
- (2) Install and torque the four attaching bolts, spacers and nuts to a torque value of 200 to 260 lbs/inch
- (3) Remove lifting eye, hoist with two spacers and rail.
- (4) Install APU exhaust pipe and support link.
- (5) Install APU air inlet duct
- (6) Reconnect drain to shroud.
- (7) Reconnect fire extinguisher hose
- (8) Reconnect oil breather hose and vent line to oil tank
- (9) Reconnect oil drain line.
- (10) Install fuel inlet and vent line
- (11) Install oil line to engine hose.
- (12) Install air pressure duct, load control valve and pressure sensing line.
- (13) Install oil tank and fill with oil (MOBIL JET II).
- (14) Install cooling air duct.
- (15) Reconnect electrical connectors J16, J18, J19, J20 and install safety wire.
- (16) Reconnect oil quantity indicator wire bundle.

C On flight deck electrical equipment :

- (1) Close all APU circuit breakers including GEN CONTROL Panel circuit breaker
- (2) Close APU MAIN BATTERY circuit breaker, BATTERY CHARGE and VOLTMETER circuit breakers.
- (3) Remove warning tag from APU START switch.

APU ENGINE HOUSING

EFFECTIVITY TCA LX-N20198  
LX-N20199

DESCRIPTION AND OPERATION

1. GENERAL

- A. The APU engine housing provides a close fitting, pressure-tight, fireproof enclosure for the APU engine, engine accessories and the AC electrical generator. The housing consists of four stainless steel sections: lower, upper, accessory cover and combustion chamber cover. Each housing section is lined with a 1/8-inch thick layer of silicone rubber foam to provide noise and thermal insulation during normal operation of the APU engine. If a fire should occur within the engine housing the increased temperature will cause the silicone rubber foam to expand and provide increased thermal insulation of the housing.
- B. The accessory section and combustion chamber covers of the housing provide access to the APU engine for maintenance and for component replacement.

2. LOWER HOUSING

- A. The lower housing section encloses the lower portion (approximately half) of the APU and extends from the APU exhaust to the generator mounting flange. The housing provides the isolation mounts for the APU engine and the structure for attaching to the APU base. The generator end of the housing is flanged to form the lower portion of the accessory cover attachment. Mating flanges are provided for clamping the engine intake air, exhaust gas and pneumatic ducts to the housing. Electrical connectors and quick-disconnects are provided for all fluid lines to expedite the installation and removal of the APU in the aft baggage compartment.

3. UPPER HOUSING

- A. The upper housing section encloses the upper portion of the APU and extends from the APU exhaust to the generator mounting flange. A large flanged hole is provided near the exhaust end of the housing for access to the engine combustion chamber. The generator end of the housing is flanged to provide a mating surface for the upper portion of the accessory cover.

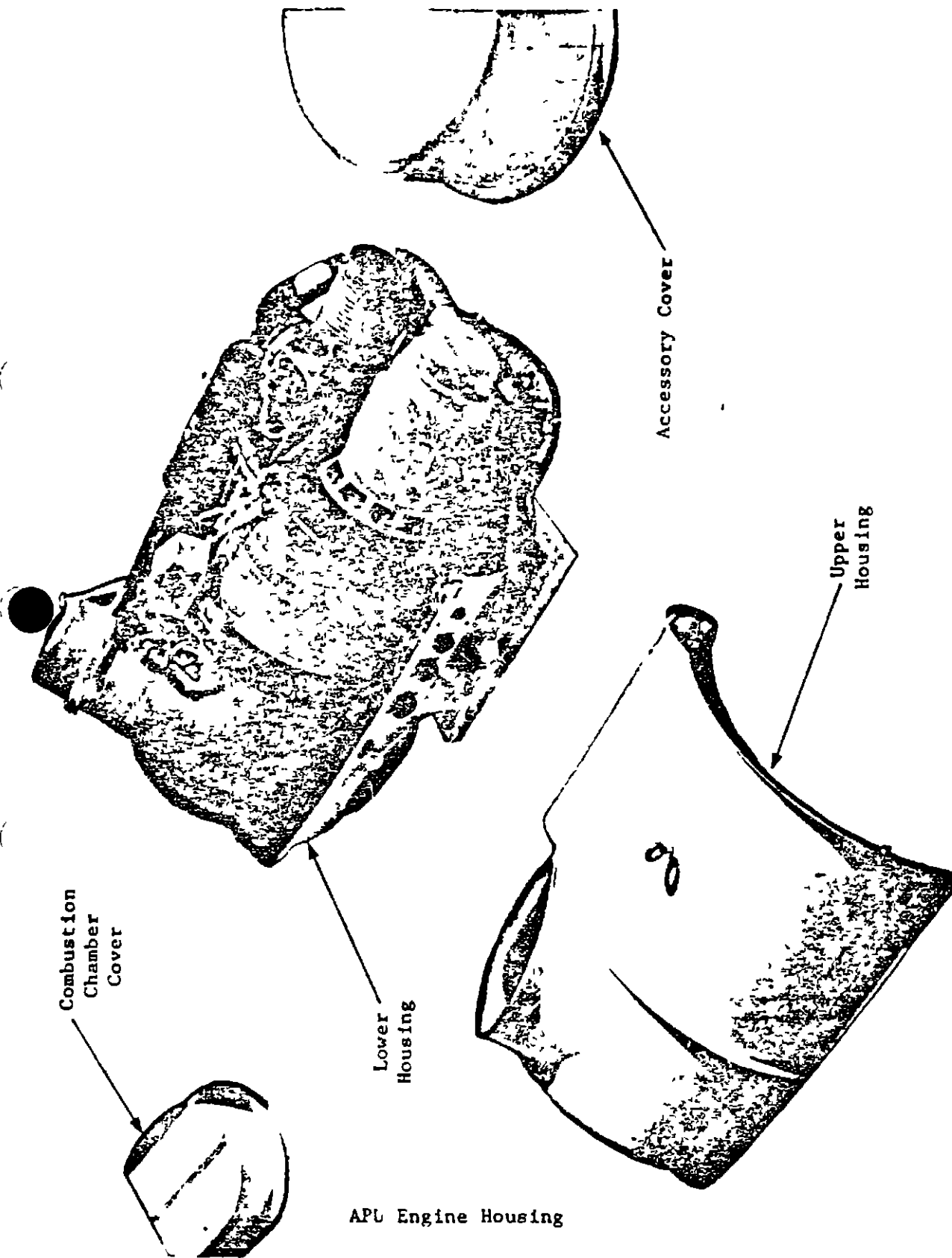
- B. A strongback, on the longitudinal centerline inside of the upper housing, contains a threaded fitting for inserting an eyebolt for lifting the APU during installation and removal. External circumferential ribs carry the load from the strongback down to the upper housing mounting flange.

#### 4. COMBUSTOR CHAMBER COVER

- A. The combustor chamber cover is an inverted dish-shaped cover bolted to the upper housing. Removal of this cover provides access to the igniter plug and the combustion chamber.

#### 5. ACCESSORY COVER

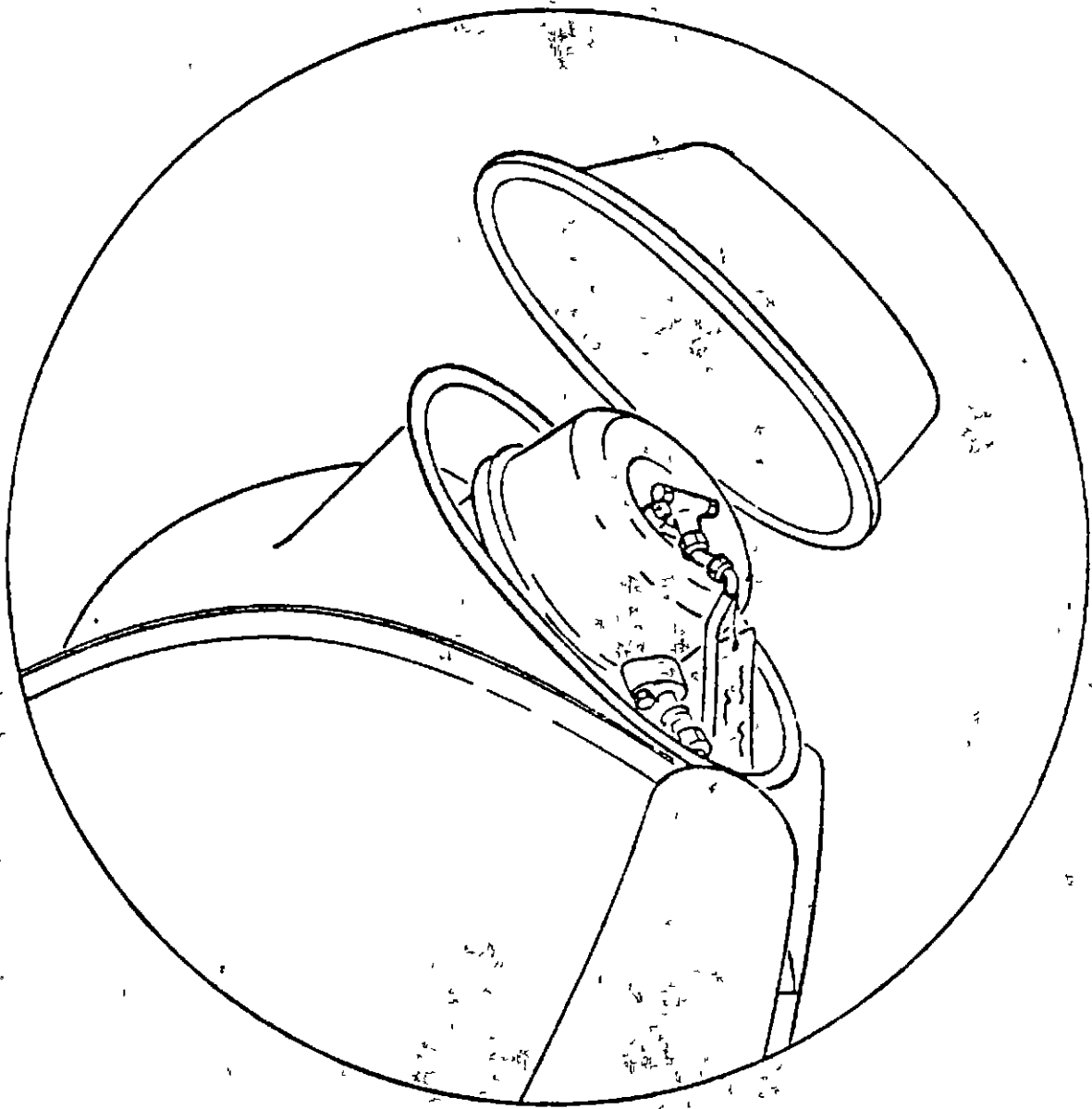
- A. The accessory cover is a large tub-shaped, flanged, component bolted to the upper and lower housings. Removal of this cover provides access to the hourmeter, AC electrical generator, engine fuel pump and control unit.
- B. The accessory cooling air intake duct coupling is clamped to this cover for quick removal and installation.



APU Engine Housing

Figure 1

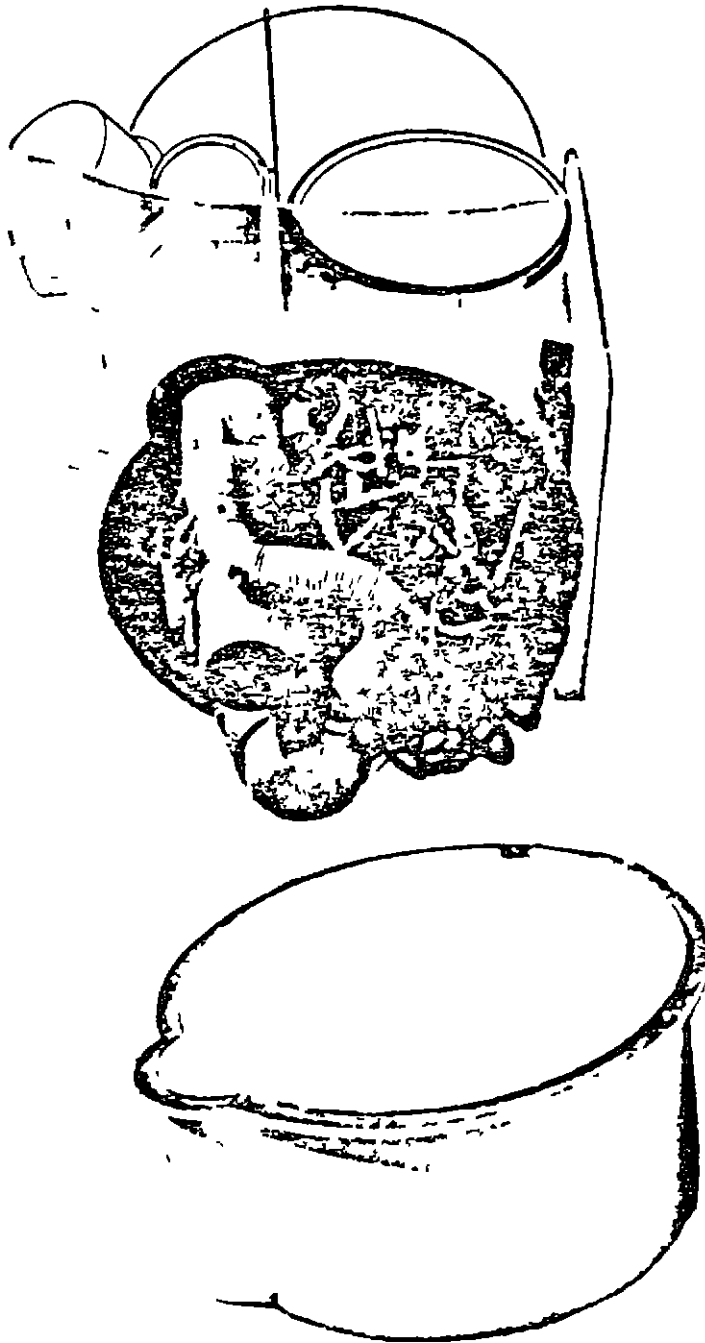
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APU Combustion Chamber

Figure 2

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APU ACCESSORY COVER  
FIGURE 3

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**APU ENGINE HOUSING**  
**DESCRIPTION AND OPERATION**

EFFECTIVITY RTCA LX-N19997 LX-N20000

**1 GENERAL**

- A The APU engine housing provides a close fitting, pressure-tight, fireproof enclosure for the APU engine, engine accessories and the AC electrical generator. The housing consists of four stainless steel sections: lower, upper, accessory cover and combustion chamber cover. Each housing section is lined with a 1/8-inch thick layer of silicone rubber foam to provide noise and thermal insulation during normal operation of the APU engine. If a fire should occur within the engine housing the increased temperature will cause the silicone rubber foam to expand and provide increased thermal insulation of the housing.
- B The accessory section and combustion chamber covers the housing provide access to the APU engine for maintenance and for component replacement.

**2 LOWER HOUSING**

- A The lower housing section encloses the lower portion (approximately half) of the APU and extends from the APU exhaust to the generator mounting flange. The housing provides the isolation mounts for the APU engine and the structure for attaching to the APU base. The generator end of the housing is flanged to form the lower portion of the accessory cover attachment. Mating flanges are provided for clamping the engine intake air, exhaust gas and pneumatic ducts to the housing. Electrical connectors and quick disconnects are provided for all fluid lines to expedite the installation and removal of the APU in the aft baggage compartment.

**3 UPPER HOUSING**

- A The upper housing section encloses the upper portion of the APU and extends from the APU exhaust to the generator mounting flange. A large flanged hose is provided near the exhaust end of the housing for access to the engine combustion chamber. The generator end of the housing is flanged to provide a mating surface for the upper portion of the accessory cover.



B. A strongback, on the longitudinal centerline inside of the upper housing, contains a threaded fitting for inserting an eyebolt for lifting the APU during installation and removal. External circumferential ribs carry the load from the strongback down to the upper housing mounting flange.

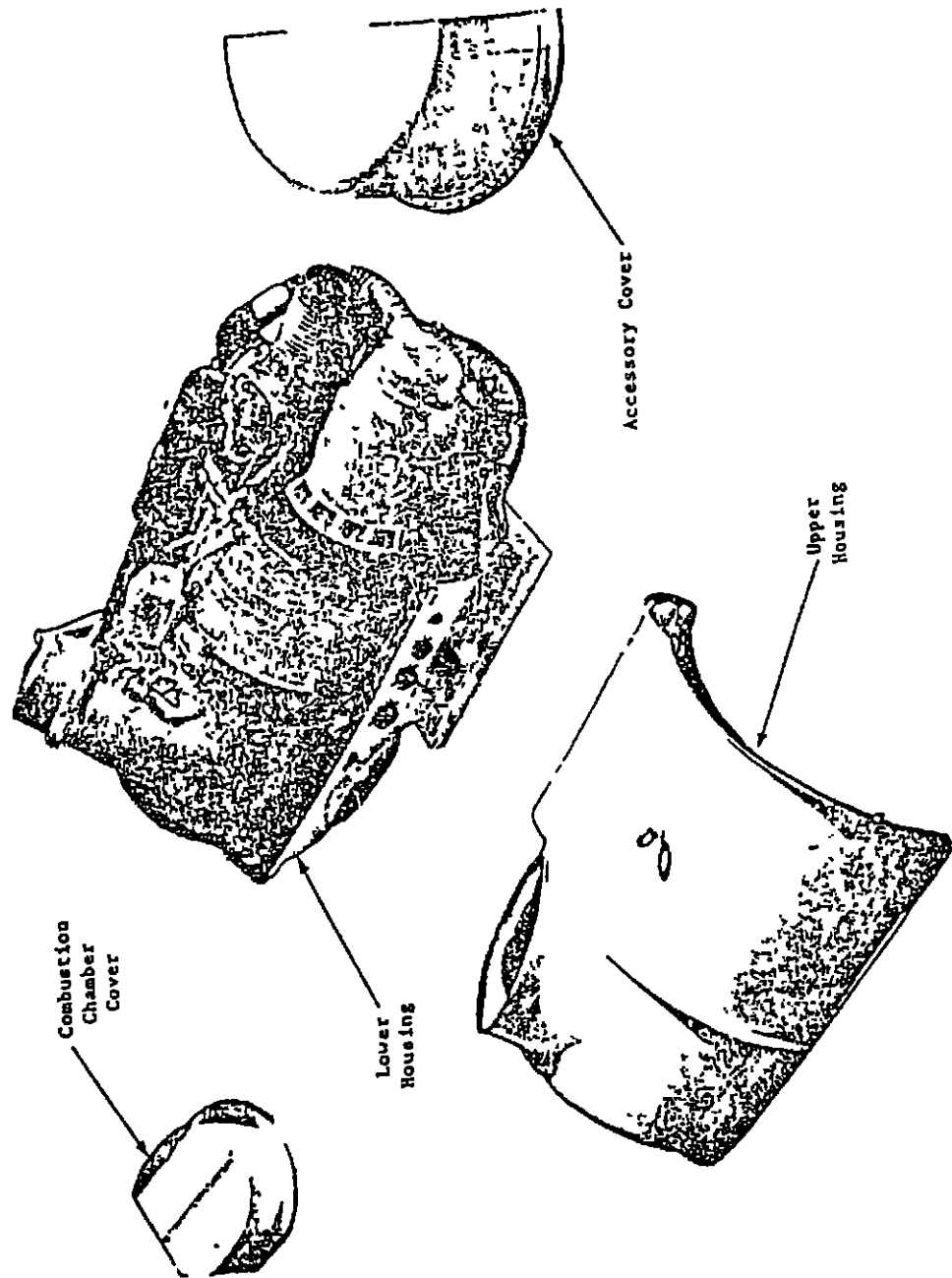
4. COMBUSTOR CHAMBER COVER

A. The combustor chamber cover is an inverted dish-shaped cover bolted to the upper housing. Removal of this cover provides access to the igniter plug and combustion chamber.

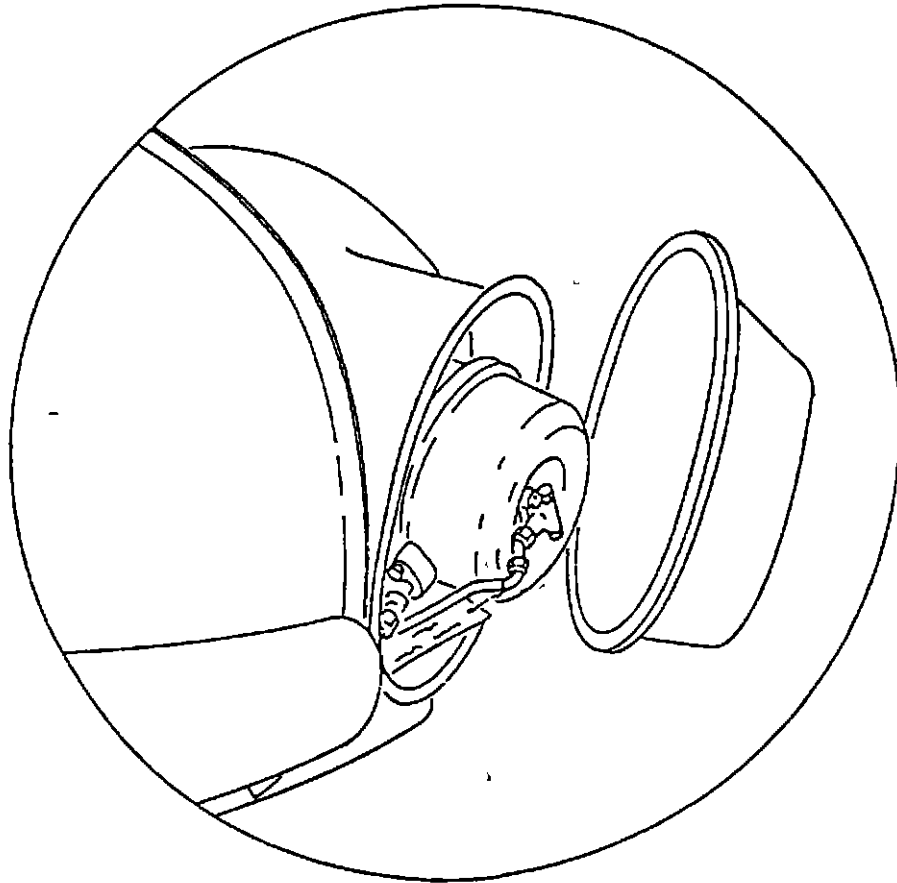
5. ACCESSORY COVER

A. The accessory cover is a large tub-shaped, flanged, component bolted to the upper and lower housings. Removal of this cover provides access to the hourmeter, AC electrical generator, engine fuel pump and control unit.

B. The accessory cooling air intake duct coupling is clamped to this cover for quick removal and installation.

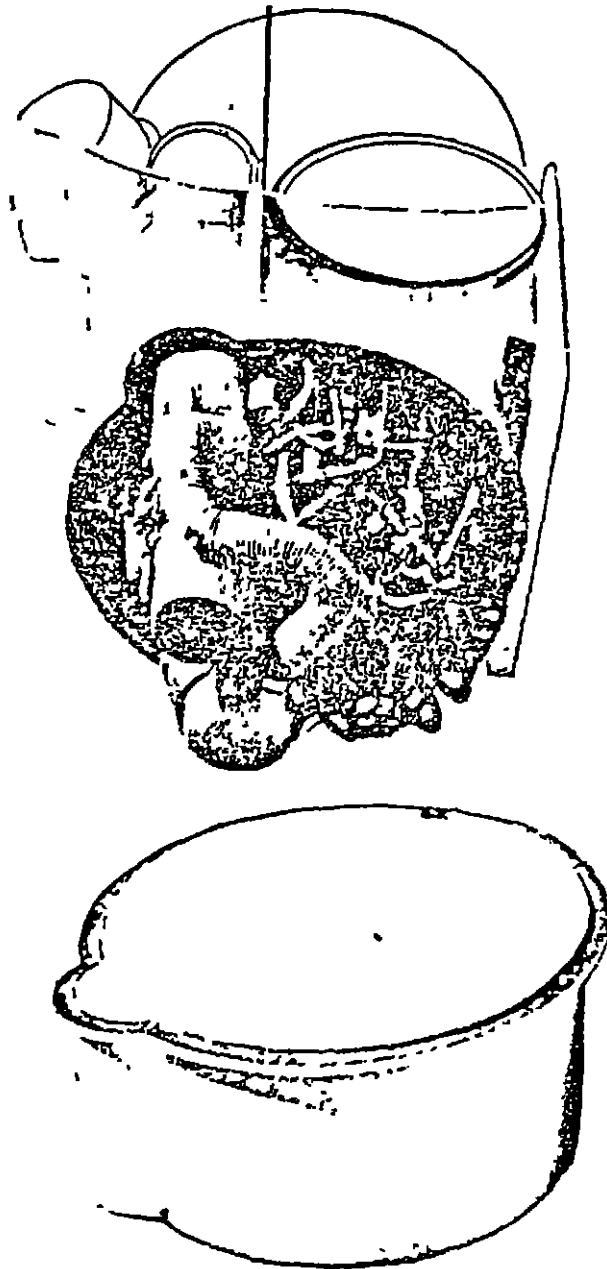


APU ENGINE HOUSING  
FIGURE 1



**APU COMBUSTION CHAMBER**  
**FIGURE 2**

Ref.: MM STEWARD-DAVIS



**APU ACCESSORY COVER**

**FIGURE 3**

APU ENGINE

DESCRIPTION AND OPERATION

EFFECTIVITY TCA LX-N20198 LX-N20199

1. GENERAL

- A. The pneumatic and shaft power gas turbine engine is a self-contained power source. Engine power is developed through compression of ambient air by a two-stage compressor. The compressed air, mixed with fuel and ignited, drives a radial inward-flow turbine wheel. The rotating shaft power of the turbine wheel drives the compressor, the accessories, and the output drive shaft.

2. COMPRESSOR AND TURBINE SECTION

- A. The compressor and turbine section develops the pneumatic and shaft power absorbed during operation of the engine. The section consists of a two-stage centrifugal compressor and a single-stage turbine wheel assembly rotating on a common shaft. The compressor is enclosed by a compressor inlet plenum assembly. The first and second stage compressor impellers are pneumatically connected through inter-stage ducts. The turbine plenum assembly encloses the turbine components and provides a receiver for compressed air from the compressor discharge housing. A combustion chamber liner assembly provides a combustion area and is perforated to provide the correct air-to-fuel mixture and burning rate. A turbine torus assembly directs combustion products to a turbine nozzle assembly which encompasses the turbine wheel blades. A shroud encloses the turbine wheel blades and directs the exhaust gases to the turbine exhaust pipe. (Figure 2 illustrates a combined cross sectional view with airflow schematic and a view of common accessory mounting pads.)

3. ACCESSORY SECTION

- A. The accessory gearcase section consists of a gearcase assembly and the following engine accessories: fuel pump and control unit, oil pump assembly, centrifugal switch assembly, electrical starter, tachometer generator and cooling air fan.

The gearcase assembly encloses a reduction gear system. A torsion shaft couples the compressor turbine main shaft to the main drive gear in the gearcase assembly. The main drive gear transmits power through the reduction gear system to drive the accessories at the required speed for each accessory. The arrangement of the accessory gear train permits the starter to drive all the accessories in addition to driving the compressor impellers and turbine wheel during engine starting.

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#### 4. OPERATION

- A. The engine incorporates control components in the fuel, air, and electrical systems which automatically control engine functions and maintain required engine speed and safe temperature from initiation of start through operation at full load.

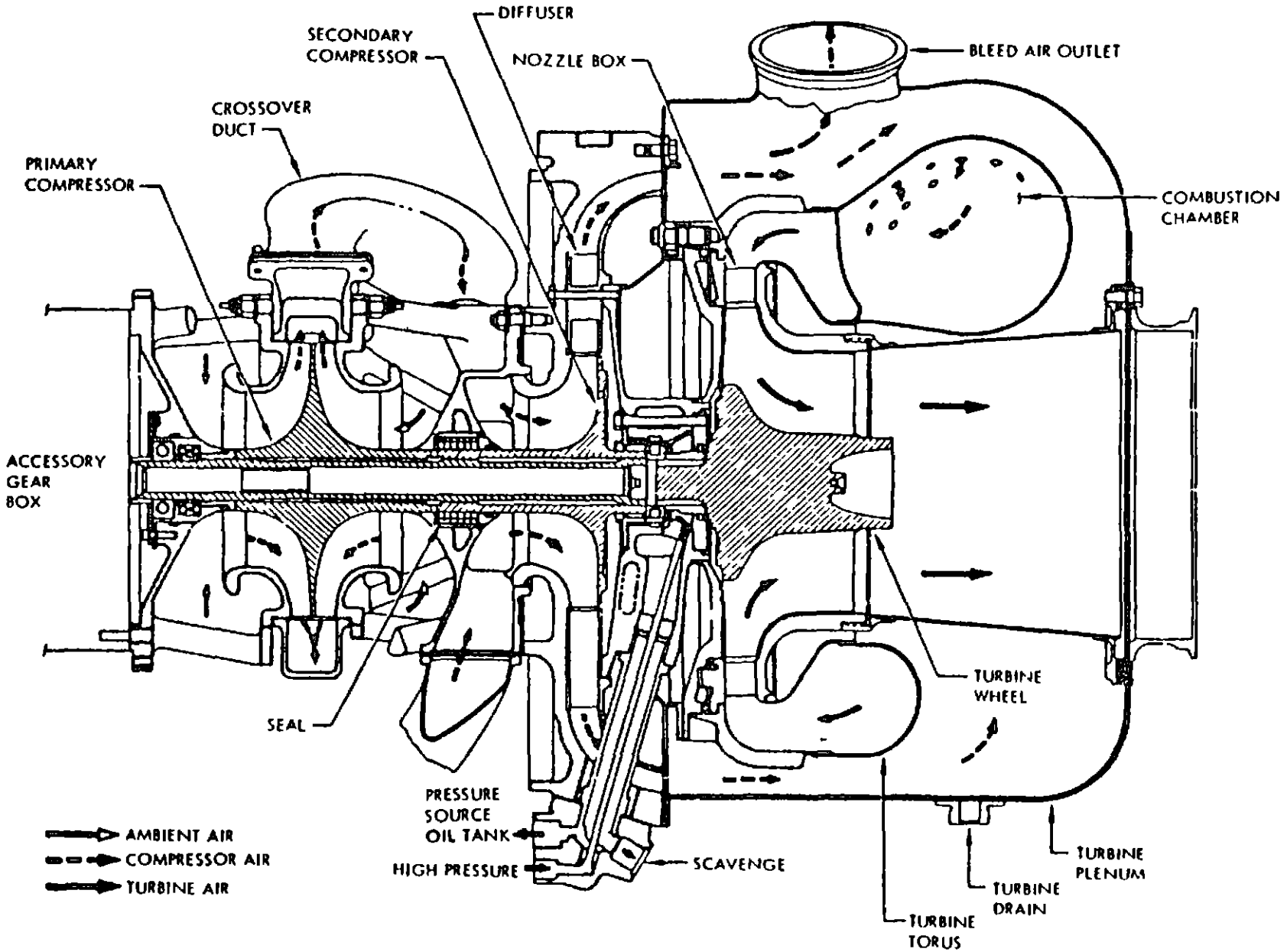
When the starter is energized, the rotating starter drive pawls engage a jaw in the accessory gearcase and start driving the gear train. The gear train drives the compressor and turbine rotating parts, the oil pump assembly and the fuel control unit, and the centrifugal switch assembly. The low oil pressure switch electrical circuit remains normally closed.

As the compressor and turbine rotating parts start turning, ambient air is drawn through the inlet into the compressor section. The air is compressed by the compressor first-stage impeller, then passed through interstage ducts to the compressor second-stage impeller for further compression. The compressed air is discharged into a vaned de-swirl assembly and from there is directed into the turbine plenum. (Clean bleed-air may be withdrawn from an outlet in the plenum through a bleed-air load control valve when the engine reaches governed speed.) From the turbine plenum the compressed air enters the combustion chamber.

When engine speed reaches its required value, rising oil pressure actuates the sequencing oil pressure switch, which completes a circuit to the fuel solenoid valve and to the ignition unit. The fuel solenoid valve is energized to open to permit fuel flow to the fuel atomizer assembly. The fuel atomizer assembly sprays fuel of proper pattern and flow into the combustion chamber where the fuel and compressed air mix. The ignition unit causes the igniter plug to ignite the fuel and air mixture in the combustion chamber.

Combustion increases the energy content of the air-fuel mixture. The gases flow into the turbine torus assembly and through the turbine nozzle assembly to the blades of the turbine wheel. The spent gases are discharged through the turbine exhaust. A portion of the power developed at the turbine wheel is used to drive the compressor impellers, the accessory gear train, and the driven accessories. The remainder of the power is available for output shaft power to drive the generator when no-load governed speed is attained.

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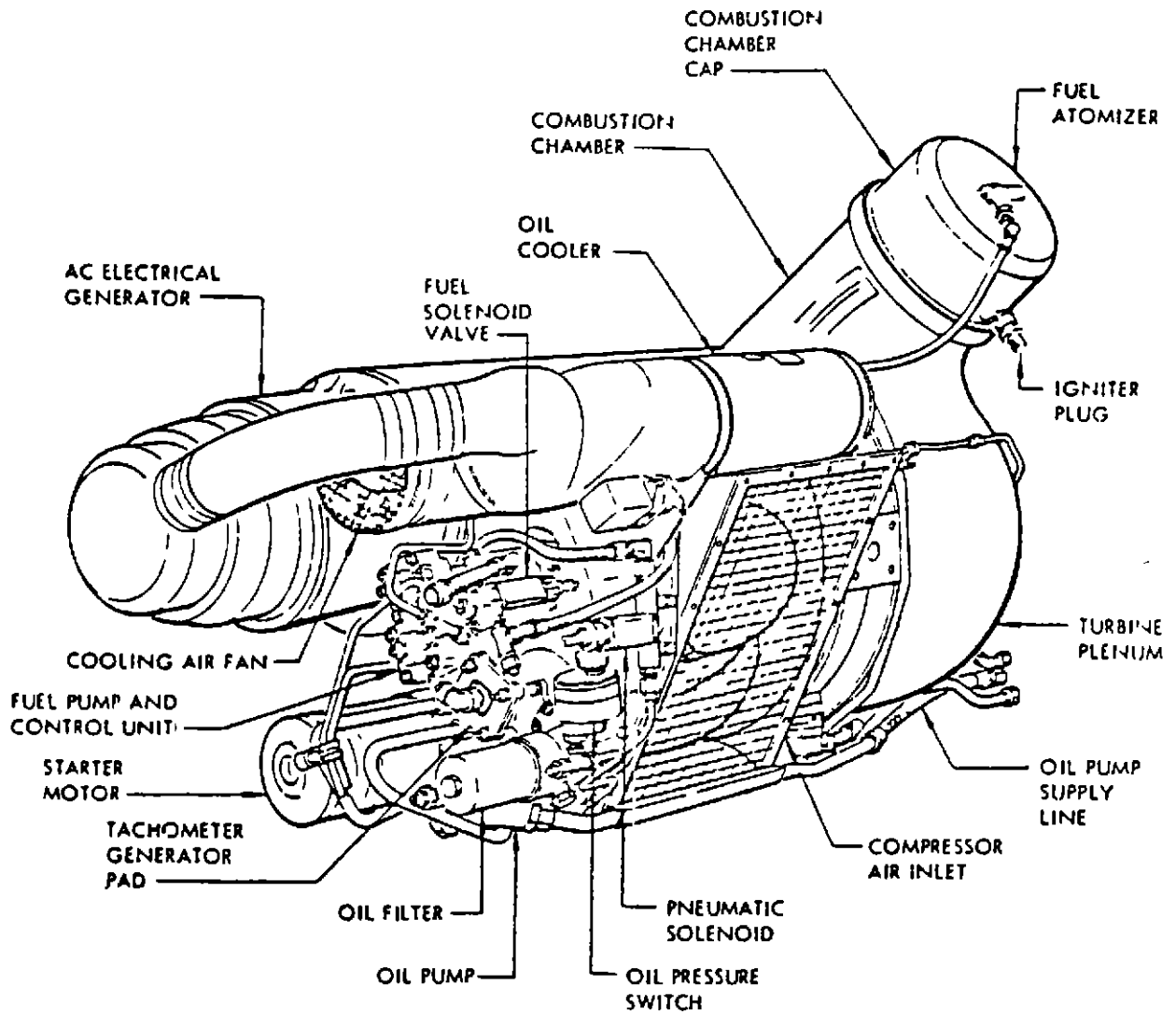


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APU Engine Schematic  
 Figure 1

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APU Engine  
 Figure 2

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4. cont.

Acceleration of the engine continues through the combined force of the starter and energy of the hot gases. When engine speed reaches its required value, the 35 percent switch in the centrifugal switch assembly opens, which breaks a circuit to the starter. Starter rotation ceases and the starter driver pawls disengage from the accessory gear train. Engine oil pressure increases until the low oil pressure switch electrical circuit is opened.

The engine continues to accelerate under turbine power. When engine speed reaches its required value, the 95 percent switch in the centrifugal switch assembly closes, which opens a circuit to the ignition unit and closes a circuit to the hourmeter, the compressor discharge valve and the speed relay. The igniter plug ceases firing, and combustion is self-sustaining. The hourmeter starts recording operating time. Acceleration continues until the no-load governed speed is reached.

After steady-state no-load governed speed is maintained for one minute, electrical loads or bleed-air loads may be imposed.

Engine speed and exhaust temperature are automatically controlled within established limits by metering of fuel by the fuel control unit.

Smooth and proper acceleration is controlled by action of the acceleration limiter valve in the fuel control unit. The valve references compressor air discharge pressure to fuel pressure, then pressure-actuated diaphragms operate a poppet valve to bypass more or less fuel to maintain the required ratio of fuel flow to compressor air pressure. During starting, when compressor air pressure is insufficient, the poppet valve is restrained from bypassing fuel by an adjustable spring pressure against the actuating diaphragm. The fuel pressure at which the spring pressure is overcome is the cracking pressure setting of the fuel control unit.

The turbine discharge temperature is controlled through a single thermostat. During start and acceleration mode the thermostat controls the fuel control limiter valve by bleeding off some of the compressor air through the three-way solenoid valve. When the engine reaches the 95 percent RPM point the 95 percent switch closes and applies 28 volts DC to the three-way solenoid valve effectively cutting off the compressed air from the fuel control limiter valve to the single thermostat. With the air control switch closed (pneumatic shutoff (load control) valve open), the turbine discharge temperature is now controlled by the single thermostat bleeding compressed air through the three-way solenoid valve from the load control valve. As the temperature rises, more air is bled through the thermostat allowing the butterfly valve in the load control valve to close reducing the load on the engine thereby reducing the turbine discharge temperature.

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4.0 cont.

Engine speed is controlled by action of the governor in the fuel control unit. The flyweight-type governor is driven by the main fuel pump drive shaft, which in turn, is driven through the accessory gear train. When engine speed exceeds the preset governed speed, the governor flyweights move outward to open a slide valve to bypass fuel and so decrease engine speed. When engine speed drops, as when load is applied, the governor flyweights move inward to close the slide valve to permit greater fuel flow and so increase engine speed.

Engine loading during bleed-air loading or combination shaft and bleed-air loading is automatically controlled within established limits by modulation of the load control valve butterfly position.

Overloading and consequent excessive turbine discharge temperature is controlled by action of the control thermostat. If turbine discharge temperature reaches a preset value, the ball valve in the control thermostat opens to bleed some of the control air from the load control valve actuator, which causes the actuator mechanism to move the valve butterfly toward a more closed position, thus reducing the load and the discharge temperature. When the temperature is reduced below the preset value, the control thermostat closes and stops bleeding the control air from the actuator.

The engine is provided with certain safety devices which shut down the engine in the event of overspeeding, excessively high oil temperature, or loss of oil pressure.

If engine speed starts to exceed governed speed and governing devices in the fuel control unit have not metered fuel sufficiently to reduce speed, the flyweight-actuated overspeed switch in the centrifugal switch assembly will close, which opens a circuit to the fuel solenoid valve. When the fuel solenoid valve is de-energized, it closes and shuts off fuel flow to the combustion chamber, thus stopping the engine.

If engine oil temperature exceeds a preset value, the high oil temperature thermostatic switch electrical circuit will close, completing a circuit to a holding relay and warning light, and to the pneumatic solenoid valve to shutdown the engine.

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4. cont.

The engine is stopped by actuation of the normally closed pneumatic solenoid valve, mounted on the gearcase assembly. The valve is connected on the inlet port side to a compressor air discharge port, and on the outlet port side to a port on the centrifugal switch assembly. When the solenoid is actuated to open position, it permits flow of compressed air into the centrifugal switch assembly. As the air pressure in the switch assembly builds up, the switch actuating lever is forced into contact with the overspeed switch. When the overspeed switch is actuated it opens a circuit to the fuel solenoid valve and so shuts off fuel flow to the combustion chamber, thus stopping the engine.

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**MAINTENANCE MANUAL**

APU ENGINE - ADJUSTMENT/TEST

EFFECTIVITY TCA LX-N20198 LX-N20199

1. GENERAL

The test and adjustment procedures described in this subject shall be performed by personnel who operate and maintain the equipment in the field, and can be accomplished with the engine removed or installed.

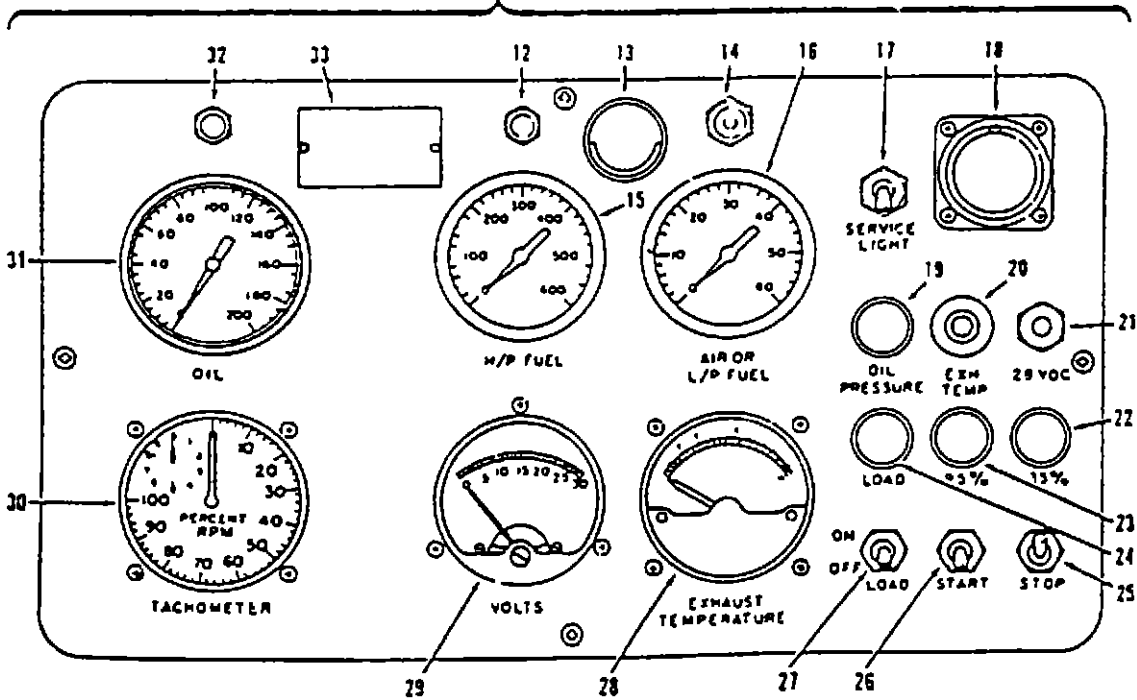
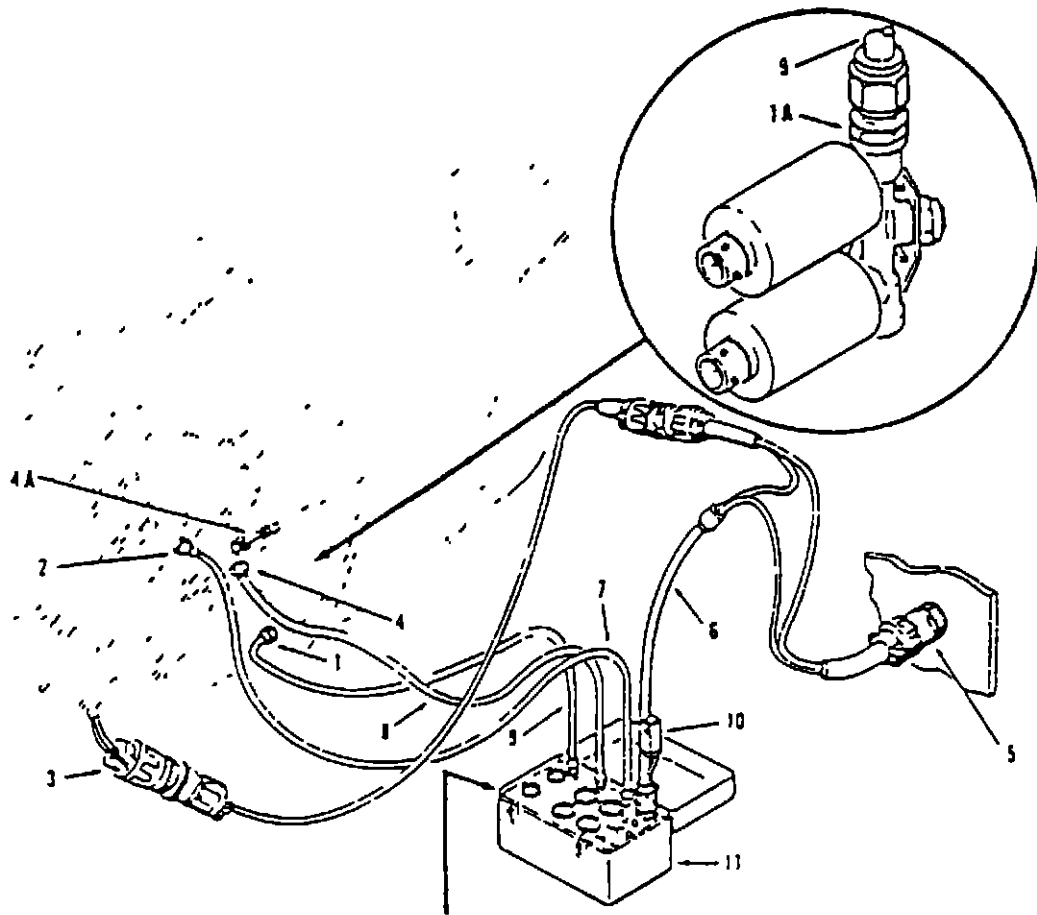
Perform test and adjustment checks when possible before the engine is installed in the aircraft. Should any heavy repairs be required, refer to trouble shooting procedures provided in Engine Trouble Shooting Section.

2. SPECIAL TOOLS

- |  |  |
|--|--|
| A. Gas Turbine Engine Tester                           | AiResearch 290122-400  |
| B. Electrical Cable                                    | AiResearch 290128-1-1  |
| C. Pressure Gage and Case Set                          | AiResearch 282645  |
| D. Screwdriver and Wrench Assembly                     | AiResearch 280353  |
| E. Thermostat Calibration Test Set                     | AiResearch 290417-2-1  |
| (1) Cable Assembly<br>(Component of 290417-2-1)        | AiResearch 290424-1  |
| (2) Thermocouple Assembly<br>(Component of 290417-2-1) | AiResearch 290416-2  |
| F. Wheatstone Bridge                                   | Model 4289-2<br>Leads and Northrup,<br>North Wales, PA 19454 |

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Connection of Tester  
to Engine (Typical)  
Figure 501

KEY TO FIGURE 501

- 1A. OIL OUTPUT PRESSURE CONNECTION (GTC85-98CK)
2. CONTROL AIR OUTPUT PRESSURE CONNECTION
3. ENGINE WIRING HARNESS RECEPTACLE
4. FUEL OUTPUT PRESSURE CONNECTION
- 4A. FUEL ATOMIZER HOSE ASSEMBLY
5. REMOTE BULKHEAD RECEPTACLE
6. ELECTRICAL CABLE
7. CONTROL AIR PRESSURE HOSE ASSY
8. FUEL PRESSURE HOSE ASSY
9. OIL PRESSURE HOSE ASSY
10. OVERSPEED TEST STOP SWITCH
11. TESTER
12. FUEL PRESSURE COUPLING
13. PANEL LIGHT
14. CONTROL AIR PRESSURE COUPLING
15. FUEL PRESSURE GAGE
16. CONTROL AIR PRESSURE GAGE
17. PANEL LIGHT SWITCH
18. RECEPTACLE
19. LOW OIL PRESSURE LIGHT (RED)
20. EXHAUST GAS TEMPERATURE SWITCH
21. 28 VDC JACK
22. 35 PERCENT LIGHT
23. 95 PERCENT LIGHT
24. LOAD LIGHT (GREEN)
25. STOP SWITCH
26. START SWITCH
27. LOAD SWITCH
28. EXHAUST TEMPERATURE INDICATOR
29. DC VOLTMETER
30. TACHOMETER INDICATOR
31. OIL PRESSURE GAGE
32. OIL PRESSURE COUPLING
33. NAMEPLATE

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### 3. EQUIPMENT CONNECTIONS

#### A. Connect Tester (290122-400) to Engine

- (1) Disconnect engine wiring harness receptacle from the APU housing receptacle.

NOTE: Connectors of electrical cable (6) are identified by aluminum marker bands.

- (2) Connect electrical cable (6) as follows:

- (a) Install CABLE TO TESTER connector in receptacle (18).

- (b) Install ENGINE CONN connector to engine wiring harness receptacle (3), and install CUSTOMER CABLE connector on main connector of remote bulkhead receptacle (5).

- (3) Remove cap from output fuel pressure connection (4, figure 501) at fuel control unit. Install fuel pressure hose assembly (8) on output fuel pressure connection (4). Install other end of fuel pressure hose assembly on fuel pressure coupling (12).

- (4) Remove cap from control air output pressure connection (2) at fuel control unit. Install control air pressure hose assembly (7) on control air output pressure connection (2). Install other end of control air pressure hose assembly on control air pressure coupling (14).

- (5) Remove cap from oil pressure connection (1) at sequencing oil pressure switch. Install oil pressure hose assembly (9) on oil pressure connection (1). Install other end of oil pressure hose assembly on oil pressure coupling (32).

- (6) Check exhaust gas temperature loop resistance at initial use of tester as follows:

- (a) Remove tester panel attaching screws and lift panel to obtain access to temperature indicating circuit components.

- (b) Disconnect wire leads from exhaust temperature indicator terminals on rear of indicator case to remove indicator from thermocouple circuit.

NOTE: Make sure that white Chromel wire lead is connected to CR terminal and that green Alumel wire lead is connected to A1 terminal.

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- (c) Connect a Wheatstone bridge to disconnected wire leads to measure resistance of thermocouple circuit. Measure thermocouple circuit resistance. Resistance shall be 8.000  $\pm$  0.035 ohms. If resistance is not within specified limit, adjust slide of variable resistor in tester to obtain specified resistance.
- (d) Disconnect Wheatstone bridge and reconnect wire leads to temperature indicator terminals. Replace panel of tester and secure with attaching screws.

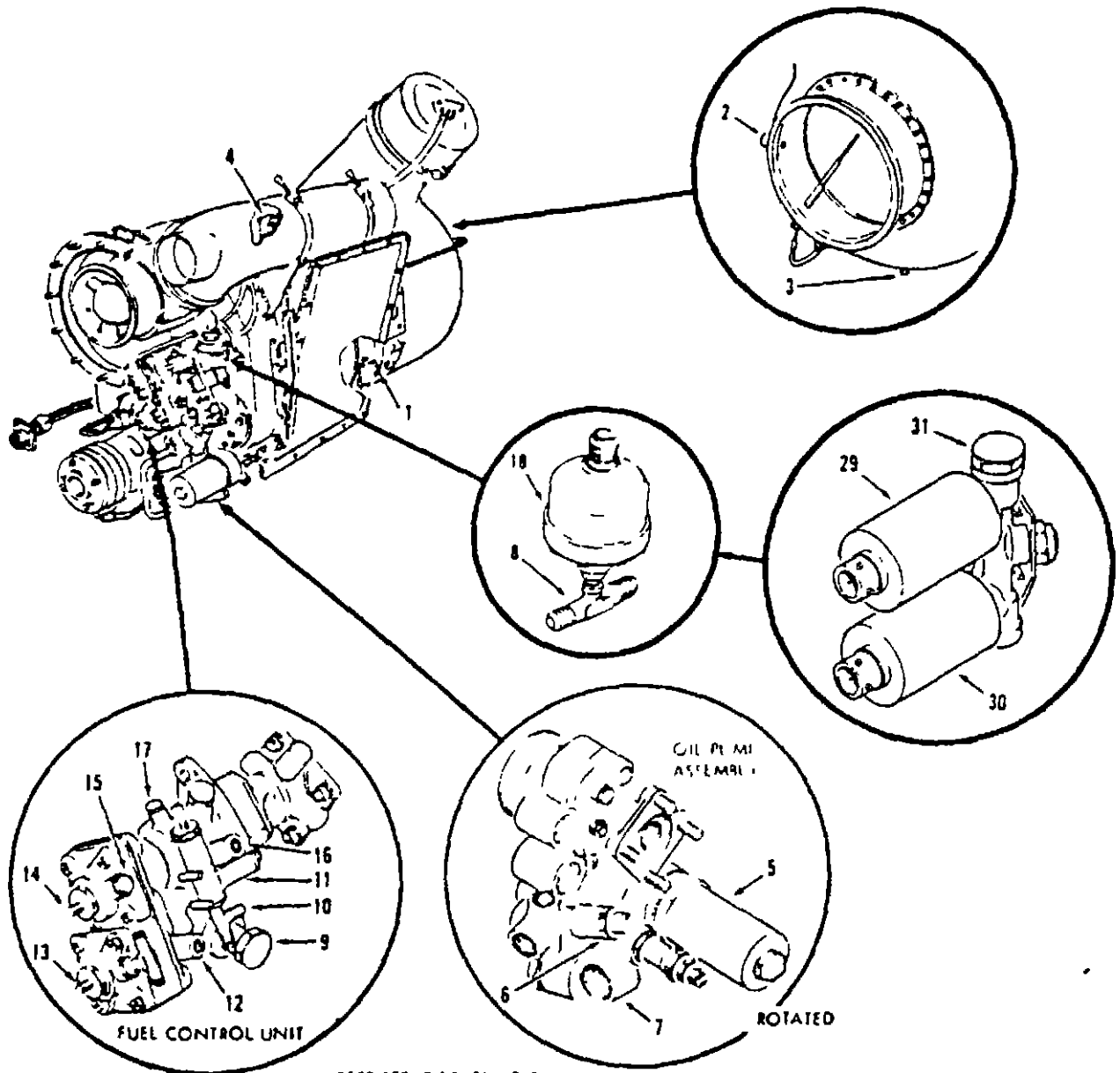
WARNING: TEST PERSONNEL SHALL STAND CLEAR OF PLANES OF ROTATION OF COMPRESSOR AND TURBINE WHEELS AND HIGH TEMPERATURE EXHAUST DUCT DURING ENGINE OPERATION ONLY QUALIFIED PERSONNEL SHALL BE PERMITTED TO OPERATE, TEST, AND MAINTAIN ENGINE. EXERCISE EXTREME CAUTION TO PREVENT INTRODUCTION OF FOREIGN MATERIALS IN COMPRESSOR AIR INLET.

- (e) Engine is now ready for test

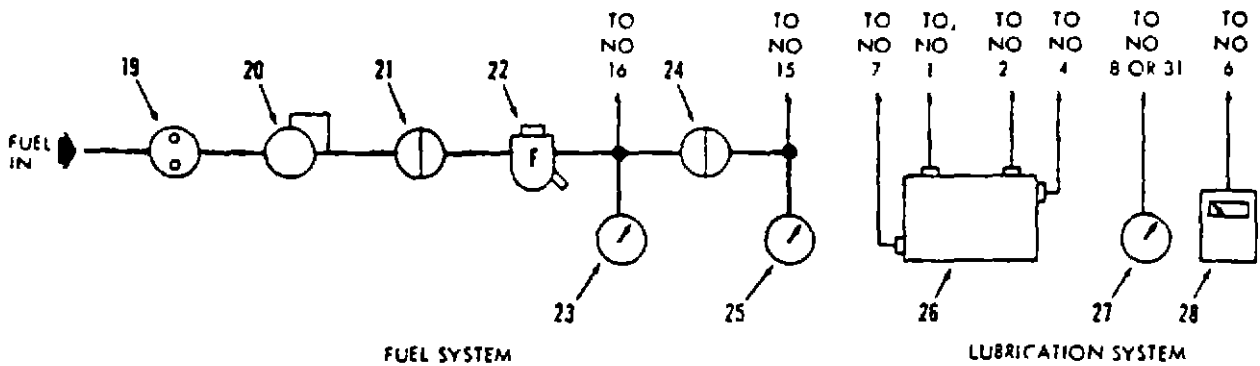
#### 4 PRECAUTIONARY REQUIREMENTS

##### A. Observe Precautionary Requirements

- (1) If operation limits tabulated in Table 501 are exceeded, or if seizing, unusual noise, smoke, fuel or oil leakage, or other obvious malfunction is observed, shut down engine immediately and correct the cause of trouble.



TEST SETUP SCHEMATIC



Fuel and Lubrication System  
 Test Setup (Typical)  
 Figure 502

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KEY TO FIGURE 502

- 1 OIL VENT CONNECTION (3/4-16 THD FOR 1/2 IN. LINE)
- 2 OIL VENT CONNECTION (3/4-16 THD FOR 1/2 IN. LINE)
- 3 FUEL DRAIN VALVE CONNECTION (7/16-20 THD FOR 1/4 IN. LINE)
4. OIL RETURN CONNECTION (TO TANK) (3/4-16 THD FOR 1/2 IN. LINE)
- 5 OIL FILTER
6. OIL TEMPERATURE BULB
- 7 OIL INLET CONNECTION (1-1/16-12 THD FOR 3/4 IN. LINE)
- 8 OIL PRESSURE CONNECTION (9/16-18 THD FOR 3/8 IN. LINE)
- 9 FUEL FILTER
- 10 FUEL OUTLET (TO ATOMIZER)
- 11 FUEL SOLENOID VALVE
12. FUEL DRAIN CONNECTION (7/16-20 THD FOR 1/4 IN. LINE)
- 13 ACCELERATION LIMITER ADJUSTMENT SCREW
14. GOVERNOR ADJUSTMENT SCREW
- 15 FUEL PRESSURE CONNECTION (7/16-20 THD FOR 1/4 IN. LINE)
- 16 FUEL INLET CONNECTION (9/16-18 THD FOR 3/8 IN. LINE)
- 17 NOT USED
- 18 SEQUENCING OIL PRESSURE SWITCH
- 19 FUEL BOOST PUMP
- 20 PRESSURE REGULATOR
- 21 SHUTOFF VALVE
- 22 FUEL FILTER
- 23 PRESSURE GAGE (FUEL INLET) (0 TO 20 PSIG)
- 24 MANUAL FUEL BYPASS VALVE
- 25 PRESSURE GAGE (FUEL DISCHARGE) (0 TO 120 PSIG)
- 26 OIL TANK
- 27 PRESSURE GAGE (OIL DISCHARGE) (0 TO 120 PSIG)
- 28 TEMPERATURE INDICATOR (OIL DISCHARGE) (0 TO 300°F)
29. SEQUENCING OIL PRESSURE SWITCH
30. LOW PRESSURE SWITCH
- 31 OIL PRESSURE CONNECTION

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TABLE 501 - OPERATING LIMITS

OBSERVATION	CONDITION	LIMIT REQUIREMENTS
<u>CAUTION:</u> STOP UNIT IF INDICATED VALUES EXCEED OR PERSIST AT THESE LIMITS.		
Compressor Inlet Air Temperature	Continuous operation	54C (130F) max.
Cooling Fan Air Inlet Temperature	Continuous operation	54C (130F) max.
<u>CAUTION:</u> TURBINE DISCHARGE TEMPERATURE DURING NORMAL ENGINE OPERATION SHOULD NOT EXCEED CONTINUOUS OPERATION LIMIT. ENGINE OPERATION AT TURBINE DISCHARGE TEMPERATURES ABOVE CONTINUOUS OPERATION LIMIT IS EVIDENCE OF ENGINE DISTRESS, AND APPROPRIATE CORRECTIVE ACTION SHOULD BE TAKEN TO RESTORE NORMAL OPERATION		
Turbine Discharge Temperature	Continuous operation	620°C (1148°F)
	Never exceed.	660°C (1220°F)
<u>NOTE:</u> Never exceed temperatures may be exceeded during engine start and acceleration, provided that start time does not exceed limit shown in Figure 503		
If turbine discharge temperature exceeds 710C (1310F) during the start/acceleration cycle, shut down APU and perform a hot start inspection. (Refer to INSPECTION/CHECK.)		
Turbine Wheel Speeds	Continuous operation	41,700 RPM max.
	10 second operation	42,500 to 44,500 RPM
	Never exceed	44,500 RPM max.
Fuel Temperature at Fuel Control Unit Inlet	Any operating condition	43C (110F) max.

TABLE 501 - OPERATING LIMITS (cont)

OBSERVATION	CONDITION	LIMIT REQUIREMENTS
Oil Temperature	Any operating condition	124C (255F) max.) shall not exceed 52C (125F) above fan inlet air temperature.
Oil pressure	30,000 RPM or higher	95 ± 5 PSIG
	Allowable fluctuation at steady-state	± 3 PSI max.
Gearcase Negative Pressure	At rated speed	-3 to -10 in. Hg
Turbine Bearing Cavity Pressure	At rated speed with vent to oil tank removed	0 to -24 in. Hg ga
<p><b>CAUTION:</b> MAXIMUM PEAK VIBRATIONS GREATER THAN THE LIMITS SHOWN MAY OCCUR AT CERTAIN CRITICAL TURBINE SPEEDS FROM 10,000 TO 13,000 RPM. DO NOT OPERATE THE UNIT CONTINUOUSLY AT ANY SPEED WHERE VIBRATION EXCEEDS THESE LIMITS OR UNDER CONDITIONS THAT CREATE SPEED DWELLINGS BETWEEN 10,000 AND 13,000 RPM.</p>		
<p><b>NOTE</b> Momentary vibration amplitudes in excess of specified limits are acceptable during start and acceleration cycles, however, the magnitude of the observed amplitude excursions should not exceed twice the specified limits, i.e., 1.2 mil at gearcase end or 0.8 mil at turbine end.</p>		
Vibration Amplitude	Gearcase end at any operating condition	0.6 mil max. at any frequency
	Turbine end at any operating condition	0.4 mil max. at any frequency
Starter Motor	Duty Cycle	One minute on max. and four minutes off min.
<p><b>NOTE:</b> A cooling period of 30 minutes is required after four starter motor duty cycles.</p>		

TABLE 501 - OPERATING LIMITS (cont)

OBSERVATION	CONDITION	LIMIT REQUIREMENTS
Light-off Time	After oil pressure reaches 5 PSIG	20 sec. max.
Leakage	Oil leakage from any shaft seal	None
	Oil leakage from first-stage compressor seal during or after shutdown	None
	Fuel leakage from accessory drain only	One drop per minute max.
	Fuel leakage from turbine plenum drain	None, except on false start or blowout
	Air leakage (other than valve bleed holes, pressure regulator, acceleration limiter valve cap)	None, except plenum drain at slow speed
Actuation of 110 Percent Switch		44,250 ± 250 RPM

NOTE: The use of the hot section components will be extended by operating the engine at no-load governed speed for at least one minute prior to application of a bleed-air load.

4. A. (2) Allow engine to operate at no-load governed speed for one minute (minimum) prior to application of a bleed-air load.

NOTE: The use of the hot section components will be extended by operating the engine at or below the recommended pneumatic thermostat setting.

- (3) Calibrate pneumatic thermostat at or below the recommended temperature setting 565°C (1050°F). (Refer to Table 502.)
- (4) Allow engine to operate at zero bleed-air for three minutes (minimum) prior to shutdown.

TABLE 502 - ENGINE EXHAUST GAS TEMPERATURE (EGT) SETTINGS

---

EGT Measurement	Pneumatic (Load Mode) Thermostat
<hr/>	
	<u>MAX.</u>
Test Set	620C (1150F)

---

5 CHECKS AND ADJUSTMENTS

A Check and Adjust Fuel Control Unit Acceleration Limiter Valve Cracking Pressure

NOTE Connection of tester is not required.

- (1) Remove cap at control air pressure connection (2, Figure 501) at fuel control unit to vent acceleration limiter valve to ambient pressure during pressure check.
- (2) Disconnect fuel atomizer hose assembly (4A) from tee fitting, then connect a suitable length of 1/4 inch high pressure hose to tee fitting.
- (3) Connect pressure gage of case set (282645) to high pressure hose installed in step (2).
- (4) Energize start switch to rotate engine by starter motor action

CAUTION DO NOT EXCEED STARTER DUTY CYCLE LIMIT SPECIFIED IN TABLE 501.

- (5) Note acceleration limiter valve cracking pressure at approximately 20 percent (3000 to 9000 RPM) engine speed. Cracking pressure shall be  $60 \pm 2$  PSIG.

NOTE If cracking pressure is not within limits, loosen locknut and adjust acceleration limiter valve adjustment screw (Figure 502) using screwdriver and wrench assembly (280153) Clockwise adjustment decreases pressure When adjustment is satisfactory, tighten locknut, and recheck acceleration limiter valve cracking pressure per instructions outlined in steps (4) and (5). Lockwire

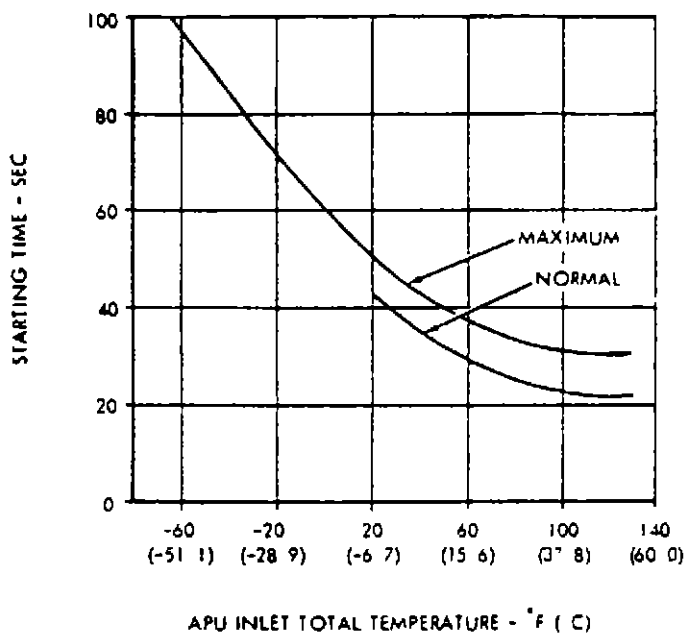
- (6) Disconnect pressure gage and high pressure hose from tee fitting, then reconnect fuel atomizer hose assembly to tee fitting
- (7) Re-install cap on control air output pressure connection (2, Figure 501) at fuel control unit

3 Check Engine Start, Acceleration, Operation, and Actuation of Automatic Controls

NOTE If engine does not operate satisfactorily, as indicated in following steps, stop engine and correct malfunction before proceeding (Refer to Engine Trouble Shooting Section )

- (1) Connect Engine Tester (290122-400) to engine
- (a) Place load switch (27, Figure 501) in OFF position.
- (b) Momentarily place start switch (26) in START position.
- 1) Low oil pressure light (red) (19) and 35 percent light (22) shall go on immediately.
  - 2) Engine shall start and accelerate smoothly, indicated by evidence of oil pressure at oil pressure gage (Figure 501) engine speed at tachometer indicator, compressor air pressure at control air pressure gage, fuel pressure at fuel pressure gage and exhaust gas temperature at exhaust gas temperature indicator If APU does not reach governed speed within time limit shown in Figure 503, terminate start

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**NOTES**

- 1 NACA STANDARD SEA LEVEL PRESSURE
- 2 STARTING TIME DEFINED AS THE PERIOD FROM STARTER ACTUATION TO NOMINAL GOVERNED SPEED WITH NO BLEED OR ELECTRICAL LOAD BEING APPLIED
- 3 DC POWER EQUIVALENT TO ONE AN3150-2 STORAGE BATTERY WITH ELECTROLYTE TEMPERATURE AT 0°F (-18°C) OR HIGHER
- 4 SERIES RESISTANCE OF CABLES FROM BATTERY TO UNIT ELECTRICAL CONNECTOR NOT TO EXCEED 0.016 OHM
- 5 TOTAL LOAD IMPOSED DURING STARTING CYCLE NOT TO EXCEED THE POLAR MOMENT OF INERTIA AND FRICTIONAL DRAG IMPOSED BY AN AIRCRAFT-TYPE, 60 KVA, AC GENERATOR AND AN AIRCRAFT-TYPE TACHOMETER
6. THE OIL VISCOSITY AT THE LOWER TEMPERATURE LIMIT FOR STARTING IS 13,000 CENTISTOKES THE LOWER TEMPERATURE LIMIT FOR TYPE I OIL IS -45°F (-53.9°C) WHICH EQUATES TO -40°F (-40°C) FOR TYPE II

Starting Time Vs APU  
 Inlet Total Temperature  
 Figure 503

- 3) Throughout start, acceleration, and operation, exhaust gas temperature, indicated on exhaust gas temperature indicator shall not exceed limits specified in Table 501.

CAUTION: SHUT DOWN ENGINE AT ONCE AND CORRECT TROUBLE IF EXHAUST GAS TEMPERATURE EXCEEDS LIMITS SPECIFIED IN TABLE 501.

- 4) When oil pressure reaches 2.5 to 3.5 PSIG, indicated at oil pressure gage, fuel solenoid circuit shall close, allowing fuel flow, indicated on fuel pressure gage.
- 5) When engine speed reaches approximately 35 percent, indicated on tachometer indicator, 35 percent switch shall actuate to break starter circuit, indicated by 35 percent light going off
- 6) When engine speed reaches 95 percent, indicated on tachometer indicator, 95 percent switch shall actuate to break ignition circuit and close time totalizing meter circuit, indicated by 95 percent light going on and engine time totalizing meter starting to record time.

NOTE Indication of 100 percent speed on tester tachometer indicator is equivalent to 41,185 RPM turbine wheel speed.

- 7) Engine shall continue to accelerate, and fuel control unit governor shall operate to control engine speed at no-load governed speed, 101.25 percent (41,700 RPM) maximum, indicated on tester tachometer indicator.
- 8) Energize pneumatic shutoff solenoid to shut down engine. Solenoid shall open to pressurize centrifugal switch and actuate centrifugal switch overspeed switch.

C. Check and Adjust Fuel Control Unit Governor Speed Setting

- (1) Connect Engine Tester (290122-400) to engine.
  - (a) Place load switch in OFF position.
  - (b) Momentarily place start switch in START position and allow engine to accelerate to no-load governed speed.

NOTE: Indication of 100 percent engine speed on tachometer indicator is equivalent to 41,185 RPM turbine wheel engine speed.

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- (c) With no-load applied, engine speed shall stabilize at 101.25 percent (41,700 RPM) maximum indicated on tester tachometer indicator.
- (d) If steady-state no-load governed speed is not within limits of 100.75 to 101.25 percent (41,500 to 41,700 RPM) indicated on tester tachometer indicator, loosen locknut and adjust governor adjustment screw (Figure 502) using screwdriver and wrench assembly. Clockwise adjustment increases speed, counterclockwise adjustment decreases speed.
- (e) When adjustment is satisfactory, tighten locknut. Lockwire.

**D. Check Air Pressure Regulator Output Pressure**

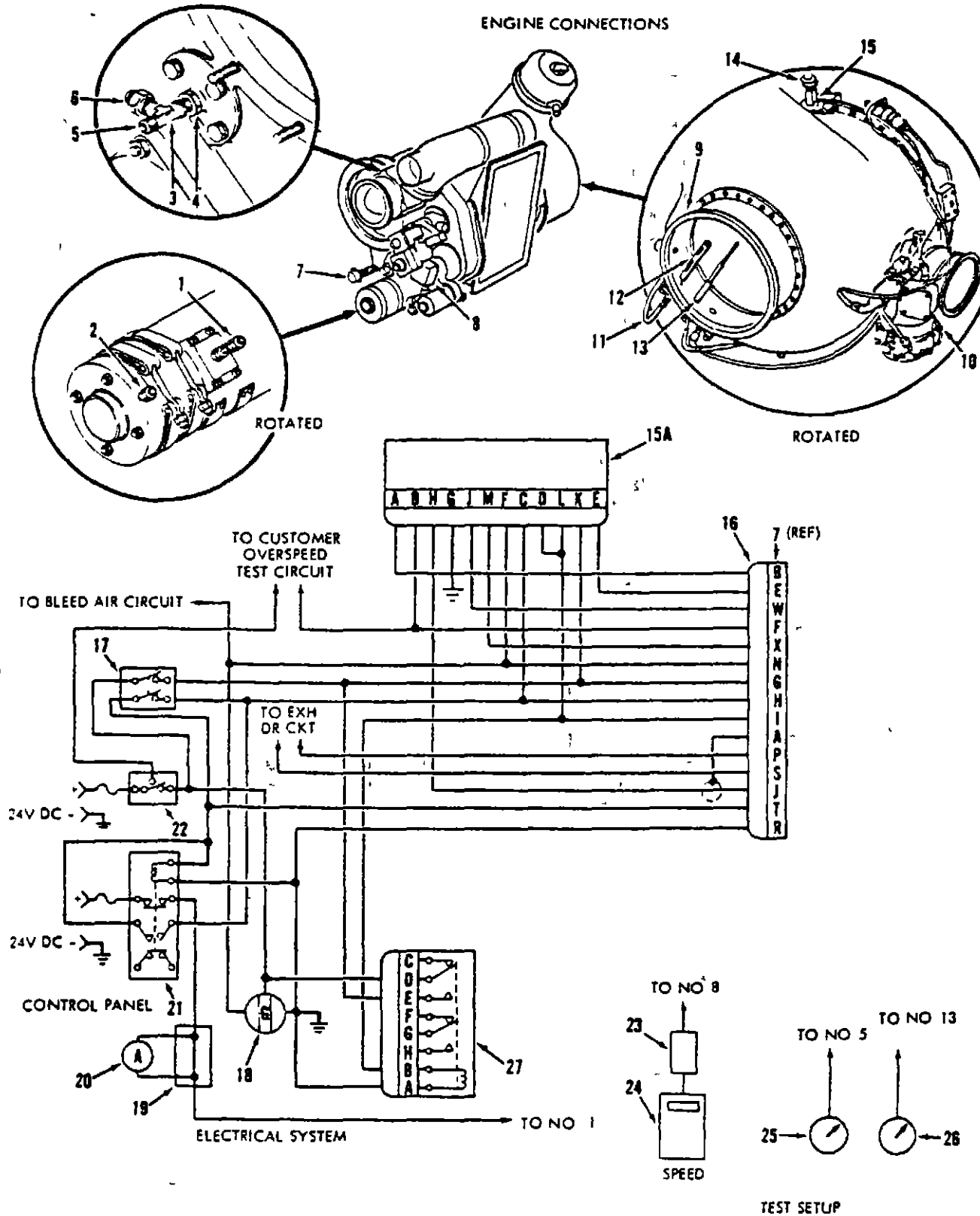
NOTE: No testing of regulator is permitted at field level.

- (1) Disconnect outlet air pressure line between air pressure regulator and load control valve at regulator.
- (2) Connect control air pressure hose assembly (Figure 501) to outlet port of pressure regulator or test port on load control valve, as applicable, and connect other end of hose to control air output pressure coupling on tester.
- (3) Start engine and allow to accelerate to no-load governed speed. Observe pressure indicated on control air pressure gage. Pressure shall be 38.0 to 39.0 inches Hg gage (18.6 to 19.2 PSIG).
- (4) If regulated outlet pressure is not within specified limits, shut down engine, loosen locknut on opposite end of air pressure regulator and turn adjustment screw clockwise to increase outlet pressure, and counterclockwise to decrease outlet pressure. Tighten locknut and repeat check procedure. Lockwire.

**4. Perform Pneumatic (Load Control) Thermostat Check and Calibration Procedure**

NOTE: It is necessary to install load control valve to provide a means of applying and controlling engine bleed air.

- (1) Remove installed engine thermocouple (Figure 504) and replace with thermocouple assembly (290416-2). Refer to 49-70-01, REMOVAL/INSTALLATION for thermocouple removal instructions.
- (2) Connect cable assembly (290424-1) to thermocouple assembly (290416-2) and receptacle on test set (290417-2-1).



Electrical System Test Setup (Typical)

Figure 504

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◀ KEY TO FIGURE 504

1. STARTER MOTOR POSITIVE TERMINAL
2. STARTER MOTOR NEGATIVE TERMINAL
3. TEE ASSY
4. NUT
5. GEARCASE NEGATIVE PRESSURE CONNECTION
6. ORIFICED CAP
7. ENGINE CONTROL INPUT RECEPTACLE
8. TACHOMETER-GENERATOR MOUNTING PAD (AND20005, TYPE XV-B)
9. TURBINE EXHAUST FLANGE
10. LOAD CONTROL VALVE
11. CONTROL AIRLINE FROM PNEUMATIC THERMOSTAT
12. PNEUMATIC THERMOSTAT
13. ENGINE THERMOCOUPLE
14. ENGINE HARNESS ASSY
15. PNEUMATIC SOLENOID VALVE (CDP)
- 15A. (CODE SD) ELECTRONIC SPEED SWITCH
16. CONTROL PANEL HARNESS RECEPTACLE
17. START SWITCH
18. GREEN READY-TO-LOAD LIGHT (95 PERCENT LIGHT)
19. SHUNT
20. AMMETER (0 TO 500 AMPS)
21. STARTER RELAY
22. MASTER STOP SWITCH
23. TACHOMETER-GENERATOR
24. EPUT METER (TACHOMETER INDICATOR)
25. COMPOUND GAGE (GEARCASE NEGATIVE PRESSURE)
26. EXHAUST GAS TEMPERATURE INDICATOR
27. LOCKOUT RELAY (CUSTOMER FURNISHED)

(3) Check load control thermostat temperature control point as follows.

(a) Start engine in accordance with applicable instructions.

NOTE. Assure that load control valve exit is clear for full bleed to atmosphere.

(b) Open engine load control valve and position air-conditioning system valves as required to load engine.

CAUTION. DO NOT ALLOW TURBINE DISCHARGE TEMPERATURE TO EXCEED LIMITS SPECIFIED IN TABLE 501

(c) Observe exhaust gas temperature reading on EGT indicator at point of temperature stabilization. If exhaust gas temperature is not within limits specified in Table 502 recalibrate thermostat in accordance with step (4).

NOTE Remove pneumatic load and operate engine three minutes (minimum) at no-load condition prior to shutting down engine.

(d) Remove pneumatic load and allow temperatures to stabilize, then shut down engine

(4) Calibrate load control thermostat if required, as follows.

(a) Determine thermostat control temperature in accordance with step (3).

(b) Remove thermostat ball valve assembly from thermostat body after disconnecting control air line.

(c) Remove and measure total thickness of shim stack using a micrometer.

(d) Determine total thickness of shim stack required to calibrate thermostat to control at desired temperature by subtracting the observed control point from the desired control point and dividing result by 30, if calibrations are made in degrees Fahrenheit, or 17, if calculations are made in degrees centigrade. Result is thickness of shims in thousandths of an inch, which shall be added or removed from total shim stack thickness to obtain required setting.

(e) Re-install thermostat ball valve assembly into thermostat body and tighten to torque value of 150 to 175 inch-pounds. If required temperature change is less than 17C (30F) adjust thermostat body within specified torque range.

- (f) Reconnect thermostat control line and tighten "B" nut to torque value of 135 to 150 inch-pounds. Use back-up wrench to hold ball valve assembly when tightening "B" nut.
- (g) Recheck temperature control point after shimming thermostat, in accordance with step (3). Controlling temperature shall repeat within 3C (5F) for two successive checks.
- (h) Remove thermostat calibration test set from engine. Re-install engine thermocouple. Refer to 49-7-1, REMOVAL/INSTALLATION for thermocouple installation instructions

**F. Check and Adjust Load Control Valve Rate Control Time**

- (1) Start and accelerate engine to no-load governed speed.
- (2) Apply bleed load and record time for load control valve to control from no-load to full bleed load.

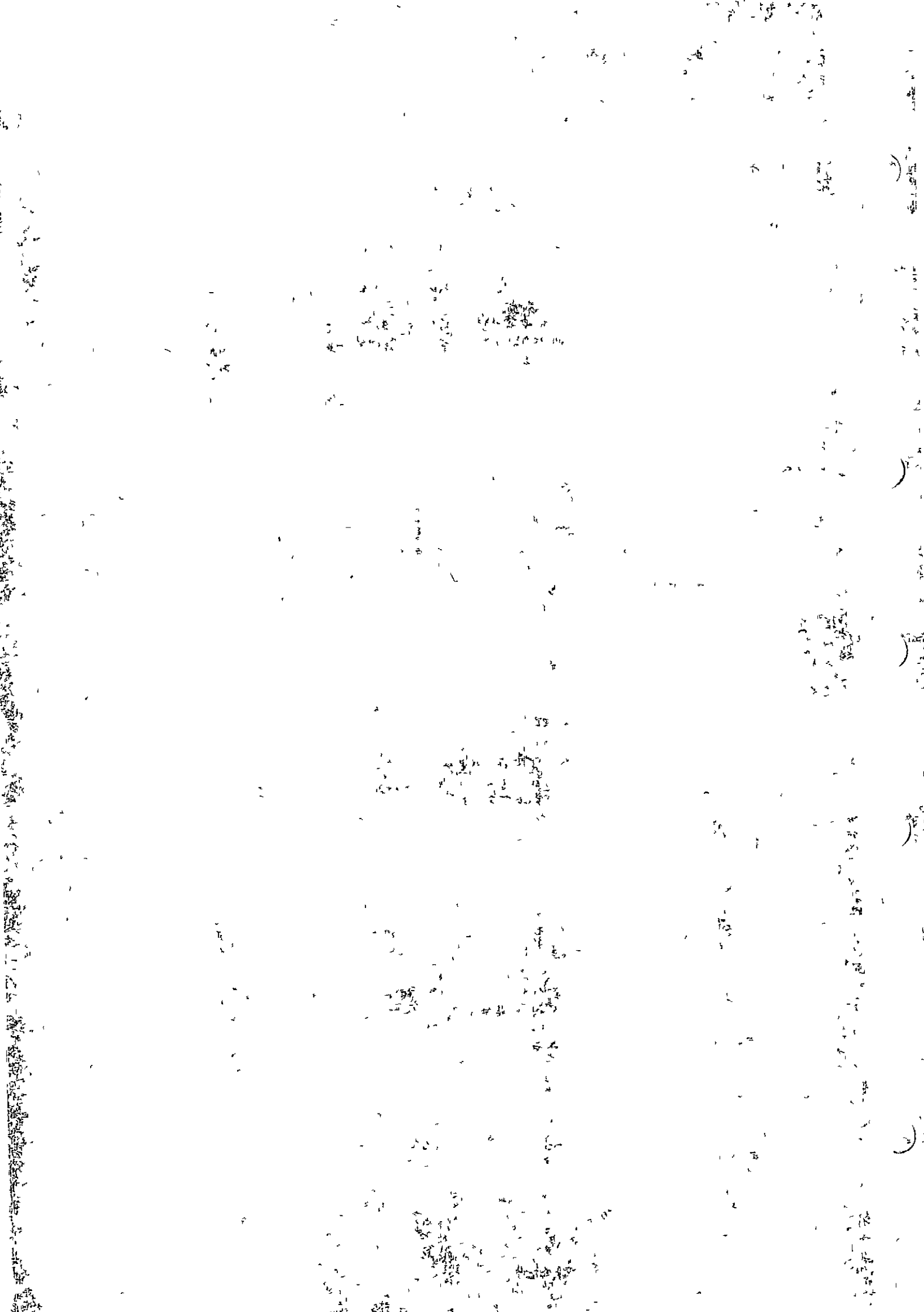
NOTE: If opening time is not within limits, hold load control valve rate adjustment screw (refer to Report No. 49-50-40) and loosen locknut. Turn adjustment clockwise to increase opening time, counterclockwise to decrease time. Hold adjustment screw and tighten locknut. Lockwire.

- (3) Full bleed load shall be reached within 9 to 14 seconds.
- (4) Repeat procedures outlined in steps (1), (2) and (3) until openings time is within limits.

**G. Perform Accessory Gearcase Assembly Negative Pressure Check**

NOTE: Connection of engine tester is not required for this check. This check need only be accomplished during trouble shooting to determine cause of high oil consumption or noticeable oil smoke from exhaust.

- (1) Remove vent plug from port on front of accessory gearcase.
- (2) Install a suitable bulkhead tee (Figure 504 with 0.035 to 0.040 inch orifice in vent port).
- (3) Connect flexible hose to bulkhead tee and connect other end of hose to a compound pressure gage.
- (4) Start engine and allow to accelerate to no-load governed speed
- (5) Note pressure reading on gage; pressure shall be -3 to -10 inches mercury gage.
- (6) Shut down engine and remove flexible hose, gage and bulkhead tee from accessory gearcase vent port. Re-install vent plug.





APU ENGINE  
DESCRIPTION AND OPERATION

EFFECTIVITY RTCA LX-N19997 LX-N20000

1 GENERAL

- A. The pneumatic and shaft power gas turbine engine is self-contained power source. Engine power is developed through compression of ambient air by a two-stage compressor. The compressed air, mixed with fuel and ignited, drives a radial inward-flow turbine wheel. The rotating shaft power of the turbine wheel drives the compressor, the accessories, and the output drive shaft.

2. COMPRESSOR AND TURBINE SECTION

- A. The compressor and turbine section develops the pneumatic and shaft power absorbed during operation of the engine. The section consists of a two-stage centrifugal compressor and a single-stage turbine wheel assembly rotating on a common shaft. The compressor is enclosed by a compressor inlet plenum assembly. The first and second stage compressor impellers are pneumatically connected through interstage ducts. The turbine plenum assembly encloses the turbine components and provides a receiver for compressed air from the compressor discharge housing. A combustion chamber liner assembly provides a combustion area and is perforated to provide the correct air-to-fuel mixture and burning rate. A turbine torus assembly directs combustion products to a turbine nozzle assembly which encompasses the turbine wheel blades. A shroud encloses the turbine wheel blades and directs the exhaust gases to the turbine exhaust pipe. (Figure 2 illustrates a combined cross sectional view with airflow schematic and a view of common accessory mounting pads.)

3 ACCESSORY SECTION

- A. The accessory gearcase section consists of a gearcase assembly and the following engine accessories: fuel pump and control unit, oil pump assembly, centrifugal switch assembly, electrical starter, tachometer generator and cooling air fan.

The gearcase assembly encloses a reduction gear system. A torsion shaft couples the compressor turbine main shaft to the main drive gear in the gearcase assembly. The main drive gear transmits power through the reduction gear system to drive the accessories at the required speed for each accessory. The arrangement of the accessory gear train permits the starter to drive all the accessories in addition to driving the compressor impellers and turbine wheel during engine starting.

#### 4 OPERATION

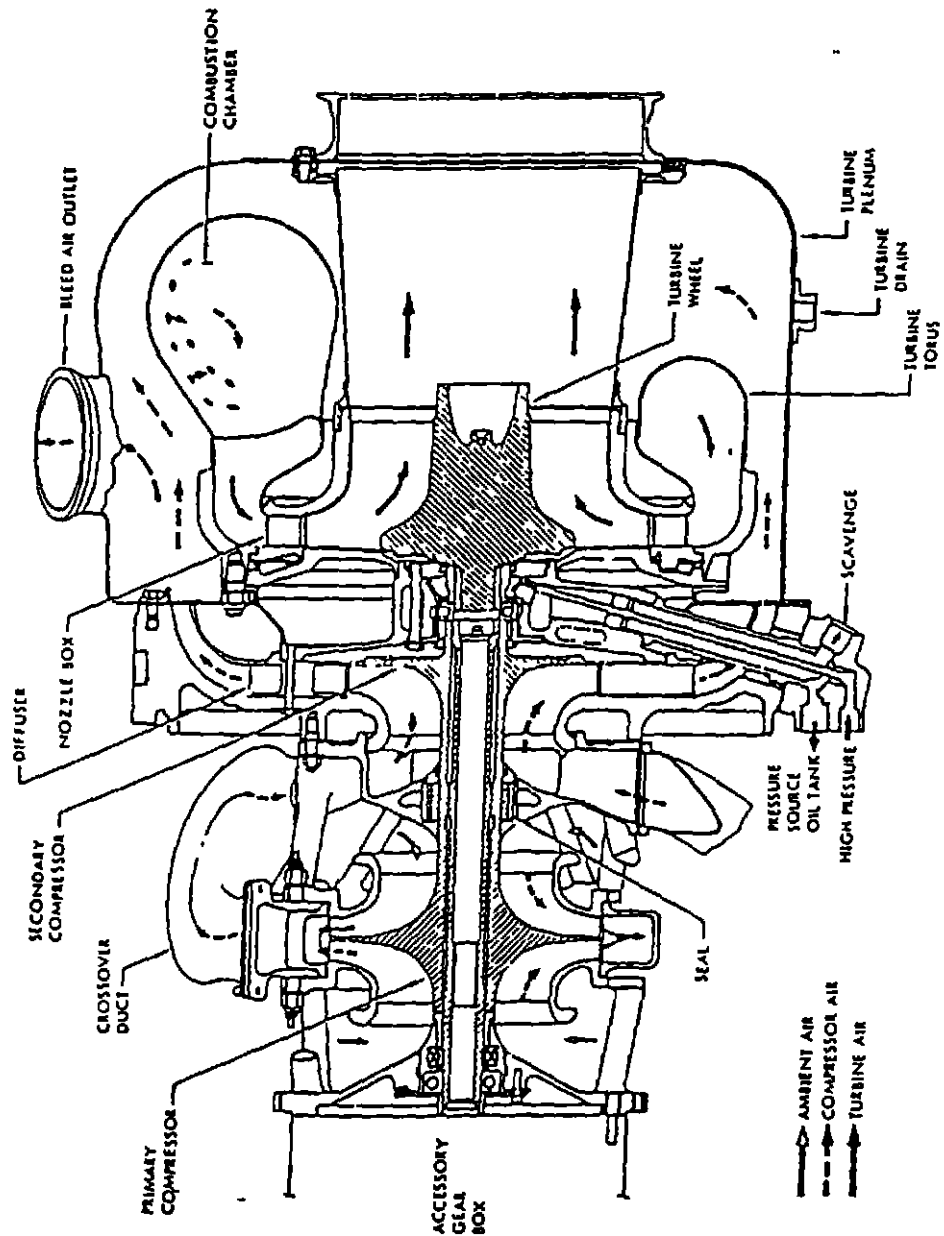
- A The engine incorporates control components in the fuel, air, and electrical systems which automatically control engine functions and maintain required engine speed and safe temperature from initiation of start through operation at full load

When the starter is energized, the rotating starter drive pawls engage a jaw in the accessory gearcase and start driving the gear train. The gear train drives the compressor and turbine rotating parts, the oil pump assembly and the fuel control unit, and the centrifugal switch assembly. The low oil pressure switch electrical circuit remains normally closed.

As the compressor and turbine rotating parts start turning, ambient air is drawn through the inlet into the compressor section. The air is compressed by the compressor first-stage impeller, then passed through interstage ducts to the compressor second-stage impeller for further compression. The compressed air is discharged into a vaned de-swirl assembly and from there is directed into the turbine plenum. (Clean Bleed-air may be withdrawn from an outlet in the plenum through a bleed-air load control valve when the engine reaches governed speed.) From the turbine plenum the compressed air enters the combustion chamber.

When engine speed reaches its required value, rising oil pressure actuates the sequencing oil pressure switch, which completes a circuit to the fuel solenoid valve and to the ignition unit. The fuel solenoid valve is energized to open to permit fuel flow to the fuel atomizer assembly. The fuel atomizer assembly sprays fuel of proper pattern and flow into the combustion chamber where the fuel and compressed air mix. The ignition unit causes the igniter plug to ignite the fuel and air mixture in the combustion chamber.

Combustion increases the energy content of the air-fuel mixture. The gases flow into the turbine torus assembly and through the turbine nozzle assembly to the blades of the turbine wheel. The spent gases are discharged through the turbine exhaust. A portion of the power developed at the turbine wheel is used to drive the compressor impellers, the accessory gear train, and the driven accessories. The remainder of the power is available for output shaft power to drive the generator when no-load governed speed is attained.



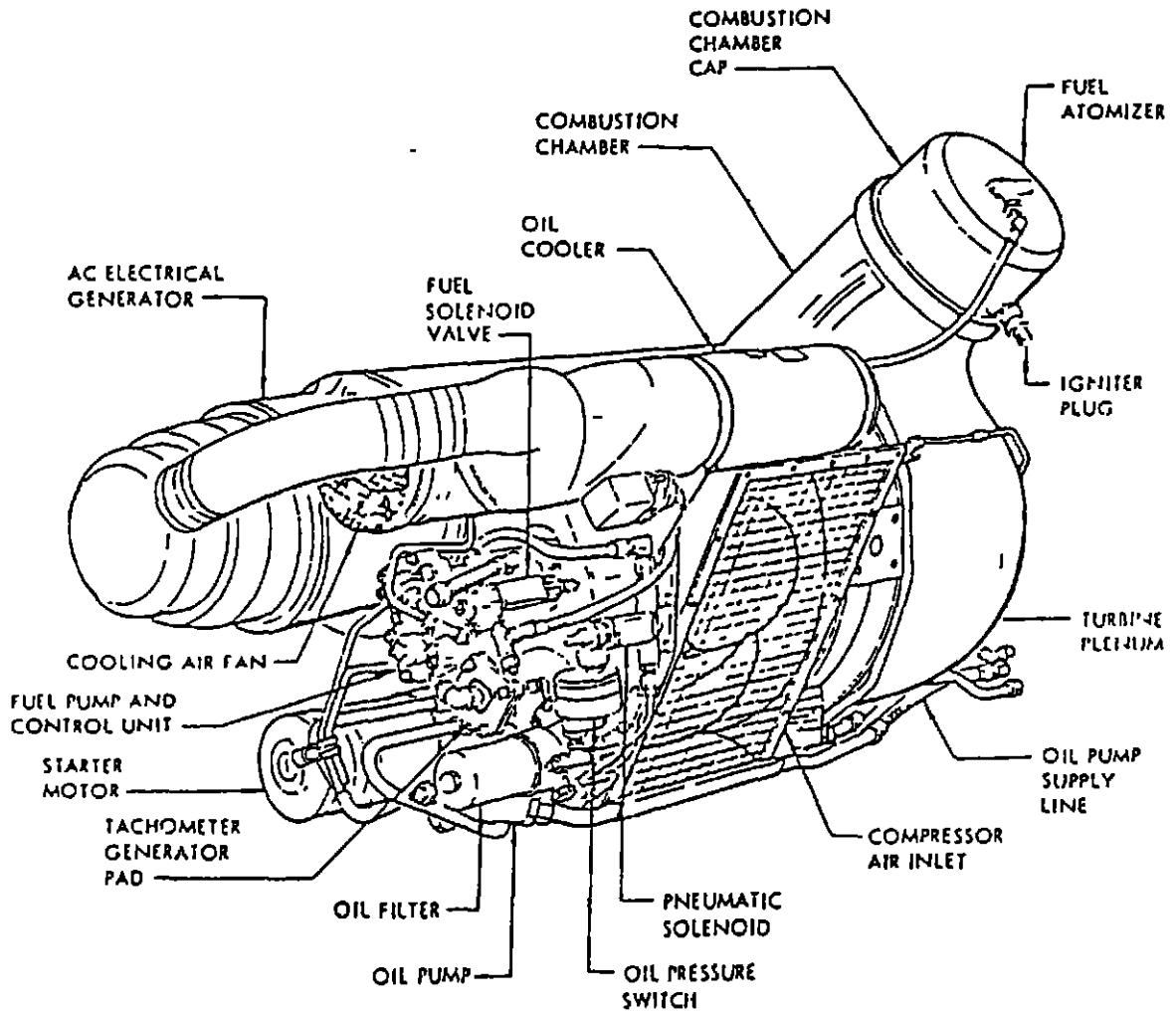
APU ENGINE SCHEMATIC

FIGURE 1

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**APU ENGINE**  
**FIGURE 2**

Ref MM STEWARD-DAVIS

#### 4 OPERATION (CONTINUED)

Acceleration of the engine continues through the combined force of the starter and energy of the hot gases. When engine speed reaches its required value, the 35 percent switch in the centrifugal switch assembly opens, which breaks a circuit to the starter. Starter rotation ceases and the starter driver pawls disengage from the accessory gear train. Engine oil pressure increases until the low oil pressure switch electrical circuit is opened.

The engine continues to accelerate under turbine power. When engine speed reaches its required value, the 95 percent switch in the centrifugal switch assembly closes, which opens a circuit to the ignition unit and closes a circuit to the hourmeter, the compressor discharge valve and the speed relay. The igniter plug ceases firing, and combustion is self-sustaining. The hourmeter starts recording operating time. Acceleration continues until the no-load governed speed is reached.

After steady-start no-load governed speed is maintained for one minute, electrical loads or bleed-air loads may be imposed.

Engine speed and exhaust temperature are automatically controlled within established limits by metering of fuel by the fuel control unit.

Smooth and proper acceleration is controlled by action of the acceleration limiter valve in the fuel control unit. The valve references compressor air discharge pressure to fuel pressure, then pressure actuated diaphragms operate a poppet valve to bypass more or less fuel to maintain the required ratio of fuel flow to compressor air pressure. During starting, when compressor air pressure is insufficient, the poppet valve is restrained from bypassing fuel by an adjustable spring pressure against the actuating diaphragm. The fuel pressure at which the spring pressure is overcome is the cracking pressure setting of the fuel control unit.

The turbine discharge temperature is controlled through a single thermostat. During start and acceleration mode the thermostat controls the fuel control limiter valve by bleeding off some of the compressor air through the three-way solenoid valve. When the engine reaches the 95 percent RPM point the 95 percent switch closes and applies 28 volts DC to the three-way solenoid valve effectively cutting off the compressed air from the fuel control limiter valve to the single thermostat. With the air control switch closed (pneumatic shutoff (load control) valve open), the turbine discharge temperature is now controlled by the single thermostat bleeding compressed air through the three-way solenoid valve from the load control valve. As the temperature rises, more air is bled through the thermostat allowing the butterfly valve in the load control valve to close reducing the load on the engine thereby reducing the turbine discharge temperature.

#### 4 OPERATION (CONTINUED)

Engine speed is controlled by action of the governor in the fuel control unit. The flyweight-type governor is driven by the main fuel pump drive shaft, which in turn, is driven through the accessory gear train. When engine speed exceeds the preset governed speed, the governor flyweights move outward to open the slide valve to bypass fuel and do decrease engine speed. When engine speed drops, as when load is applied, the governor flyweights move inward to close the slide valve to permit greater fuel flow and so increase engine speed.

Engine loading during bleed-air loading or combination shaft and bleed-air loading is automatically controlled with established limits by modulation of the load control valve butterfly position.

Overloading and consequent excessive turbine discharge temperature is controlled by action of the control thermostat. If turbine discharge temperature reaches a preset value, the ball valve in the control thermostat opens to bleed some of the control air from the load control valve actuator, which causes the actuator mechanism to move the valve butterfly toward a more closed position, thus reducing the load and the discharge temperature. When the temperature is reduced below the preset valve, the control thermostat closes and stops bleeding the control air from the actuator.

The engine is provided with certain safety devices which shut down the engine in the event of overspeeding, excessively high oil temperature, or loss of oil pressure.

If engine speed starts to exceed governed speed and governing devices in the fuel control unit have not metered fuel sufficiently to reduce speed, the flyweight-actuated overspeed switch in the centrifugal switch assembly will close, which opens a circuit to the fuel solenoid valve. When the fuel solenoid valve is de-energized, it closes and shuts off fuel flow to the combustion chamber, thus stopping the engine.

If engine oil temperature exceeds a preset value, the high oil temperature thermostatic switch electrical circuit will close, completing a circuit to a holding relay and warning light, and to the pneumatic solenoid valve to shutdown the engine.



## MAINTENANCE MANUAL

### 4 OPERATION (CONTINUED)

The engine is stopped by actuation of the normally closed pneumatic solenoid valve, mounted on the gearcase assembly. The valve is connected on the inlet port side to a compressor air discharge port, and on the outlet port side to a port on the centrifugal switch assembly. When the solenoid is actuated to open position, it permits flow of compressed air into the centrifugal switch assembly. As the air pressure in the switch assembly builds up, the switch actuating lever is forced into contact with the overspeed switch. When the overspeed switch is actuated it opens a circuit to the fuel solenoid valve and so shuts off fuel flow to the combustion chamber, thus stopping the engine.



## APU ENGINE - ADJUSTMENT/TEST

EFFECTIVITY RTCA LX-N19997 LX-N20000

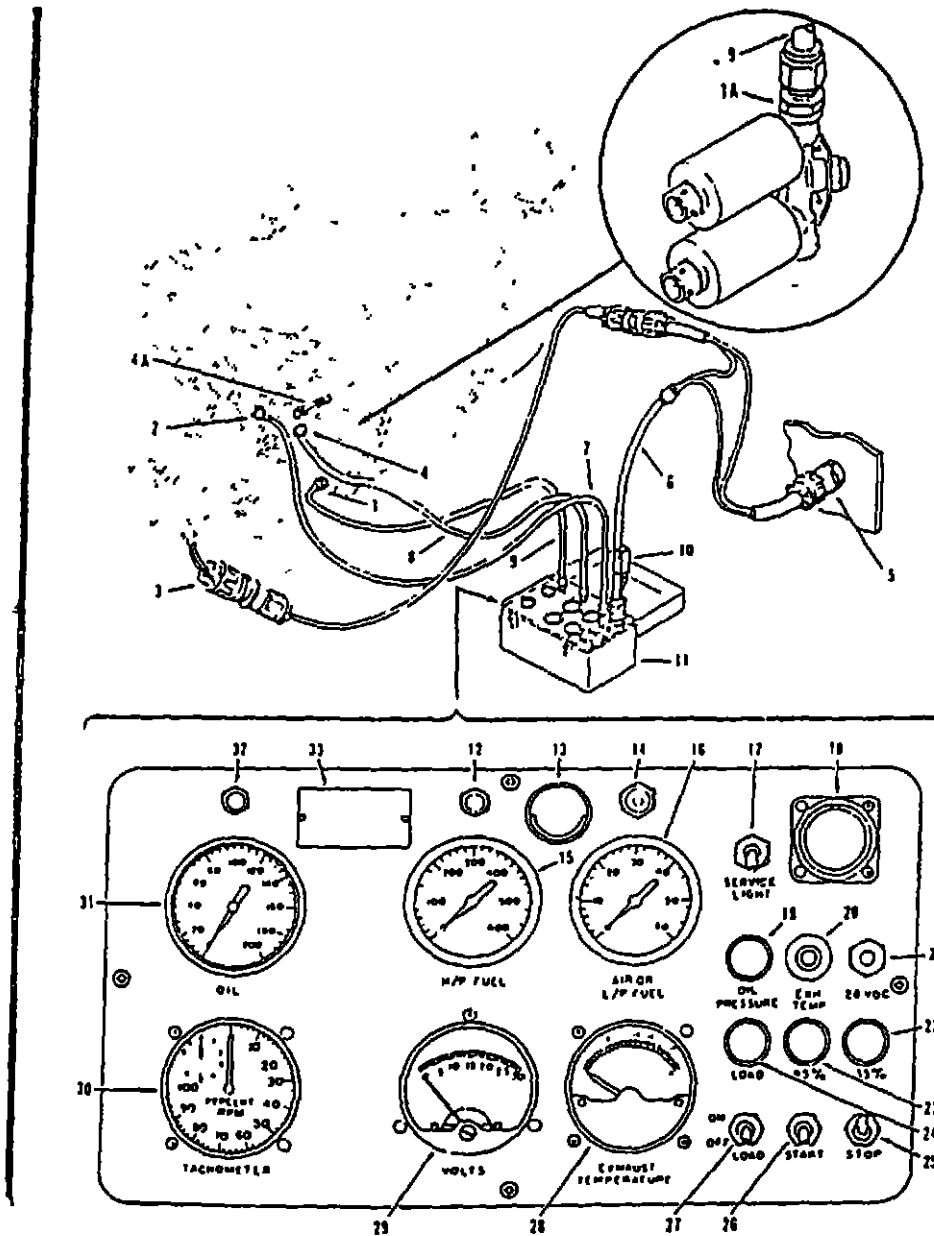
### 1 GENERAL

The test and adjustment procedures described in this subject shall be performed by personnel who operate and maintain the equipment in the field, and can be accomplished with the engine removed or installed.

Perform test and adjustment checks when possible before the engine is installed in the aircraft. Should any heavy repairs be required, refer to trouble shooting procedures provided in Engine Trouble Shooting Section.

### 2 SPECIAL TOOLS

A	Gas Turbine Engine Tester	AiResearch 290122-400
B	Electrical Cable	AiResearch 290128-1-1
C	Pressure Gage and Case Set	AiResearch 282645
D	Screwdriver and Wrench Assembly	Airesearch 280353
E	Thermostat Calibration	AiResearch 290417-2-1
	(1) Cable Assembly (Component of 290417-2-1)	AiResearch 290424-1
	(2) Thermocouple Assembly (Component of 290417-2-1)	AiResearch 290416-2
F	Wheatstone Bridge	Model 4289-2 Leads and Northrup North Wales, PA 19454



CONNECTION OF TESTER TO ENGINE (TYPICAL)

FIGURE 501

Ref MM STEWARD-DAVIS



## MAINTENANCE MANUAL

- 1A. OIL OUTPUT PRESSURE CONNECTION (GTCP85-98CK)
2. CONTROL AIR OUTPUT PRESSURE CONNECTION
3. ENGINE WIRING HARNESS RECEPTACLE
4. FUEL OUTPUT PRESSURE CONNECTION
- 4A. FUEL ATOMIZER HOSE ASSEMBLY
5. REMOTE BULKHEAD RECEPTACLE
6. ELECTRICAL CABLE
7. CONTROL AIR PRESSURE HOSE ASSY
8. FUEL PRESSURE HOSE ASSY
9. OIL PRESSURE HOSE ASSY
10. OVERSPEED TEST STOP SWITCH
11. TESTER
12. FUEL PRESSURE COUPLING
13. PANEL LIGHT
14. CONTROL AIR PRESSURE COUPLING
15. FUEL PRESSURE GAGE
16. CONTROL AIR PRESSURE GAGE
17. PANEL LIGHT SWITCH
18. RECEPTACLE
19. LOW OIL PRESSURE LIGHT (RED)
20. EXHAUST GAS TEMPERATURE SWITCH
21. 28 VDC JACK
22. 35 PERCENT LIGHT
23. 95 PERCENT LIGHT
24. LOAD LIGHT (GREEN)
25. STOP SWITCH
26. START SWITCH
27. LOAD SWITCH
28. EXHAUST TEMPERATURE INDICATOR
29. DC VOLTMETER
30. TACHOMETER INDICATOR
31. OIL PRESSURE GAGE
32. OIL PRESSURE COUPLING
33. NAMEPLATE

### KEY TO FIGURE 501

### 3. EQUIPMENT CONNECTIONS

#### A Connect Tester (290122-400) to Engine.

- (1) Disconnect engine wiring harness receptacle from the APU housing receptacle.

**NOTE** Connectors of electrical cable (6) are identified by aluminum marker bands.

- (2) Connect electrical cable (6) as follows
  - (a) Install CABLE TO TESTER connector in receptacle (18)
  - (b) Install ENGINE CONN connector to engine wiring harness receptacle (3), and install CUSTOMER CABLE connector on main connector of remote bulkhead receptacle (5)
- (3) Remove cap from output fuel pressure connection (4, Figure 501) at fuel control unit. Install fuel pressure hose assembly (8) on output fuel pressure connection (4). Install other end of fuel pressure hose assembly on fuel pressure coupling (12).
- (4) Remove cap from control air output pressure connection (2) at fuel control unit. Install control air pressure hose assembly (7) on control air output pressure connection (2). Install other end of control air pressure hose assembly on control air pressure coupling (14).
- (5) Remove cap from oil pressure connection (1) at sequencing oil pressure switch. Install oil pressure hose assembly (9) on oil pressure connection (1). Install other end of oil pressure hose assembly on oil pressure coupling (32).
- (6) Check exhaust gas temperature loop resistance at initial use of tester as follows.
  - (a) Remove tester panel attaching screws and lift panel to obtain access to temperature indicating circuit components.
  - (b) Disconnect wire leads from exhaust temperature indicator terminals on rear of indicator case to remove indicator from thermocouple circuit.

**NOTE** Make sure that white Chromel wire lead is connected to CR terminal and that green Alumel wire lead is connected to A1 terminal.

- (c) Connect a Wheatstone bridge to disconnected wire leads to measure resistance of thermocouple circuit. Measure thermocouple circuit resistance. Resistance shall be  $8\ 000 \pm 0\ 035$  ohms. If resistance is not within specified limit, adjust slide of variable resistor in tester to obtain specified resistance.
- (d) Disconnect Wheatstone bridge and reconnect wire leads to temperature indicator terminals. Replace panel of tester and secure with attaching screws.

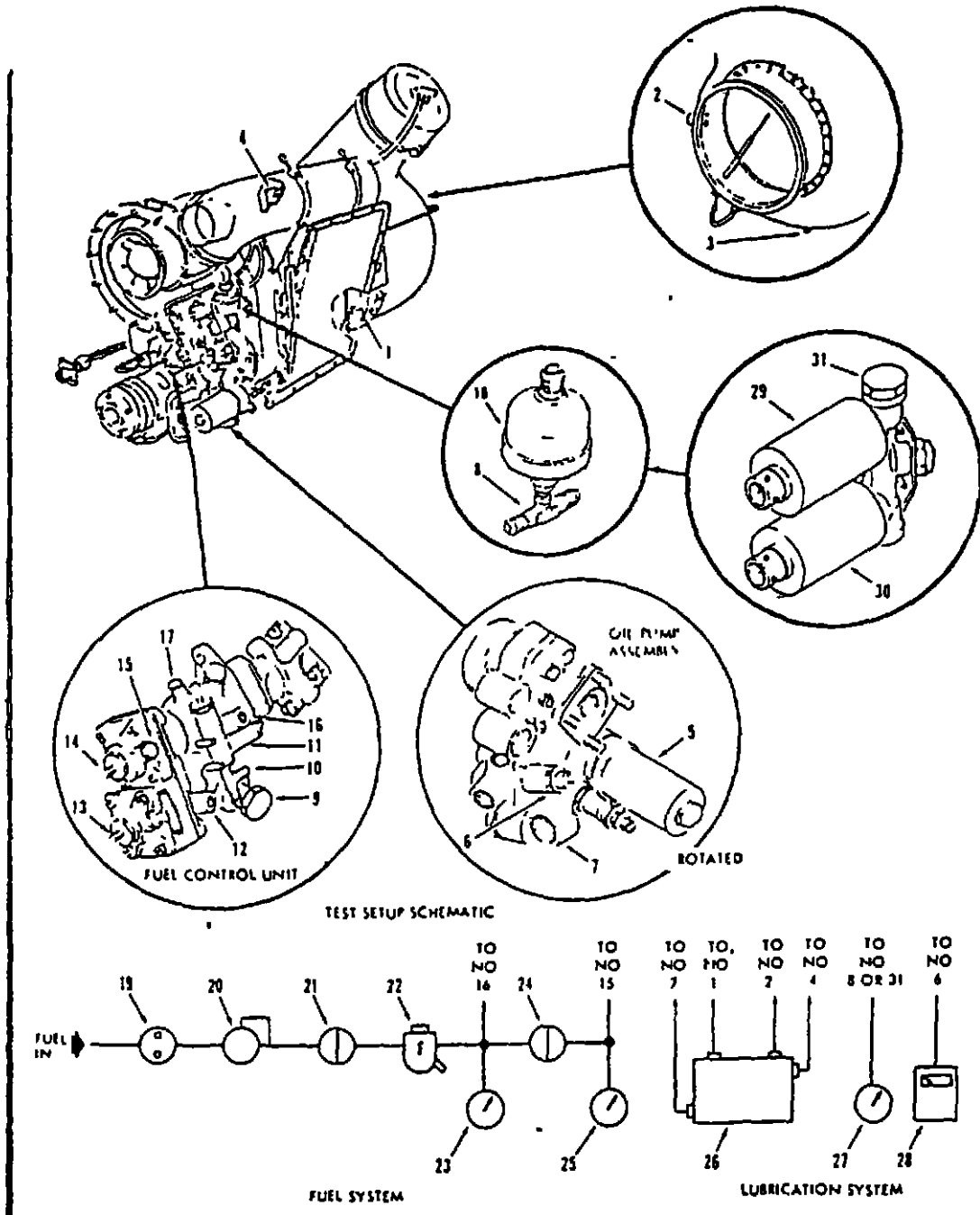
WARNING. TEST PERSONNEL SHALL STAND CLEAR OF PLANES OF ROTATION OF COMPRESSOR AND TURBINE WHEELS AND HIGH TEMPERATURE EXHAUST DUCT DURING ENGINE OPERATION. ONLY QUALIFIED PERSONNEL SHALL BE PERMITTED TO OPERATE, TEST, AND MAINTAIN ENGINE. EXERCISE EXTREME CAUTION TO PREVENT INTRODUCTION OF FOREIGN MATERIALS IN COMPRESSOR AIR INLET.

(E) Engine is now ready for test

#### 4 PRECAUTIONARY REQUIREMENTS

##### A Observe Precautionary Requirements

- (1) If operation limits tabulated in Table 501 are exceeded, or if seizing, unusual noise, smoke, fuel or oil leakage, or other obvious malfunction is observed, shut down engine immediately and correct the cause of trouble.



**FUEL AND LUBRICATION SYSTEM TEST SETUP (TYPICAL)**

**FIGURE 502**

Ref. MM STEWARD-DAVIS



## MAINTENANCE MANUAL

### KEY TO FIGURE 502

1. OIL VENT CONNECTION (3/4-16 THD FOR 1/2 IN. LINE)
2. OIL VENT CONNECTION (3/4-16 THD FOR 1/2 IN. LINE)
3. FUEL DRAIN VALVE CONNECTION (7/16-20 THD FOR 1/4 IN. LINE)
4. OIL RETURN CONNECTION (TO TANK) (3/4-16 THD FOR 1/2 IN. LINE)
5. OIL FILTER
6. OIL TEMPERATURE BULB
7. OIL INLET CONNECTION (1-1/16-12 THD FOR 3/4 IN LINE)
8. OIL PRESSURE CONNECTION (9/16-18 THD FOR 3/8 IN. LINE)
9. FUEL FILTER
10. FUEL OUTLET (TO ATOMIZER)
11. FUEL SOLENOID VALVE
12. FUEL DRAIN CONNECTION (7/16-20 THD FOR 1/4 IN. LINE)
13. ACCELERATION LIMITER ADJUSTMENT SCREW
14. GOVERNOR ADJUSTMENT SCREW
15. FUEL PRESSURE CONNECTION (7/16-20 THD FOR 1/4 IN LINE)
16. FUEL INLET CONNECTION (9/16-18 THD FOR 3/8 IN. LINE)
17. NOT USED
18. SEQUENCING OIL PRESSURE SWITCH
19. FUEL BOOST PUMP
20. PRESSURE REGULATOR
21. SHUTOFF VALVE
22. FUEL FILTER
23. PRESSURE GAGE (FUEL INLET (0 TO 20 PSIG)
24. MANUAL FUEL BYPASS VALVE
25. PRESSURE GAGE (FUEL DISCHARGE) (0 TO 120 PSIG)
26. OIL TANK
27. PRESSURE GAGE (OIL DISCHARGE) (0 TO 120 PSIG)
28. TEMPERATURE INDICATOR (OIL DISCHARGE) (0 TO 300°F)
29. SEQUENCING OIL PRESSURE SWITCH
30. LOW PRESSURE SWITCH
31. OIL PRESSURE CONNECTION

  
**BOEING**  
*Intercontinental*  
**707**  
**MAINTENANCE MANUAL**

OBSERVATION	CONDITION	LIMIT REQUIREMENTS
<b>CAUTION :</b> STOP UNIT IF INDICATED VALUES EXCEED OR PERSIST AT THESE LIMITS.		
Compressor Inlet Air Temperature	Continuous operation	54C (130F) max
Cooling Fan Air Inlet Temperature	Continuous operation	54C (130F) max.
<p><b>CAUTION:</b> TURBINE DISCHARGE TEMPERATURE DURING NORMAL ENGINE OPERATION SHOULD NOT EXCEED CONTINUOUS OPERATION LIMIT. ENGINE OPERATION AT TURBINE DISCHARGE TEMPERATURES ABOVE CONTINUOUS OPERATION LIMIT IS EVIDENCE OF ENGINE DISTRESS, AND APPROPRIATE CORRECTIVE ACTION SHOULD BE TAKEN TO RESTORE NORMAL OPERATION</p>		
Turbine Discharge Temperature	Continuous operation	620 <sup>o</sup> C (1148 <sup>o</sup> F)
	Never exceed.	660 <sup>o</sup> C (1220 <sup>o</sup> F) .
<p><b>NOTE.</b> Never exceed temperatures may be exceeded during engine start and acceleration, provided that start time does not exceed limit shown in Figure 503</p> <p>If turbine discharge temperature exceeds 710C (1310F) during the start/acceleration cycle, shut down APU and perform a hot start inspection. (Refer to INSPECTION/CHECK.)</p>		
Turbine Wheel Speeds	Continuous operation	41,700 RPM max.
	10 second operation	42,500 to 44,500 RPM
	Never exceed	44,500 RPM max.
Fuel Temperature at Fuel Control Unit Inlet	Any operating condition	43C (110F) max.

**TABLE 501 - OPERATING LIMITS**

Ref : MM STEWARD-DAVIS



MAINTENANCE MANUAL

OBSERVATION	CONDITION	LIMIT REQUIREMENTS
Oil Temperature	Any operating condition	124C (255F) max.) shall not exceed 52C (125F) above fan inlet air temperature.
Oil pressure	30,000 RPM or higher	95 ± 5 PSIG
	Allowable fluctuation at steady-state	± 3 PSI max.
Gearcase Negative Pressure	At rated speed	-3 to -10 in. Hg
Turbine Bearing Cavity Pressure	At rated speed with vent to oil tank removed	0 to -24 in. Hg ga
<p><b>CAUTION</b> MAXIMUM PEAK VIBRATIONS GREATER THAN THE LIMITS SHOWN MAY OCCUR AT CERTAIN CRITICAL TURBINE SPEEDS FROM 10,000 TO 13,000 RPM. DO NOT OPERATE THE UNIT CONTINUOUSLY AT ANY SPEED WHERE VIBRATION EXCEEDS THESE LIMITS OR UNDER CONDITIONS THAT CREATE SPEED DWELLINGS BETWEEN 10,000 AND 13,000 RPM.</p>		
<p><b>NOTE:</b> Momentary vibration amplitudes in excess of specified limits are acceptable during start and acceleration cycles, however, the magnitude of the observed amplitude excursions should not exceed twice the specified limits, i e., 1.2 mil at gearcase end or 0.8 mil at turbine end.</p>		
Vibration Amplitude	Gearcase end at any operating condition	0.6 mil max. at any frequency
	Turbine end at any operating condition	0.4 mil max. at any frequency
Starter Motor	Duty Cycle	One minute on max. and four minutes off min.
<p><b>NOTE:</b> A cooling period of 30 minutes is required after four starter motor duty cycles.</p>		

TABLE 501 - OPERATING LIMITS (CONTINUED)

  
**BOEING**  
*Intercontinental*  
**707**  
**MAINTENANCE MANUAL**

OBSERVATION	CONDITION	LIMIT REQUIREMENTS
Light-off Time	After oil pressure reaches 5 PSIG	20 sec. max.
Leakage	Oil leakage from any shaft seal	None
	Oil leakage from first-stage compressor seal during or after shutdown	None
	Fuel leakage from accessory drain only	One drop per minute max.
	Fuel leakage from turbine plenum drain	None, except on false start or blowout
	Air leakage (other than valve bleed holes, pressure regulator, acceleration limiter valve cap)	None, except plenum drain at slow speed
Actuation of 110 Percent Switch		44,250 ± 250 RPM

**NOTE.** The use of the hot section components will be extended by operating the engine at no-load governed speed for at least one minute prior to application of a bleed-air load

4. A. (2) Allow engine to operate at no-load governed speed for one minute (minimum) prior to application of a bleed-air load.

**NOTE:** The use of the hot section components will be extended by operating the engine at or below the recommended pneumatic thermostat setting.

- (3) Calibrate pneumatic thermostat at or below the recommended temperature setting 565°C (1050°F). (Refer to Table 502.)
- (4) Allow engine to operate at zero bleed-air for three minutes (minimum) prior to shutdown.

**TABLE 501 - OPERATING LIMITS (CONTINUED)**

Ref : MM STEWARD-DAVIS

**BOEING**  
  
**MAINTENANCE MANUAL**

EGT Measurement	Pneumatic (Load Mode) Thermostat
	<u>MAX.</u>
Test Set	620C (1150F)

**5. CHECKS AND ADJUSTMENTS**

**A. Check and Adjust Fuel Control Unit Acceleration Limiter Valve Cracking Pressure**

NOTE Connection of tester is not required

- (1) Remove cap at control air pressure connection (2, Figure 501) at fuel control unit to vent acceleration limiter valve to ambient pressure during pressure check.
- (2) Disconnect fuel atomizer hose assembly (4A) from tee fitting, then connect a suitable length of 1/4 inch high pressure hose to tee fitting.
- (3) Connect pressure gage of case set (282645) to high pressure hose installed in step (2).
- (4) Energize start switch to rotate engine by starter motor action

CAUTION: DO NOT EXCEED STARTER DUTY CYCLE LIMIT SPECIFIED IN TABLE 501.

**TABLE 502 - ENGINE EXHAUST GAS TEMPERATURE (EGT) SETTINGS**

- (5) Note acceleration limiter valve cracking pressure at approximately 20 percent (8000 to 9000 RPM) engine speed. Cracking pressure shall be  $60 \pm 2$  PSIG.

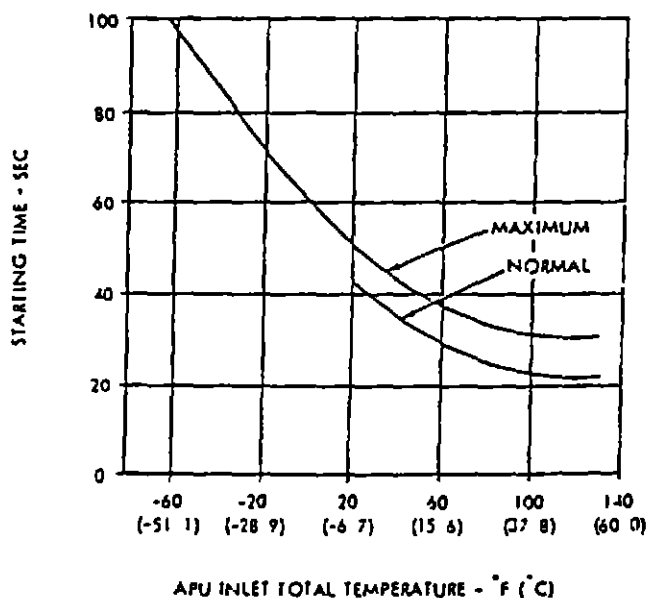
**NOTE:** If cracking pressure is not within limits, loosen locknut and adjust acceleration limiter valve adjustment screw (Figure 502) using screwdriver and wrench assembly (280353). Clockwise adjustment decreases pressure. When adjustment is satisfactory, tighten locknut, and recheck acceleration limiter valve cracking pressure per instructions outlined in steps (4) and (5). Lockwire.

- (6) Disconnect pressure gage and high pressure hose from tee fitting, then reconnect fuel atomizer hose assembly to tee fitting.
- (7) Re-install cap on control air output pressure connection (2, Figure 501) at fuel control unit.

B Check Engine Start, Acceleration, Operation, and Actuation of Automatic Controls

**NOTE** If engine does not operate satisfactorily as indicated in following steps, stop engine and correct malfunction before proceeding (Refer to Engine Trouble Shooting Section.)

- (1) Connect Engine Tester (290122-400) to engine.
- (a) Place load switch (27, Figure 501) in OFF position.
- (b) Momentarily place start switch (26) in START position.
- 1) Low oil pressure light (red) (19) and 35 percent light (22) shall go on immediately.
- 2) Engine shall start and accelerate smoothly, indicated by evidence of oil pressure at oil pressure gage (Figure 501), engine speed at tachometer indicator, compressor air pressure at control air pressure gage, fuel pressure at fuel pressure gage and exhaust gas temperature at exhaust gas temperature indicator. If APU does not reach governed speed within time limit shown in Figure 503, terminate start.



**NOTES**

- 1 NACA STANDARD SEA LEVEL PRESSURE
2. STARTING TIME DEFINED AS THE PERIOD FROM STARTER ACTUATION TO NOMINAL GOVERNED SPEED WITH NO BLEED OR ELECTRICAL LOAD BEING APPLIED
- 3 DC POWER EQUIVALENT TO ONE AN3150-2 STORAGE BATTERY WITH ELECTROLYTE TEMPERATURE AT 0° F (-18° C) OR HIGHER.
- 4 SERIES RESISTANCE OF CABLES FROM BATTERY TO UNIT ELECTRICAL CONNECTOR NOT TO EXCEED 0.016 OHM
- 5 TOTAL LOAD IMPOSED DURING STARTING CYCLE NOT TO EXCEED THE POLAR MOMENT OF INERTIA AND FRICTIONAL DRAG IMPOSED BY AN AIRCRAFT-TYPE, 60 KVA, AC GENERATOR AND AN AIRCRAFT-TYPE TACHOMETER
- 6 THE OIL VISCOSITY AT THE LOWER TEMPERATURE LIMIT FOR STARTING IS 13,000 CENTISTOKES. THE LOWER TEMPERATURE LIMIT FOR TYPE I OIL IS -65° F (-53.9° C) WHICH EQUATES TO -40° F (-40° C) FOR TYPE II

**STARTING TIME Vs APU  
 INLET TOTAL TEMPERATURE  
 FIGURE 503**

- 3) Throughout start, acceleration, and operation, exhaust gas temperature, indicated on exhaust gas temperature indicator shall not exceed limits specified in Table 501

**CAUTION SHUT DOWN ENGINE AT ONE  
AND CORRECT TROUBLE IF  
EXHAUST GAS TEMP-  
ERATURE EXCEEDS LIMITS  
SPECIFIED IN TABLE 501**

- 4) When oil pressure reaches 2.5 to 3.5 PSIG, indicated at oil pressure gage, fuel solenoid circuit shall close, allowing fuel flow, indicated on fuel pressure gage
- 5) When engine speed reaches approximately 35 percent, indicated on tachometer indicator, 35 percent switch shall actuate to break starter circuit, indicated by 35 percent light going off
- 6) When engine speed reaches 95 percent, indicated on tachometer indicator, 95 percent switch shall actuate to break ignition circuit and close time totalizing meter circuit, indicated by 95 percent light going on and engine time totalizing meter starting to record time

**NOTE** Indication of 100 percent speed on tester tachometer indicator is equivalent to 41,185 RPM turbine wheel speed

- 7) Engine shall continue to accelerate, and fuel control unit governor shall operate to control engine speed at no-load governed speed, 101.25 percent (41,700 RPM) maximum, indicated on tester tachometer indicator
- 8) Energize pneumatic shutoff solenoid to shut down engine. Solenoid shall open to pressurize centrifugal switch and actuate centrifugal switch overspeed switch.

**C Check and Adjust Fuel Control Unit Governor Speed Setting**

- (1) Connect Engine Tester (290122-400) to engine
  - (a) Place load switch in OFF position
  - (b) Momentarily place start switch in START position and allow engine to accelerate to no-load governed speed.

**NOTE** Indication of 100 percent engine speed on tachometer indicator is equivalent to 41,185 RPM turbine wheel engine speed.



## MAINTENANCE MANUAL

- (c) With no-load applied, engine speed shall stabilize at 101.25 percent (41,700 RPM) maximum indicated on tester tachometer indicator.
- (d) If steady-state no-load governed speed is not within limits of 100.75 to 101.25 percent (41,500 to 41,700 RPM) indicated on tester tachometer indicator, loosen locknut and adjust governor adjustment screw (Figure 502) using screwdriver and wrench assembly. Clockwise adjustment increases speed, counterclockwise adjustment decreases speed.
- (e) When adjustment is satisfactory, tighten locknut. Lockwire.

### D Check Air Pressure Regulator Output Pressure

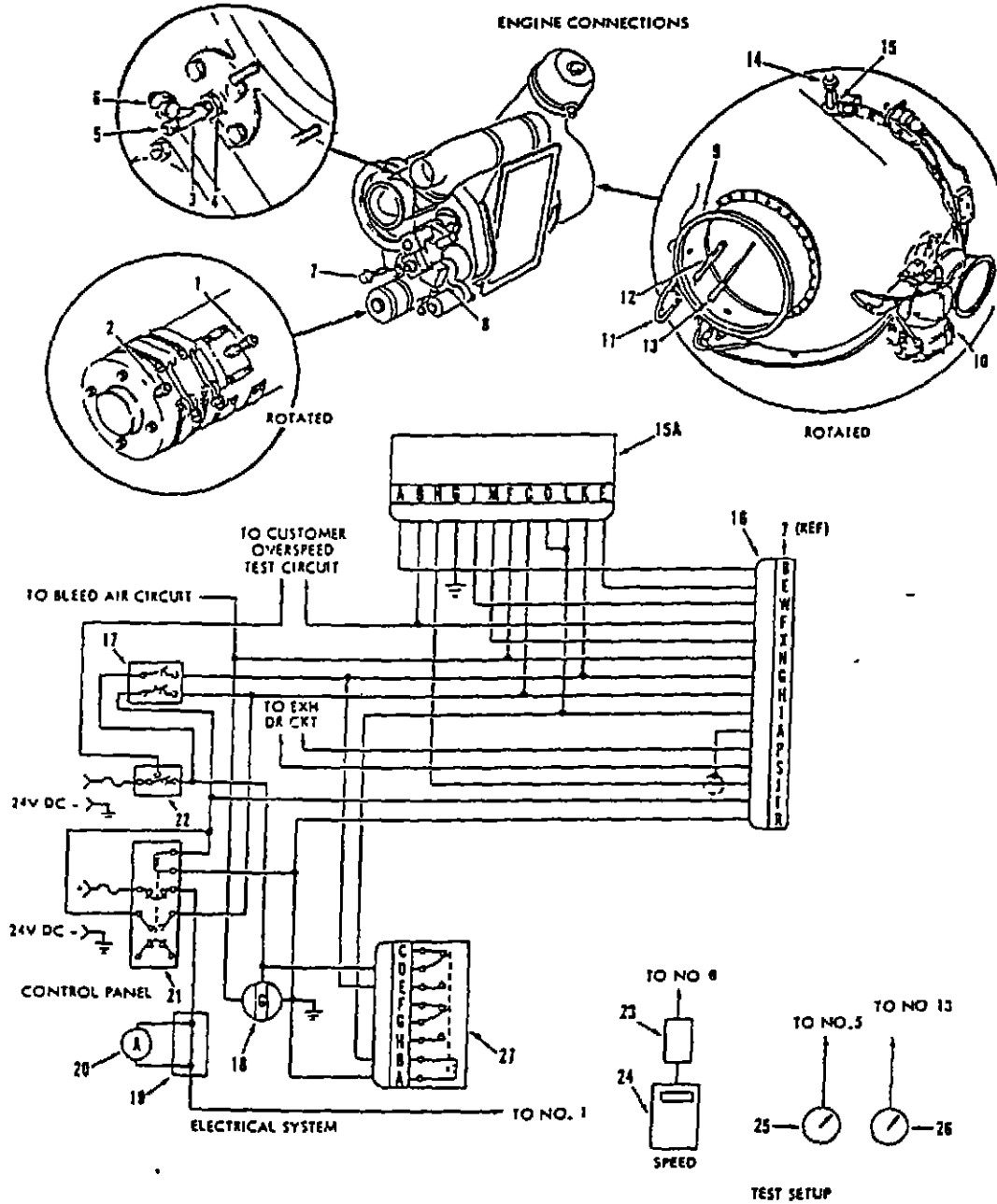
**NOTE** No testing of regulator is permitted at field level.

- (1) Disconnect outlet air pressure line between air pressure regulator and load control valve at regulator.
- (2) Connect control air pressure hose assembly (Figure 501) to outlet port of pressure regulator or test port on load control valve, as applicable, and connect other end of hose to control air output pressure coupling on tester.
- (3) Start engine and allow to accelerate to no-load governed speed. Observe pressure indicated on control air pressure gage. Pressure shall be 38.0 to 39.0 inches Hg gage (18.6 to 19.2 PSIG).
- (4) If regulated outlet pressure is not within specified limits, shut down engine, loosen locknut on opposite end of air pressure regulator and turn adjustment screw clockwise to increase outlet pressure, and counterclockwise to decrease outlet pressure. Tighten locknut and repeat check procedure. Lockwire.

### E Perform Pneumatic (Load Control) Thermostat Check and Calibration Procedure

**NOTE.** It is necessary to install load control valve to provide a means of applying and controlling engine bleed air.

- (1) Remove installed engine thermocouple (Figure 504) and replace with thermocouple assembly (290416-2). Refer to 49-70-02, REMOVAL/INSTALLATION for thermocouple removal instructions.
- (2) Connect cable assembly (290424-1) to thermocouple assembly (290416-2) and receptacle on test set (290417-2-1).



**ELECTRICAL SYSTEM TEST SETUP (TYPICAL)**

**FIGURE 504**

Ref MM STEWARD-DAVIS

1. STARTER MOTOR POSITIVE TERMINAL
2. STARTER MOTOR NEGATIVE TERMINAL
3. TEE ASSY
4. NUT
5. GEARCASE NEGATIVE PRESSURE CONNECTION
6. ORIFICED CAP
7. ENGINE CONTROL INPUT RECEPTACLE
8. TACHOMETER-GENERATOR MOUNTING PAD (AND20005, TYPE XV-B)
9. TURBINE EXHAUST FLANGE
10. LOAD CONTROL VALVE
11. CONTROL AIRLINE FROM PNEUMATIC THERMOSTAT
12. PNEUMATIC THERMOSTAT
13. ENGINE THERMOCOUPLE
14. ENGINE HARNESS ASSY
15. PNEUMATIC SOLENOID VALVE (CDP)
- 15A. (CODE SD) ELECTRONIC SPEED SWITCH
16. CONTROL PANEL HARNESS RECEPTACLE
17. START SWITCH
18. GREEN READY-TO-LOAD LIGHT (95 PERCENT LIGHT)
19. SHUNT
20. AMMETER (0 TO 500 AMPS)
21. STARTER RELAY
22. MASTER STOP SWITCH
23. TACHOMETER-GENERATOR
24. EPUT METER (TACHOMETER INDICATOR)
25. COMPOUND GAGE (GEARCASE NEGATIVE PRESSURE)
26. EXHAUST GAS TEMPERATURE INDICATOR
27. LOCKOUT RELAY (CUSTOMER FURNISHED)

**KEY TO FIGURE 504**

- (3) Check load control thermostat temperature control point as follows:
- (a) Start engine in accordance with applicable instructions.

NOTE Assure that load control valve exit is clear for full bleed to atmosphere
  - (b) Open engine load control valve and position air-conditioning system valves as required to load engine

CAUTION DO NOT ALLOW TURBINE DISCHARGE TEMPERATURE TO EXCEED LIMITS SPECIFIED IN TABLE 501
  - (c) Observe exhaust gas temperature reading on EGT indicator at point of temperature stabilization. If exhaust gas temperature is not within limits specified in Table 502 recalibrate thermostat in accordance with step (4)

NOTE. Remove pneumatic load and operate engine three minutes (minimum) at no-load condition prior to shutting down engine
  - (d) Remove pneumatic load and allow temperatures to stabilize, then shut down engine
- (4) Calibrate load control thermostat, if required, as follows
- (a) Determine thermostat control temperature in accordance with step (3)
  - (b) Remove thermostat ball valve assembly from thermostat body after disconnecting control air line
  - (c) Remove and measure total thickness of shim stack using a micrometer
  - (d) Determine total thickness of shim stack required to calibrate thermostat to control at desired temperature by subtracting the observed control point from the desired control point and dividing result by 30, if calibrations are made in degrees Fahrenheit, or 17, if calculations are made in degrees centigrade. Result is thickness of shims in thousandths of an inch, which shall be added or removed from total shim stack thickness to obtain required setting
  - (e) Re-install thermostat ball valve assembly into thermostat body and tighten to torque value of 150 to 175 inch-pounds. If required temperature change is less than 17C (30F) adjust thermostat body within specified torque range

Ref : MM STEWARD-DAVIS

- (f) Reconnect thermostat control line and tighten "B" nut to torque value of 135 to 150 inch-pounds Use back-up wrench to hold ball valve assembly when tightening "B" nut.
- (g) Recheck temperature control point after shimming thermostat, in accordance with step (3) Controlling temperature shall repeat within 3C (5F) for two successive checks
- (h) Remove thermostat calibration test set from engine Re-install engine thermocouple Refer to 49-7-1, REMOVAL/INSTALLATION for thermocouple installation instructions

**F Check and adjust Load Control Valve Rate Control Time**

- (1) Start and accelerate engine to no-load governed speed
- (2) Apply bleed load and record time for load control valve to control from no-load to full bleed load.

NOTE If opening time is not within limits, hold load control valve rate adjustment screw (refer to Report No 49-50-40) and loosen locknut Turn adjustment clockwise to increase opening time, counterclockwise to decrease time Hold adjustment screw and tighten locknut Lockwire

- (3) Full bleed load shall be reached within 9 to 14 seconds
- (4) Repeat procedures outlined in steps (1), (2), and (3) until openings time is within limits

**G Perform Accessory Gearcase Assembly Negative Pressure Check**

NOTE Connection of engine tester is not required for this check This check need only be accomplished during trouble shooting to determine cause of high oil consumption or noticeable oil smoke from exhaust

- (1) Remove vent plug from port on front of accessory gearcase
- (2) Install a suitable bulkhead tee (Figure 504 with 0 035 to 0 040 inch orifice in vent port.
- (3) Connect flexible hose to bulkhead tee and connect other end of hose to a compound pressure gage
- (4) Start engine and allow to accelerate to no-load governed speed
- (5) Note pressure reading on gage, pressure shall be -3 to -10 inches mercury gage.
- (6) Shut down engine and remove flexible hose, gage and bulkhead tee from accessory gearcase vent port Re-install vent plug

APU ENGINE COMBUSTION AND EXHAUST SECTION

INSPECTION/CHECK

EFFECTIVITY TCA LX-N20198 LX-N20199

1. GENERAL

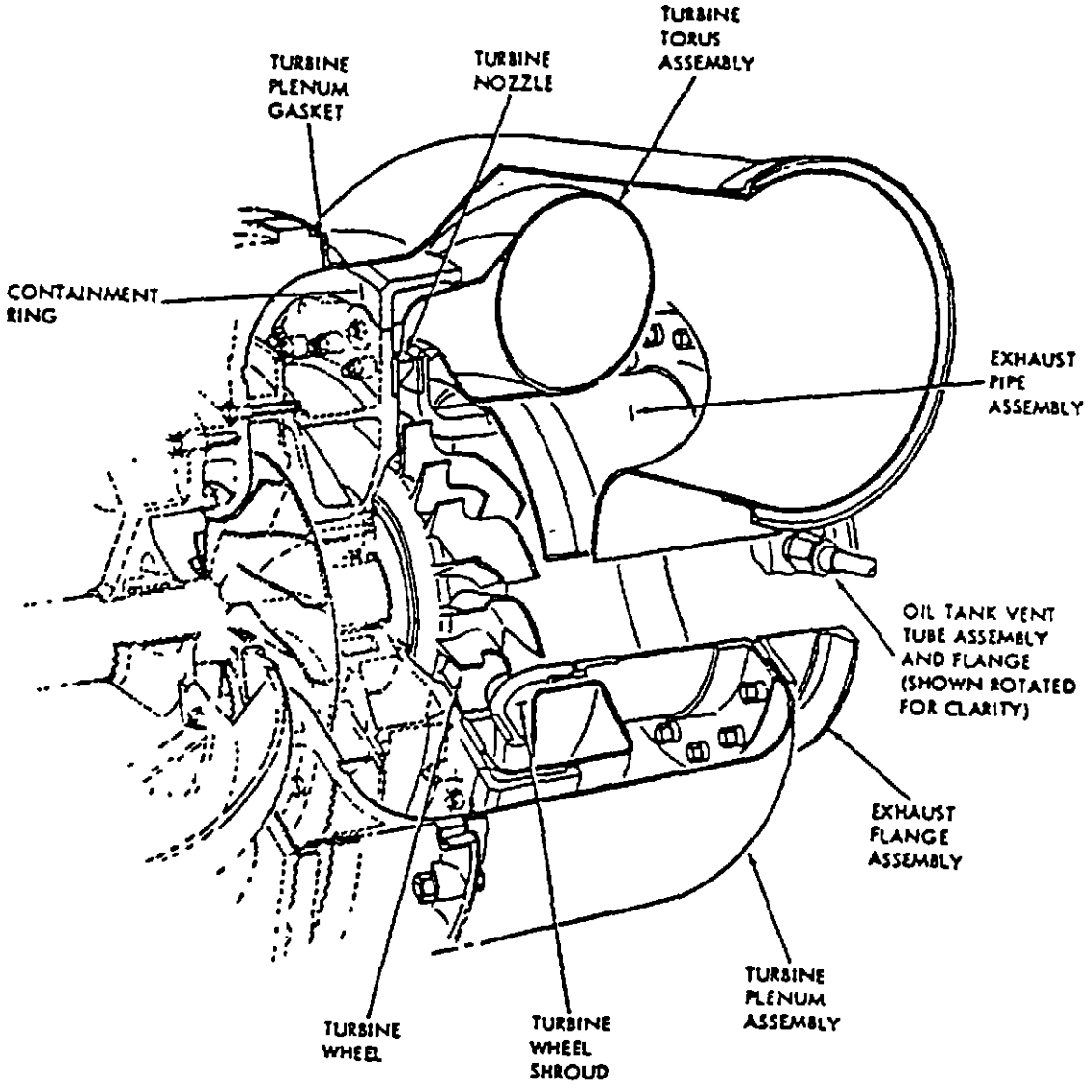
The following methods and procedures can be accomplished by personnel who maintain the equipment in the field. A careful visual inspection shall precede any detail checks to eliminate unnecessary inspection procedures and to determine the extent of further checking. Long life and continued efficient operations of the engine depend upon the care and accuracy with which inspections are conducted.

2. INSPECT HOT SECTION COMPONENTS (See Figure 201)

NOTE: If cracks, erosion, deformation or other obvious damage is evident during this inspection, remove engine from installation and perform a detailed hot section inspection. Refer to Heavy Maintenance Section of AirResearch Report No. 49-20-37 for detailed hot section inspection of removed engine.

- A. Visually inspect containment ring for security and attaching washers for fretting.
- B. Check turbine plenum gasket for evidence of deterioration or leakage.
- C. Visually inspect turbine nozzle for cracks, scoring, erosion and feathering damage.
- D. Visually inspect turbine torus assembly for cracks, erosion, deformation and wear.
- F. Visually inspect exhaust pipe assembly for cracks.
- G. Check that oil tank vent tube assembly ID and opening in flange are not obstructed.
- H. Visually inspect exhaust flange assembly for cracks.
- I. Visually inspect turbine plenum assembly for cracks in welds and adjoining material.
- J. Visually inspect turbine wheel shroud for cracks, rubbing and fretting.
- K. Visually inspect turbine wheel for cracks, rubbing, blade tip bending and thinning due to erosion.

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Inspection of Hot Section Component

Figure 201

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**APU ENGINE COMBUSTION AND EXHAUST SECTION**

**INSPECTION/CHECK**

EFFECTIVITY RTCA LX-N19997 LX-N20000

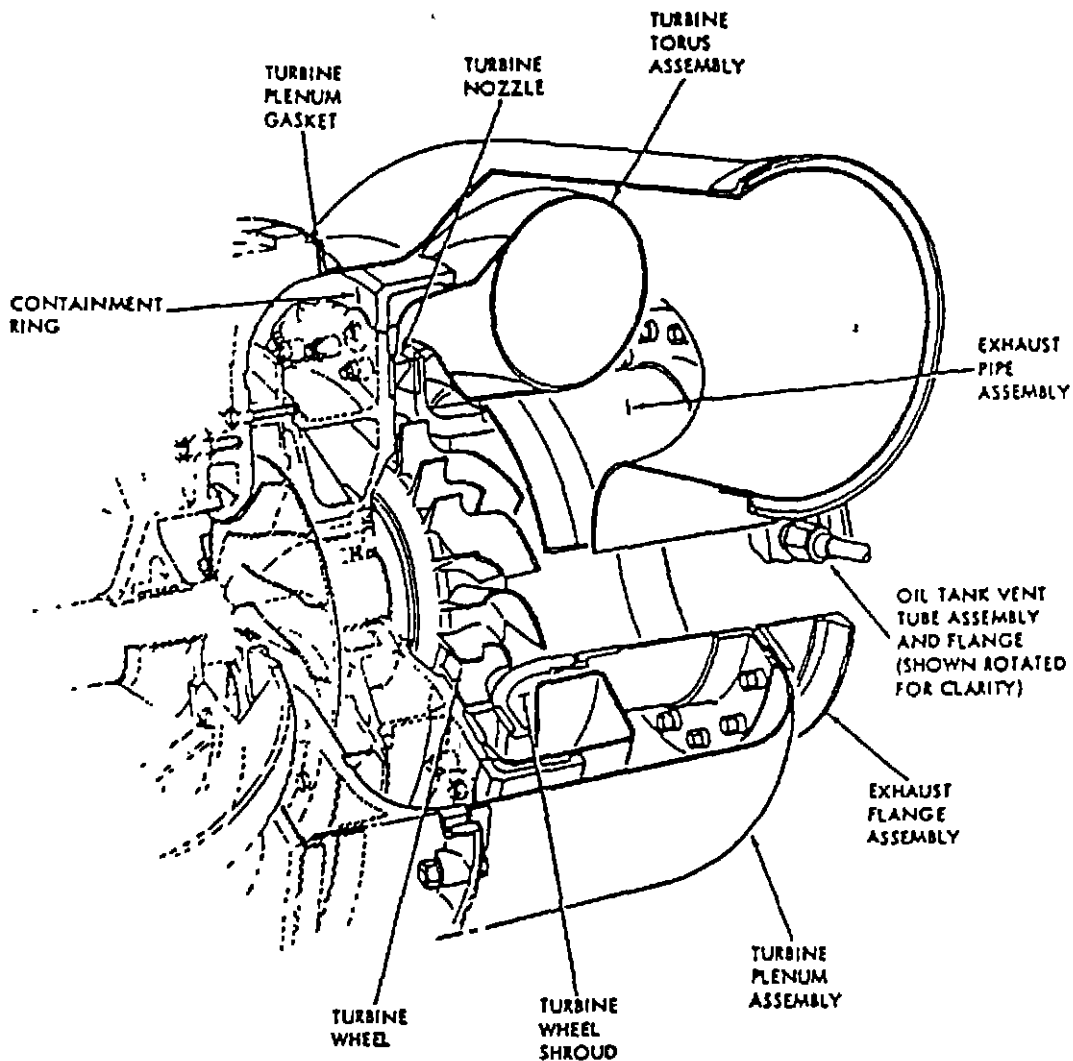
1 **GENERAL**

The following methods and procedures can be accomplished by personnel who maintain the equipment in the field. A careful visual inspection shall precede any detail checks to eliminate unnecessary inspection procedures and to determine the extent of further checking. Long life and continued efficient operations of the engine depend upon the care and accuracy with which inspections are conducted.

2 **INSPECT HOT SECTION COMPONENTS** (See Figure 201)

**NOTE** If cracks, erosion, deformation or other obvious damage is evident during their inspection, remove engine from installation and perform a detailed hot section inspection. Refer to Heavy Maintenance Section of A1 Research Report No 49-20-37 for detailed hot section inspection of removed engine.

- A Visually inspect containment ring for security and attaching washers for fretting
- B Check turbine plenum gasket for evidence of deterioration or leakage
- C Visually inspect turbine nozzle for cracks, scoring, erosion and feathering damage
- D Visually inspect turbine torus assembly for cracks, erosion, deformation and wear
- F Visually inspect exhaust pipe assembly for cracks
- G Check that oil tank vent tube assembly ID and opening in flange are not obstructed
- H Visually inspect exhaust flange assembly for cracks
- I Visually inspect turbine plenum assembly for cracks in welds and adjoining material
- J Visually inspect turbine wheel shroud for cracks, rubbing and fretting
- K Visually inspect turbine wheel for cracks, rubbing, blade tip bending and thinning due to erosion.



**INSPECTION OF HOT SECTION COMPONENT**

**FIGURE 201**

Ref MM STEWARD-DAVIS



COMBUSTION CHAMBER LINER - REMOVAL/INSTALLATION

1. REMOVE COMBUSTION CHAMBER LINER

- A. Open all APU circuit breakers on APU starter relay box at bulkhead Sta. 960L.
- B. Remove combustion chamber cover.
- C. Disconnect high voltage lead from igniter plug.

WARNING: THE CURRENT INVOLVED IN THE IGNITION UNIT IS OF VERY HIGH VOLTAGE AND CAN BE FATAL. BE SURE THAT POWER IS REMOVED FROM THE UNIT FOR A MINIMUM OF 3 MINUTES BEFORE MAKING ANY DISCONNECTIONS. AFTER DISCONNECTING A HIGH TENSION LEAD, ENSURE COMPLETE DISCHARGE OF CAPACITORS BY IMMEDIATELY SHORTING EXCITER UNIT TERMINAL TO GROUND.

- D. Remove igniter plug mounting bolts and washers.
- E. Withdraw igniter plug from combustion chamber cap.
- F. Remove and discard old gasket.
- G. Disconnect fuel line from fuel atomizer assembly.
- H. Remove fuel atomizer mounting bolts.
- I. Remove fuel atomizer assembly and packing from unit.
- J. Remove clamp from combustion chamber cap.
- K. Remove combustion chamber cap from turbine plenum.
- L. Carefully withdraw combustion chamber liner from turbine plenum.

2. INSTALL COMBUSTION CHAMBER LINER

- A. Position combustion chamber cap over end of liner with igniter plug holes in cap and liner aligned with each other.
- B. Using new packing, position fuel atomizer on combustion chamber cap.
- C. Install atomizer mounting bolts with washers. Tighten bolts to a torque range of 20 to 25 pound-inches.
- D. Place new packing on turbine plenum and insert liner into turbine plenum.

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- E. Install combustion chamber clamp. Tighten clamp bolt to a torque range of 50 to 70 pound-inches.
- F. Connect fuel line to atomizer.
- G. Place new gasket on igniter plug.
- H. Insert igniter plug into combustion chamber cap.
- I. Install igniter plug mounting bolts with washers. Tighten bolts to a torque range of 50 to 70 pound-inches. Lockwire bolts.
- J. Connect high voltage lead to igniter plug.
- K. Position combustion chamber shroud on unit and install clamp.
- L. Close all APU circuit breakers on APU starter relay box at bulkhead Sta. 960L.

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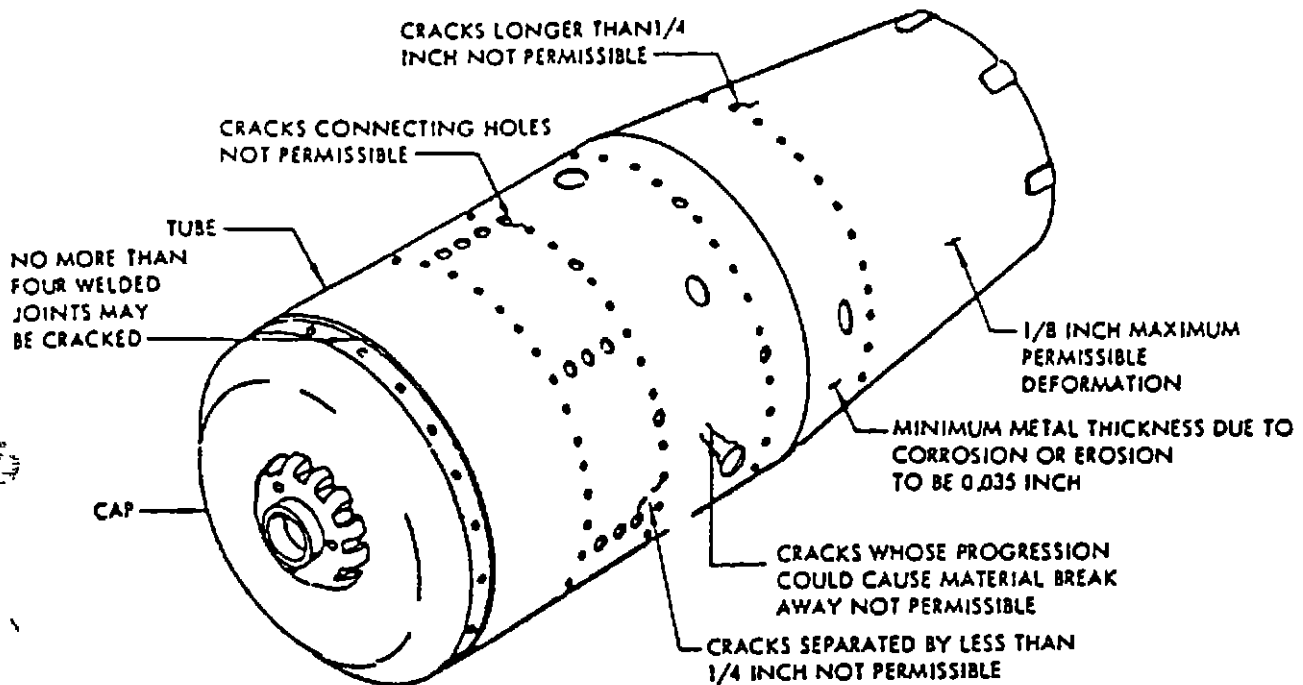
MAINTENANCE MANUAL

EFFECTIVITY TCA LX-N20198 LX-N20199

COMBUSTION CHAMBER LINER - INSPECTION/CHECK

1. CHECK COMBUSTION CHAMBER LINER

- A. Remove combustion chamber liner from APU. Refer to Combustion Chamber Liner - Removal/Installation.
- B. Check combustion chamber liner for cracked welded joints, deformation and cracks. See figure 601 for permissible extent of damage.
- C. Install combustion chamber liner on APU. Refer to Combustion Chamber Liner - Removal/Installation.



Combustion Chamber Liner Check  
Figure 601

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EFFECTIVITY TCA LX-N20198 LX-N20199  
COMBUSTION CHAMBER LINER - CLEANING/PAINTING

1. CLEAN COMBUSTION CHAMBER LINER

A. Remove combustion chamber liner from APU. Refer to Combustion Chamber Liner - Removal/Installation.

B. Scrape excessive carbon deposits from liner with a soft non-abrasive material such as wood.

NOTE: If facilities are available, liner may be cleaned by vapor blast.

C. Using compressed air or soft bristle brush remove all loosened carbon.

D. Install combustion chamber liner on APU. Refer to Combustion Chamber Liner - Removal/Installation.

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## MAINTENANCE MANUAL

EFFECTIVITY RTCA LX-N19997 LX-N20000

### COMBUSTION CHAMBER LINER - REMOVAL/INSTALLATION

#### 1. REMOVE COMBUSTION CHAMBER LINER

- A Open all APU circuit breakers on APU starter relay box at bulkhead Sta. 960L
- B Remove combustion chamber cover
- C Disconnect high voltage lead from igniter plug

**WARNING** THE CURRENT INVOLVED IN THE IGNITION UNIT IS OF VERY HIGH VOLTAGE AND CAN BE FATAL. BE SURE THAT POWER IS REMOVED FROM THE UNIT FOR A MINIMUM OF 3 MINUTES BEFORE MAKING ANY DISCONNECTIONS. AFTER DISCONNECTING A HIGH TENSION LEAD, ENSURE COMPLETE DISCHARGE OF CAPACITORS BY IMMEDIATELY SHORTING EXCITER UNIT TERMINAL TO GROUND.

- D Remove igniter plug mounting bolts and washers
- E Withdraw igniter plug from combustion chamber cap
- F Remove and discard old gasket
- G Disconnect fuel line from fuel atomizer assembly
- H Remove fuel atomizer mounting bolts
- I Remove fuel atomizer assembly and packing from unit
- J Remove clamp from combustion chamber cap
- K Remove combustion chamber cap from turbine plenum
- L Carefully withdraw combustion chamber liner from turbine plenum

#### 2. INSTALL COMBUSTION CHAMBER LINER

- A. Position combustion chamber cap over end of liner with igniter plug holes in cap and liner aligned with each other.
- B. Using new packing, position fuel atomizer on combustion chamber cap.
- C. Install atomizer mountings bolts and washers. Tighten bolts to a torque range of 20 to 25 pound-inches.
- D. Place new packing on turbine plenum and insert liner into turbine plenum.

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- E. Install combustion chamber clamp Tighten clamp bolt to a torque range of 50 to 70 pound-inches.
- F Connect fuel line to atomizer
- G Place new gasket on igniter plug
- H Insert igniter plug into combustion chamber cap
- I Install igniter plug mounting bolts with washers Tighten bolts to a torque range of 50 to 70 pound-inches Lockwire bolts
- J Connect high voltage lead to igniter plug.
- K Position combustion chamber shroud on unit and install clamp
- L Close all APU circuit breakers on APU starter relay box at bulkhead Sta 960L

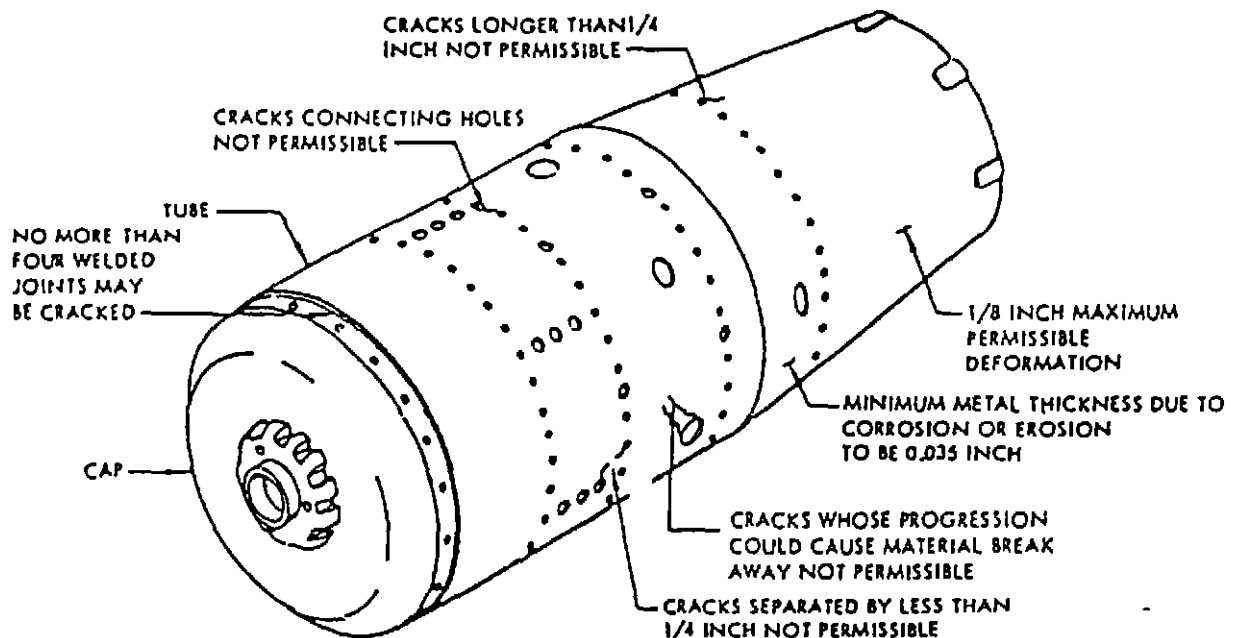
Ref MM STEWARD-DAVIS

COMBUSTION CHAMBER LINER - INSPECTION/CHECK

EFFECTIVITY RTCA LX-N19997 LX-N20000

1 CHECK COMBUSTION CHAMBER LINER

- A. Remove combustion chamber liner from APU Refer to Combustion Chamber Liner - Removal/Installation
- B. Check combustion chamber liner for cracked welded joints, deformation and cracks. See Figure 601 for permissible extent of damage
- C. Install combustion chamber liner on APU Refer to Combustion Chamber Liner - Removal/Installation



COMBUSTION CHAMBER LINER CHECK

FIGURE 601

**COMBUSTION CHAMBER LINER - CLEANING/PAINTING**

EFFECTIVITY RTCA LX-N19997 LX-N20000

1 **CLEAN COMBUSTION CHAMBER LINER**

- A Remove combustion chamber liner from APU Refer to Combustion Chamber Liner - Removal/Installation
- B Scrape excessive carbon deposits from liner with a soft non-abrasive material such as wood.  
  
NOTE If facilities are available, liner may be cleaned by vapor blast
- C Using compressed air or soft bristle brush remove all loosened carbon
- D Install combustion chamber liner on APU Refer to Combustion Chamber Liner - Removal/Installation



## MAINTENANCE MANUAL

APU FUEL SUPPLY SYSTEM  
DESCRIPTION AND OPERATION  
EFFECTIVITY RTCA LX-N19997 LX-N20000

### 1. General

- A. The APU fuel supply system delivers fuel from the airplane fuel tank to the APU engine fuel and control system. The APU receives fuel from main fuel tank No. 3. The APU fuel supply system consists of electrical, electro-mechanical and mechanical components which along with the necessary plumbing, function to supply pressurized fuel to the APU engine fuel and control system. The system is made up of a fuel tap, a fuel shutoff (manual) valve, a fuel supply (solenoid) valve, a water separator, a fuel boost pump, a fuel boost relay, a pressure relief valve and suitable plumbing. The fuel tap, provided by Boeing, is on the wing rear spar at the 606 gallon level (approximately 4100 pounds indicated fuel quantity) of No. 3 main fuel tank. The fuel shutoff valve, fuel supply valve and pressure relief valve are all located at the wing rear spar. The water separator and fuel boost pump are mounted on a fuel panel located on the keel beam structure in the right hand main landing gear wheel well. The fuel boost relay is located in the Sta. 960 junction box.
- B. Fuel is taken through the tap on the rear spar and enters the APU "supply" system through the manually actuated fuel shutoff and the electrical solenoid actuated fuel supply valves. The fuel passes through the water separator before entering the boost pump to be pressurized for delivery to the APU engine fuel and control system. The fuel boost relay controls power for operating the boost pump and for actuating the fuel supply (solenoid) valve to the open position. The pressure relief valve bypasses the fuel supply valve to return fuel to the airplane wing tank if pressure builds up in the fuel supply line due to thermal expansion of entrapped fuel when the APU is not operating.
- C. With the APU BATTERY switch and APU MASTER switch in the ON position the fuel boost relay is actuated to provide power to open the solenoid actuated fuel supply valve and to run the fuel boost pump. The valve will remain open and the pump will continue to run until the fuel boost relay is de-energized by action of the MASTER switch/master relay or the fire lockout relay.

**NOTE:** When operating the APU unattended for an extended period of time, follow Airplane Maintenance Manual (AMM) instructions regarding necessary fuel quantity based on APU fuel burn rate.

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APU FUEL SUPPLY SYSTEM

DESCRIPTION AND OPERATION

EFFECTIVITY TCA LX-N20198 LX-N20199

1. GENERAL

- A. The APU fuel supply system delivers fuel from the airplane fuel tank to the APU engine fuel and control system. The APU receives fuel from main fuel tank No. 3. The APU fuel supply system consists of electrical, electro-mechanical and mechanical components which along with the necessary plumbing, function to supply pressurized fuel to the APU engine fuel and control system. The system is made up of a fuel tap, a fuel shutoff (manual) valve, a fuel supply (solenoid) valve, a water separator, a fuel boost pump, a fuel boost relay, a pressure relief valve and suitable plumbing. The fuel tap, provided by Boeing, is on the wing rear spar at the 606 gallon level (approximately 4100 pounds indicated fuel quantity) of No. 3 main fuel tank. The fuel shutoff valve, fuel supply valve and pressure relief valve are all located at the wing rear spar. The water separator and fuel boost pump are mounted on a fuel panel located on the keel beam structure in the right hand main landing gear wheel well. The fuel boost relay is located in the Sta. 960 junction box.
- B. Fuel is taken through the tap on the rear spar and enters the APU "supply" system through the manually actuated fuel shutoff and the electrical solenoid actuated fuel supply valves. The fuel passes through the water separator before entering the boost pump to be pressurized for delivery to the APU engine fuel and control system. The fuel boost relay controls power for operating the boost pump and for actuating the fuel supply (solenoid) valve to the open position. The pressure relief valve bypasses the fuel supply valve to return fuel to the airplane wing tank if pressure builds up in the fuel supply line due to thermal expansion of entrapped fuel when the APU is not operating.
- C. With the APU BATTERY switch and APU MASTER switch in the ON position the fuel boost relay is actuated to provide power to open the solenoid actuated fuel supply valve and to run the fuel boost pump. The valve will remain open and the pump will continue to run until the fuel boost relay is de-energized by action of the MASTER switch/master relay or the fire lockout relay.

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2. FUEL SHUTOFF VALVE

A. The fuel shutoff valve is a manually operated valve mounted at the fuel tap on the wing rear spar. The valve permits isolating the wing tank during maintenance of the APU fuel supply system. The valve is normally lock-wired in the open position.

3. FUEL SUPPLY VALVE

A. The fuel supply valve is a normally closed, solenoid actuated valve that provides for remote control of fuel flow into the APU fuel system. The valve is located at the wing rear spar, downstream from the fuel shutoff valve. The valve receives power from the APU aft bus through NO contacts of the fuel boost relay.

4. FUEL BOOST PUMP

A. The fuel boost pump delivers fuel under pressure from the airplane main tank to its APU engine fuel and control system. The pump is a centrifugal type pump driven by a 24 volt DC electric motor. The boost pump receives power from the APU aft bus through NO contacts of the fuel boost relay. The boost pump is mounted on the fuel panel located in the main gear wheel well.

5. FUEL BOOST RELAY

A. The fuel boost relay is a single coil, two pole 28VDC relay located in the Sta. 960 APU junction box. The relay controls power from the APU aft bus to the fuel supply valve and the fuel boost pump through its NO contacts. The relay is actuated by power from the APU, aft bus through NO contacts of the master relay and therefore reflects the position of the master relay (MR, open - FBR, open, MR, closed - FBR closed.) With the APU BATTERY - switch ON and the MASTER switch closed (light on) the master relay closes to close the fuel boost relay and apply power to actuate (open) the fuel supply valve and to run the fuel boost pump. The fuel boost relay remains closed until power to the master relay is interrupted by action of the MASTER switch or by the fire lockout relay.

6. WATER SEPARATOR

A. The water separator is a coarse filter (bronze screen) that separates water from the fuel passing through. The separator is mounted on the fuel panel, in the main gear wheel well, at the lowest point in the fuel supply system and its case serves as a sump to collect the separated water.

APU FUEL SUPPLY SYSTEM  
DESCRIPTION AND OPERATION

EFFECTIVITY RTCA LX-N19997 LX-N20000

1 GENERAL

- A The APU fuel supply system delivers fuel from the airplane fuel tank to the APU engine fuel and control system. The APU receives fuel from main fuel tank No 3. The APU fuel supply system consists of electrical, electro-mechanical and mechanical components which along with the necessary plumbing, function to supply pressurized fuel to the APU engine fuel and control system. The system is made up of a fuel tap, a fuel shutoff (manual) valve, a fuel supply (solenoid) valve, a water separator, a fuel boost pump, a fuel boost relay, a pressure relief valve and suitable plumbing. The fuel tap, provided by Boeing, is on the wing rear spar at the 606 gallon level (approximately 4100 pounds indicated fuel quantity) of No 3 main fuel tank. The fuel shutoff valve, fuel supply valve and pressure relief valve are all located at the wing rear spar. The water separator and fuel boost pump are mounted on a fuel panel located on the keel beam structure in the right hand main landing gear wheel well. The fuel boost relay is located in the Sta. 960 junction box.
- B Fuel is taken through the tap on the rear spar and enters the APU "supply" system through the manually actuated fuel shutoff and the electrical solenoid actuated fuel supply valves. The fuel passes through the water separator before entering the boost pump to be pressurized for delivery to the APU engine fuel and control system. The fuel boost relay controls power for operating the boost pump and for actuating the fuel supply (solenoid) valve to the open position. The pressure relief valve bypasses the fuel supply valve to return fuel to the airplane wing tank if pressure builds up in the fuel supply line due to thermal expansion of entrapped fuel when the APU is not operating.
- C With the APU BATTERY switch and APU MASTER switch in the ON position the fuel boost relay is actuated to provide power to open the solenoid actuated fuel supply valve and to run the fuel boost pump. The valve will remain open and the pump will continue to run until the fuel boost relay is de-energized by action of the MASTER switch/master relay or the fire lockout relay.

## 2 FUEL SHUTOFF VALVE

- A The fuel shutoff valve is a manually operated valve mounted at the fuel tap on the wing rear spar. The valve permits isolating the wing tank during maintenance of the APU fuel supply system. The valve is normally lock-wired in the open position.

## 3 FUEL SUPPLY VALVE

- A The fuel supply valve is a normally closed, solenoid actuated valve that provides for remote control of fuel flow into the APU fuel system. The valve is located at the wing rear spar, downstream from the fuel shutoff valve. The valve receives power from the APU aft bus through NO contacts of the fuel boost relay.

## 4 FUEL BOOST PUMP

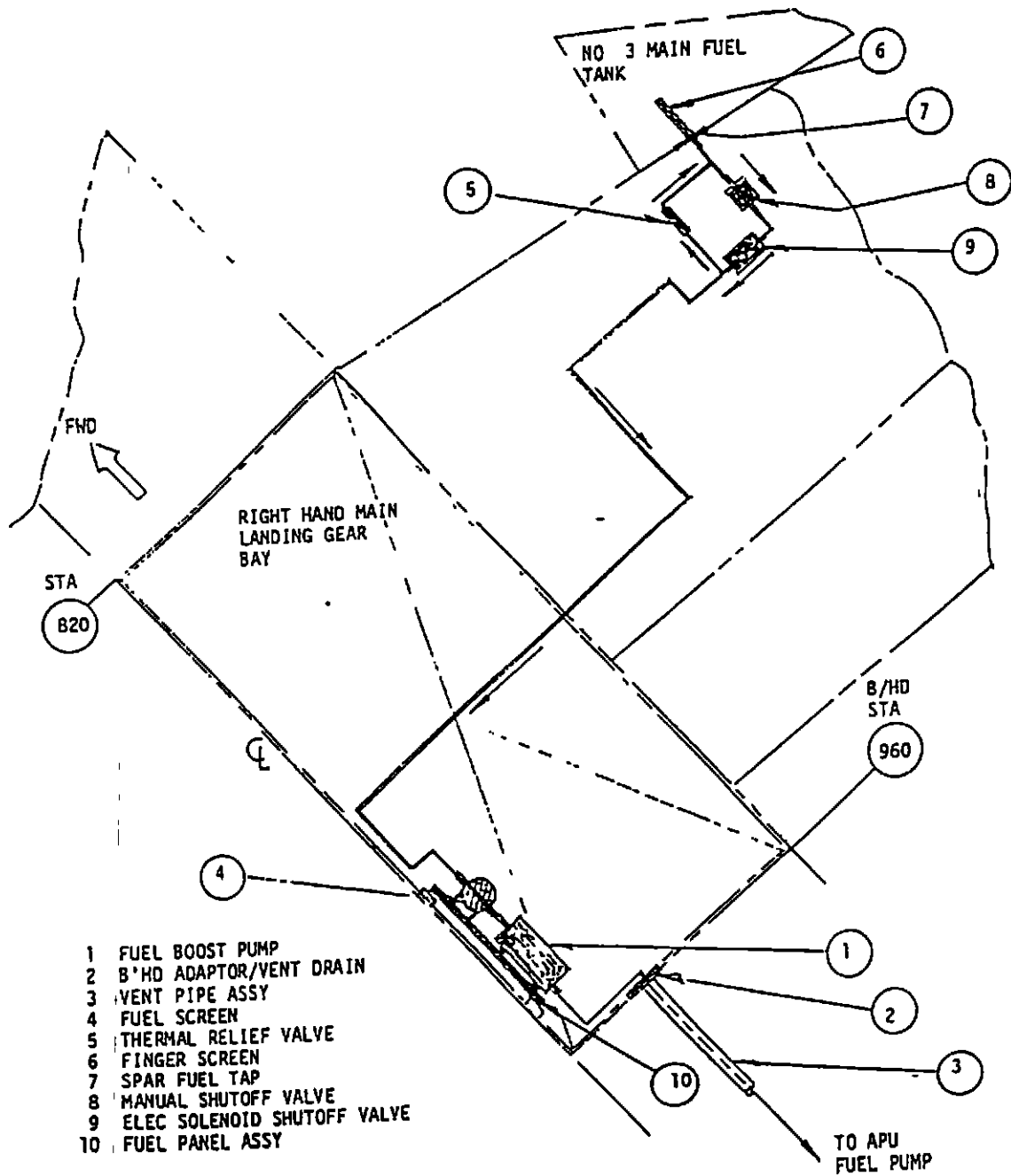
- A The fuel boost pump delivers fuel under pressure from the airplane main tank to its APU engine fuel and control system. The pump is a centrifugal type pump driven by a 24 volt DC electric motor. The boost pump receives power from the APU aft bus through NO contacts of the fuel boost relay. The boost pump is mounted on the fuel panel located in the main gear wheel well.

## 5 FUEL BOOST RELAY

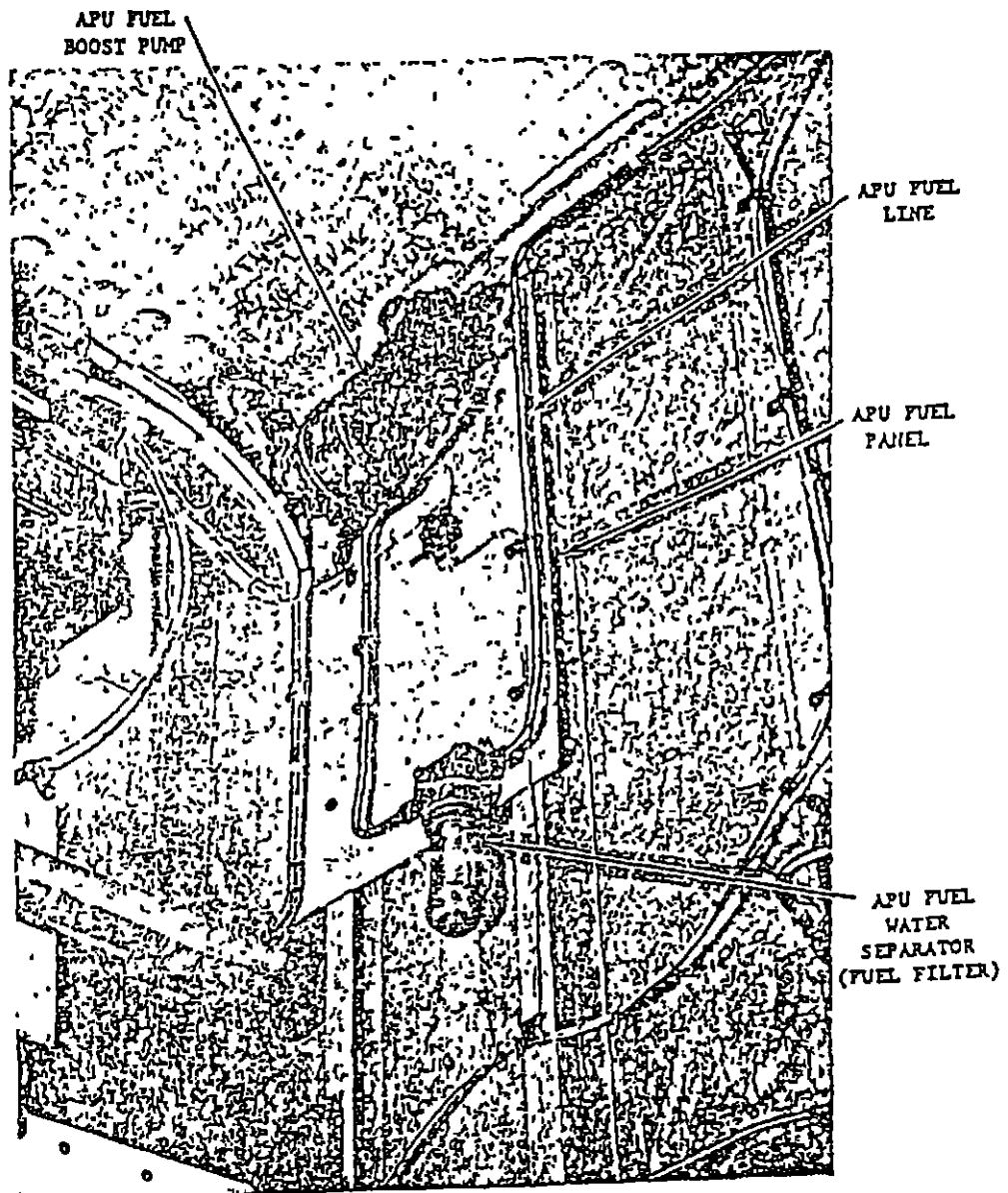
- A The fuel boost relay is a single coil, two pole 28 VDC relay located in the Sta 960 APU junction box. The relay controls power from the APU aft bus to the fuel supply valve and the fuel boost pump through its NO contacts. The relay is actuated by power from the APU, aft bus through NO contacts of the master relay and therefore reflects the position of the master relay (MR, open - FBR, open, MR, closed - FBR closed.) With the APU BATTERY switch ON and the MASTER switch closed (light on) the master relay closes to close the fuel boost relay and apply power to actuate (open) the fuel supply valve and to run the fuel boost pump. The fuel boost relay remains closed until power to the master relay is interrupted by action of the MASTER switch or by the fire lockout relay.

## 6 WATER SEPARATOR

- A The water separator is a coarse filter (bronze screen) that separates water from the fuel passing through. The separator is mounted on the fuel panel, in the main gear wheel well, at the lowest point in the fuel supply system and its case serves as a sump to collect the separated water.



APU FUEL SYSTEM  
 SCHEMATIC



APU FUEL PANEL  
(MAIN GEAR WHEEL WELL)  
FIGURE 2

Ref MM STEWARD-DAVIS



## MAINTENANCE MANUAL

EFFECTIVITY TCA LX-N20198 LX-N20199

### APU ENGINE FUEL AND CONTROL

#### DESCRIPTION AND OPERATION

#### 1. GENERAL

- A. The APU engine fuel and control system is fully automatic in operation and does not require external controls. The system consists of a fuel control unit mounted on the front of the accessory section, a fuel solenoid valve mounted on the fuel control unit, a fuel atomizer assembly mounted on the turbine section combustor cap assembly, a pneumatic thermostat mounted in the turbine exhaust flange, a turbine plenum drain mounted in the turbine plenum assembly, and the necessary plumbing and wiring.
- B. With the APU BATTERY switch and the APU MASTER switch in the ON position, pressurized fuel is provided by the fuel supply system to the fuel control unit. When the APU is started, the fuel pump and control unit supplies and regulates the flow of fuel to the fuel atomizer in the combustion chamber. The regulated fuel flow controls the acceleration of the turbine rotor during the starting operation. When a load is applied to the APU, the fuel control unit meters the fuel flow to maintain a near constant speed.

#### 2. FUEL PUMP AND CONTROL UNIT

- A. The fuel pump and control unit, mounted on the engine accessory section, is the major component in the fuel system. The fuel pump is driven by the accessory gear train at approximately 10% turbine RPM. A governor, in the fuel control unit, senses turbine speed and regulates quantity of fuel injected into the combustion chamber. This sequence is a continuous cycle, thereby, controlling turbine speed. The fuel pump and control unit is a single assembly made up of the engine-driven fuel pump, fuel filter, acceleration limiter valve, fuel pressure relief valve, fuel solenoid valve, electrical and pneumatic connections and connections for fuel inlet, fuel outlet, fuel pressure gages, and a seal-leakage drain manifold.
- (1) The engine-driven fuel pump is a gear-type positive-displacement pump. The pump housing contains a spring-loaded ball-type pressure relief valve which allows fuel to return to the pump inlet after sufficient fuel pressure is built up in the fuel control unit. A micron fuel filter is located downstream of the pump outlet port and filters all fuel passing from the pump to the fuel control system components.

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MAINTENANCE MANUAL

- (2) The acceleration limiter valve consists of an adjusting spring, two diaphragm assemblies and a spring-loaded relief valve. The valve cover is provided with a connection for controlling air pressure, and a fixed orifice which vents the control air to ambient. This orifice tends to bleed out any moisture which may be present in the control air supply.
- (3) The governor senses the engine speed and controls the fuel flow into the combustion chamber to maintain the engine speed nearly constant under varying loading conditions. The governor consists of an input shaft, governor cage, flyweights, spring, and an adjustment screw and nut. High pressure fuel surrounds the spring-loaded flyweights. At high RPM or overspeed, the flyweights overcome the spring force and open a fuel bypass. Part of the high pressure fuel escapes into the low pressure area of the fuel pump and control unit, thus reducing the fuel pressure and the amount of fuel injected into the combustion chamber.

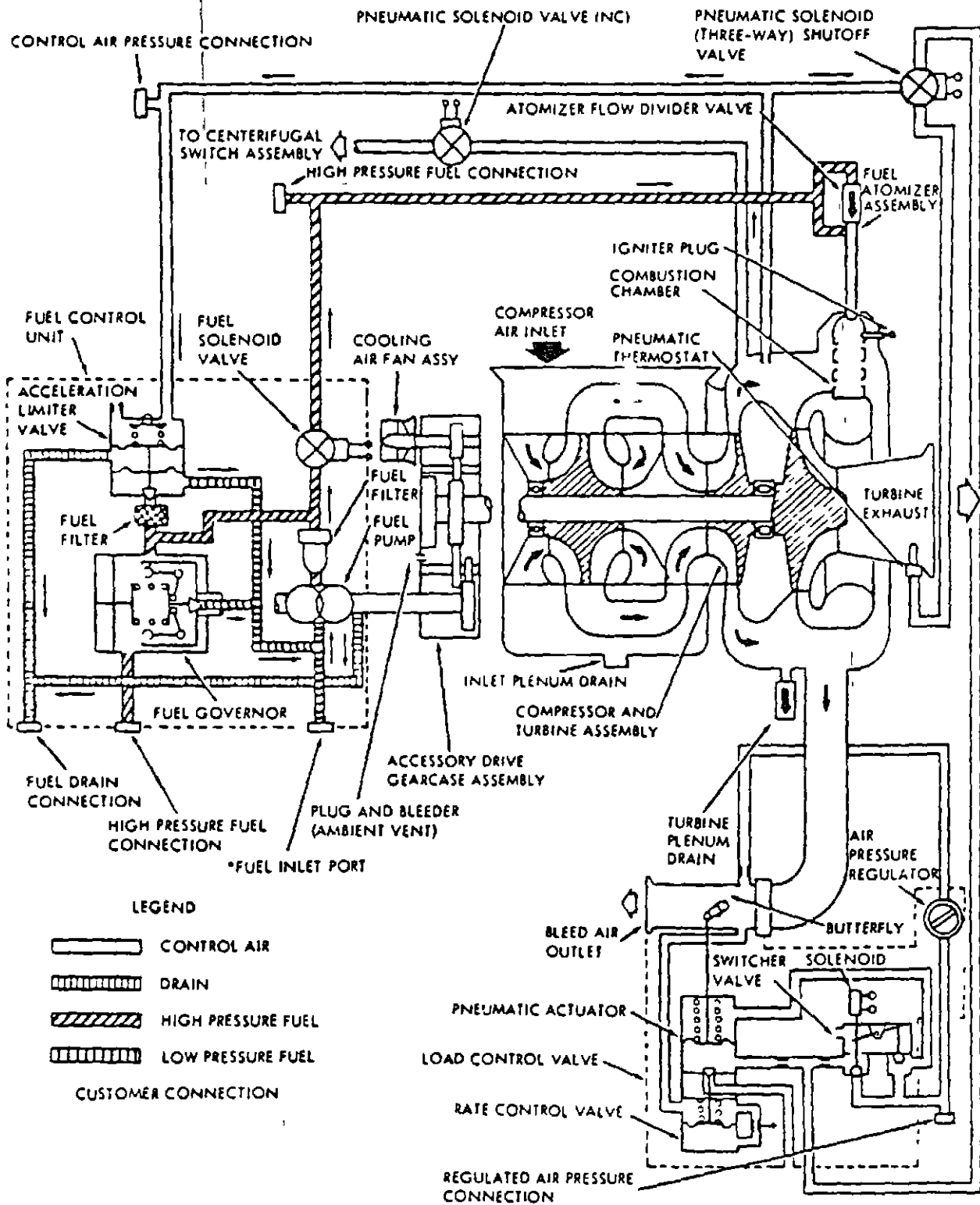
### 3. FUEL SOLENOID VALVE

- A. The fuel solenoid valve is a normally closed electromagnetic shutoff valve, and is a component of the fuel pump and control unit. It is installed in the outlet port of the fuel control unit. The valve consists of two body assemblies, a coil, plunger, and spring. The valve is energized to pass fuel to the combustion chamber when the oil pressure sensing switch closes during a starting operation.

### 4. FUEL ATOMIZER

- A. The fuel atomizer is a dual orifice assembly mounted on the combustor cap assembly attached to the flame tube and plenum assemblies. The fuel atomizer assembly consists of a screen, flow-divider valve, distributor head, and housing. The distributor head functions as a dividing passageway, with a core in the center leading to a large orifice plate located at the tip. The distributor head and orifice plates located within the housing, are covered by an atomizer nut. Also located within the housing is the screen and flow divider valve. The screen strains all fuel entering the fuel atomizer. The flow-divider valve functions to direct all fuel at lower pressures to the small orifice which provides proper atomization of fuel under these conditions. At higher fuel pressures the valve actuates to permit combined flow to both orifices.

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FUEL CONTROL SYSTEM AND BLEED-AIR CONTROL SYSTEM

5. PNEUMATIC THERMOSTAT

- A. The pneumatic thermostat projects into the turbine exhaust duct. It consists of an alloy steel housing, spring-loaded ball valve, thermostatic core, and connection for a pneumatic line. The thermostat functions as a temperature controlled orifice over a range of turbine exhaust gas temperatures. It is connected by pneumatic line to the three-way solenoid valve which applies its signal to the acceleration limiter valve during engine start and transfers its signal to the pneumatic shutoff (load control) valve when the engine reaches governed speed. The thermostat is closed when cold and begins to open between 555° to 565°C (1030° to 1050°F) when it will bleed control air from one side of a diaphragm in the acceleration limiter valve during engine start, to control the fuel bypass valve, or the pneumatic shutoff (load control) valve after governed speed is reached to control air bleed.

6. OPERATION

- A. With the APU BATTERY switch and MASTER switch in the ON position clean pressurized fuel is delivered to the fuel control unit fuel inlet by the APU fuel supply system. Fuel is pumped by the fuel control unit gears through a fuel filter to the fuel solenoid valve. The fuel solenoid valve is automatically opened as engine oil pressure builds up, and permits fuel flow to the fuel atomizer assembly. Low pressure fuel passes through the primary orifices in the fuel atomizer assembly and is sprayed into the combustion chamber. As fuel pressure increases, fuel passes through both primary and secondary orifices in the fuel atomizer assembly to provide adequate fuel spray. Small quantities of fuel which may collect in the bottom of the turbine plenum are drained overboard through the turbine plenum drain. Other fuel drain connections are located at the fuel control unit acceleration limiter valve and drive shaft seal.
- B. Fuel flow during acceleration is metered by the acceleration limiter valve in the fuel control unit to provide smooth acceleration; fuel flow during normal speed operation is metered by the fuel governor in the fuel control unit to maintain constant speed. Fuel flow at overtemperature conditions is modulated during engine start and acceleration to governed speed by action of the pneumatic thermostat operating in conjunction with the three-way solenoid valve to bleed control air from the acceleration limiter valve in the fuel control unit. At governed speed the three-way solenoid valve actuates to transfer the pneumatic thermostat's output to the pneumatic shutoff (load control) valve to control air bleed as required to prevent excessive exhaust gas temperatures.

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**APU ENGINE FUEL AND CONTROL**  
**DESCRIPTION AND OPERATION**

EFFECTIVITY RTCA LX-N19997 LX-N20000

**1 GENERAL**

- A The APU engine fuel and control system is fully automatic in operation and does not require external controls. The system consists of a fuel control unit mounted on the front of the accessory section, a fuel solenoid valve mounted on the fuel control unit, a fuel atomizer assembly mounted on the turbine section combustor cap assembly, a pneumatic thermostat mounted in the turbine exhaust flange, a turbine plenum drain mounted in the turbine plenum assembly, and the necessary plumbing and wiring.
- B With the APU BATTERY switch and the APU MASTER switch in the ON position, pressurized fuel is provided by the fuel supply system to the fuel control unit. When the APU is started, the fuel pump and control unit supplies and regulates the flow of fuel to the fuel atomizer in the combustion chamber. The regulated fuel flow controls the acceleration of the turbine rotor during the starting operation. When a load is applied to the APU, the fuel control unit meters the fuel flow to maintain a near constant speed.

**2 FUEL PUMP AND CONTROL UNIT**

- A The fuel pump and control unit, mounted on the engine accessory section, is the major component in the fuel system. The fuel pump is driven by the accessory gear train at approximately 10% turbine RPM. A governor, in the fuel control unit, senses turbine speed and regulates quantity of fuel injected into the combustion chamber. This sequence is a continuous cycle, thereby, controlling turbine speed. The fuel pump and control unit is a single assembly made up of the engine-driven fuel pump, fuel filter, acceleration limiter valve, fuel pressure relief valve, fuel solenoid valve, electrical and pneumatic connections and connections for fuel inlet, fuel outlet, fuel pressure gages, and a seal-leakage drain manifold.
  - (1) The engine-driven fuel pump is a gear-type positive-displacement pump. The pump housing contains a spring-loaded ball-type pressure relief valve which allows fuel to return to the pump inlet after sufficient fuel pressure is built up in the fuel control unit. A micron fuel filter is located downstream of the pump outlet port and filters all fuel passing from the pump to the fuel control system components.

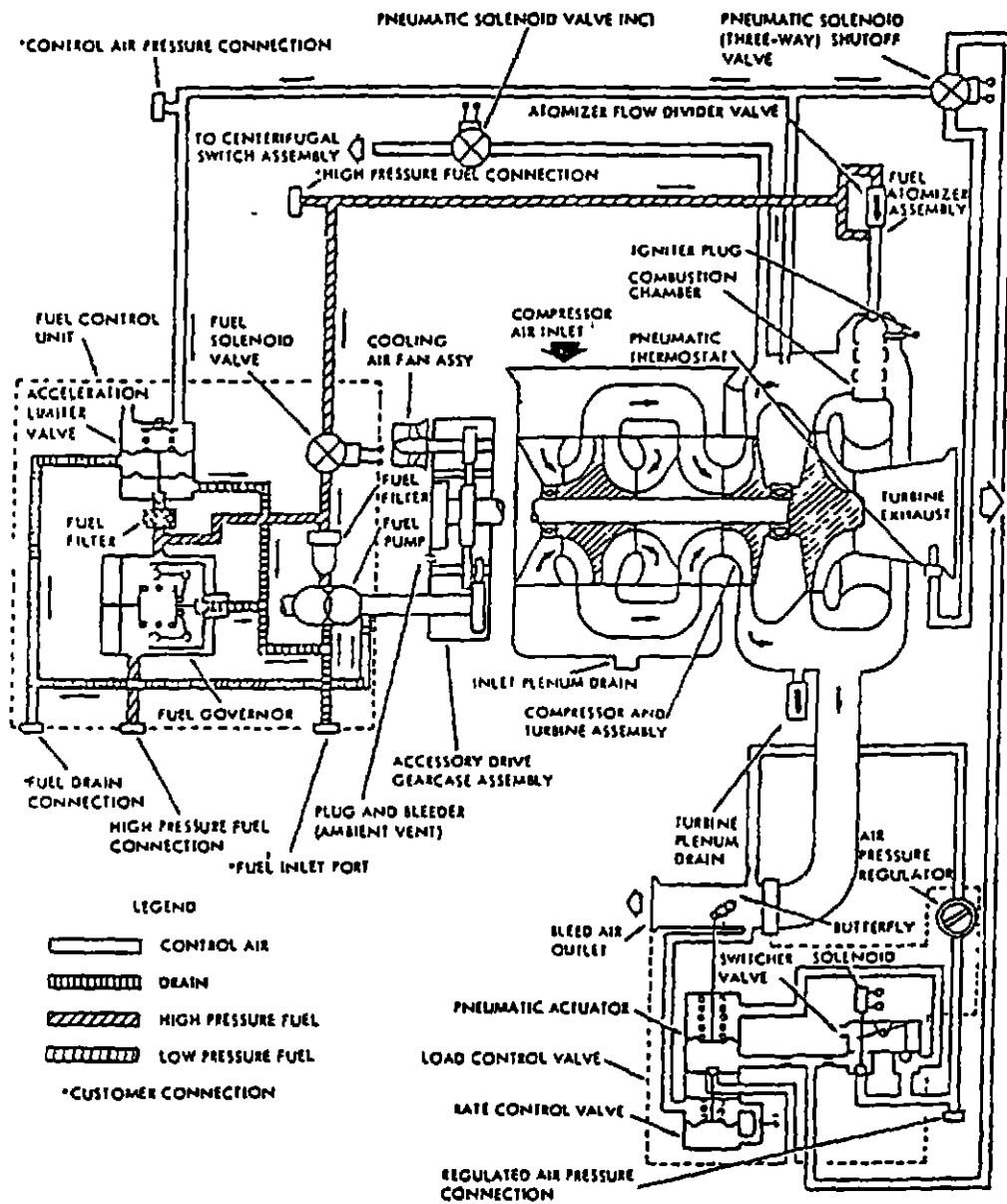
- (2) The acceleration limiter valve consists of an adjusting spring, two diaphragm assemblies and a spring-loaded relief valve. The valve cover is provided with a connection for controlling air pressure, and a fixed orifice which vents the control air to ambient. This orifice tends to bleed out any moisture which may be present in the control air supply
- (3) The governor senses the engine speed and controls the fuel flow into the combustion chamber to maintain the engine speed nearly constant under varying loading conditions. The governor consists of an input shaft, governor cage, flyweights, spring, and an adjustment screw and nut. High pressure fuel surrounds the spring-loaded flyweights. At high RPM or overspeed, the flyweights overcome the spring force and open a fuel bypass. Part of the high pressure fuel escapes into the low pressure area of the fuel pump and control unit, thus reducing the fuel pressure and the amount of fuel injected into the combustion chamber.

### 3 FUEL SOLENOID VALVE

- A The fuel solenoid valve is a normally closed electromagnetic shutoff valve, and is a component of the fuel pump and control unit. It is installed in the outlet port of the fuel control unit. The valve consists of two body assemblies, a coil, plunger, and spring. The valve is energized to pass fuel to the combustion chamber when the oil pressure sensing switch closes during a starting operation.

### 4 FUEL ATOMIZER

- A The fuel atomizer is a dual orifice assembly mounted on the combustor cap assembly attached to the flame tube and plenum assemblies. The fuel atomizer assembly consists of a screen, flow-divider valve, distributor head, and housing. The distributor head functions as a dividing passageway, with a core in the center leading to a large orifice plate located at the tip. The distributor head and orifice plates located within the housing, are covered by an atomizer nut. Also located within the housing is the screen and flow divider valve. The screen strains all fuel entering the fuel atomizer. The flow divider valve functions to direct all fuel at lower pressures to the small orifice which provides proper atomization of fuel under these conditions. At higher fuel pressures the valve actuates to permit combined flow to both orifices.



**FUEL CONTROL SYSTEM  
AND BLEED-AIR CONTROL SYSTEM**

## 5 PNEUMATIC THERMOSTAT

- A The pneumatic thermostat projects into the turbine exhaust duct. It consists of an alloy steel housing, spring-loaded ball valve, thermostatic core, and connection for a pneumatic line. The thermostat functions as a temperature controlled orifice over a range of turbine exhaust gas temperatures. It is connected by pneumatic line to the three-way solenoid valve which applies its signal to the acceleration limiter valve during engine start and transfers its signal to the pneumatic shutoff (load control) valve when the engine reaches governed speed. The thermostat is closed when cold and begins to open between 555° to 565°C (1030° to 1050°F) when it will bleed control air from one side of a diaphragm in the acceleration limiter valve during engine start, to control the fuel bypass valve, or the pneumatic shutoff (load control) valve after governed speed is reached to control air bleed.

## 6 OPERATION

- A With the APU BATTERY switch and MASTER switch in the ON position clean pressurized fuel is delivered to the fuel control unit fuel inlet by the APU fuel supply system. Fuel is pumped by the fuel control unit gears through a fuel filter to the fuel solenoid valve. The fuel solenoid valve is automatically opened as engine oil pressure builds up, and permits fuel flow to the fuel atomizer assembly. Low pressure fuel passes through the primary orifices in the fuel atomizer assembly and is sprayed into the combustion chamber. As fuel pressure increases, fuel passes through both primary and secondary orifices in the fuel atomizer assembly to provide adequate fuel spray. Small quantities of fuel which may collect in the bottom of the turbine plenum are drained overboard through the turbine plenum drain. Other fuel drain connections are located at the fuel control unit acceleration limiter valve and drive shaft seal.
- B Fuel flow during acceleration is metered by the acceleration limiter valve in the fuel control unit to provide smooth acceleration, fuel flow during normal speed operation is metered by the fuel governor in the fuel control unit to maintain constant speed. Fuel flow at overtemperature conditions is modulated during engine start and acceleration to governed speed by action of the pneumatic thermostat operating in conjunction with the three-way solenoid valve to bleed control air from the acceleration limiter valve in the fuel control unit. At governed speed the three-way solenoid valve actuates to transfer the pneumatic thermostat's output to the pneumatic shutoff (load control) valve to control air bleed as required to prevent excessive exhaust gas temperatures.

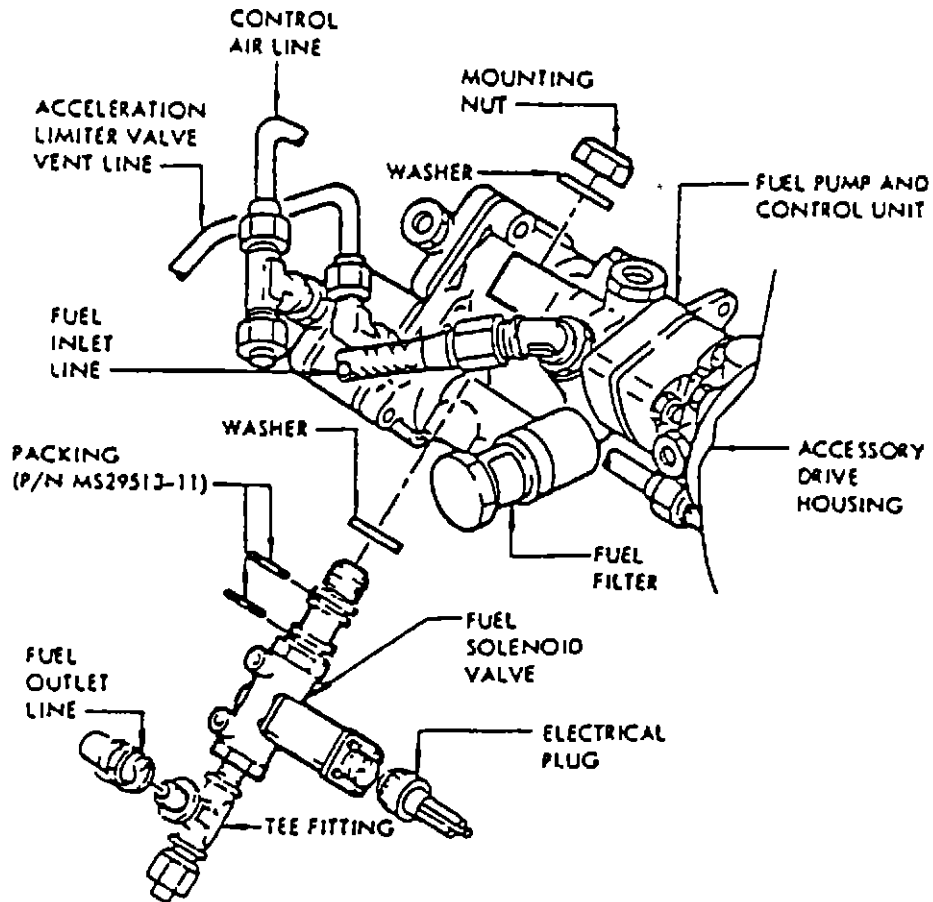
FUEL SOLENOID VALVE - REMOVAL/INSTALLATION

1. REMOVE FUEL SOLENOID VALVE

- A. Remove accessory cover from APU housing. Refer to 49-11-01, APU Housing Accessory Cover - Removal/Installation.
- B. Remove fuel filter from fuel pump and control unit. Refer to 49-32-31, Fuel Pump and Control Unit - Servicing.
- C. Place suitable container under valve to catch dripping fuel.
- D. Disconnect fuel outlet line from fuel solenoid valve tee fitting. (See figure 401.)
- E. Remove valve retaining nut and washer.
- F. Pull fuel solenoid valve straight down until clear of fuel pump and control unit housing.
- G. Pull valve to full extent of electrical wires; disconnect electrical connector and lift valve clear.
- H. Remove packing and washer from valve fitting.

2. INSTALL FUEL SOLENOID VALVE

- A. Install washer and new packing lightly lubricated with fuel on fuel solenoid valve fitting. (See figure 401.)
- B. Insert valve through shroud access door; connect and lockwire electrical connector to valve.
- C. Insert fuel solenoid valve fitting into fuel pump and control unit housing and push straight up. Rotate valve backward and forward while pushing up for easier insertion.
- D. Install washer and valve retaining nut.
- E. Connect fuel outlet line to fuel solenoid valve tee fitting.
- F. Install fuel filter. Refer to 49-32-31, Fuel Pump and Control Unit - Servicing.
- G. Install accessory cover on APU housing. Refer to 49-11-01, APU Housing Accessory Cover - Removal/Installation.



Fuel Solenoid Valve Installation  
 Figure 401

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**FUEL SOLENOID VALVE - REMOVAL/INSTALLATION**

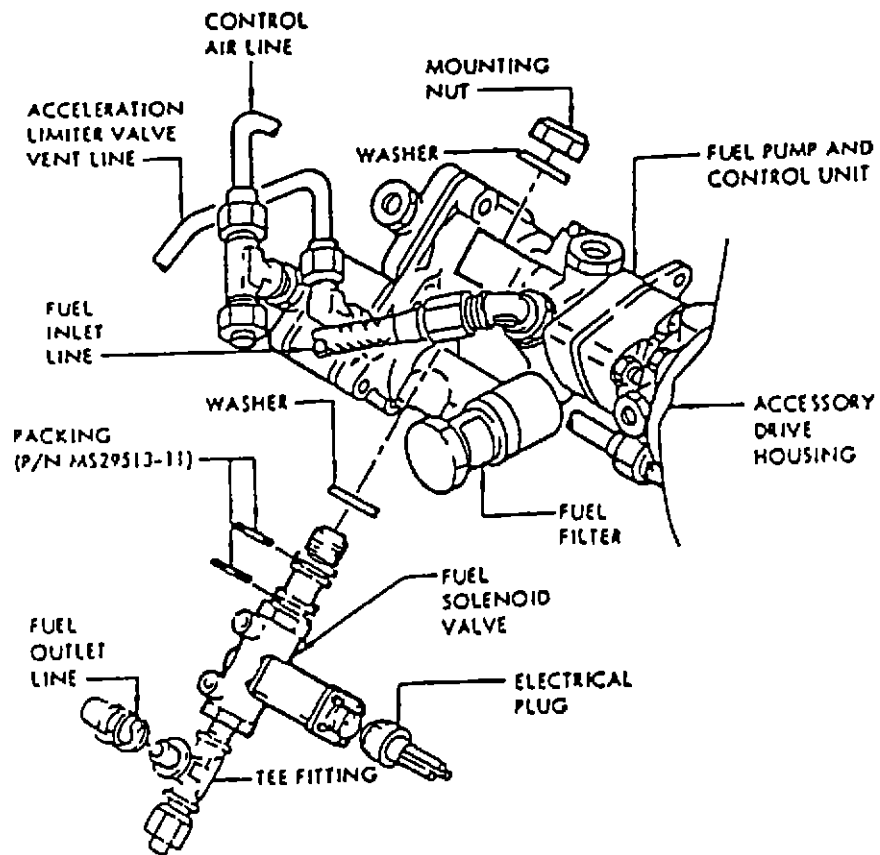
EFFECTIVITY RTCA LX-N19997 LX-N20000

**1 REMOVE FUEL SOLENOID VALVE**

- A Remove accessory cover from APU housing Refer to 49-11-02, APU Housing Accessory Cover - Removal/Installation
- B Remove fuel filter from fuel pump and control unit Refer to 49-32-32, Fuel Pump and Control Unit - Servicing
- C Place suitable container under valve to catch dripping fuel
- D Disconnect fuel outlet line from fuel solenoid valve tee fitting (See Figure 401 )
- E Remove valve retaining nut and washer
- F Pull fuel solenoid valve straight down until clear of fuel pump and control unit housing
- G Pull valve to full extent of electrical wires, disconnect electrical connector and lift valve clear
- H Remove packing and washer from valve fitting

**2 INSTALL FUEL SOLENOID VALVE**

- A Install washer and new packing lightly lubricated with fuel on fuel solenoid valve fitting (see Figure 401 )
- B Insert valve through shroud access door, connect and lockwire electrical connector to valve
- C Insert fuel solenoid valve fitting into fuel pump and control unit housing and push straight up Rotate valve backward and forward while pushing up for easier insertion
- D Install washer and valve retaining nut
- E. Connect fuel outlet line to fuel solenoid valve tee fitting.
- F Install fuel filter Refer to 49-32-32, Fuel Pump and Control Unit - Servicing.
- G Install accessory cover on APU housing Refer to 49-11-02, APU Housing Accessory Cover - Removal/Installation.



**FUEL SOLENOID VALVE INSTALLATION**  
**FIGURE 401**

Ref MM STEWARD-DAVIS



## MAINTENANCE MANUAL

EFFECTIVITY TCA LX-N20198 LX-N20199

### FUEL ATOMIZER - REMOVAL/INSTALLATION

#### 1. REMOVE FUEL ATOMIZER

- A. Open circuit breakers FD1, FD2 and bus feed on Sta. 960 Starter Relay Box.

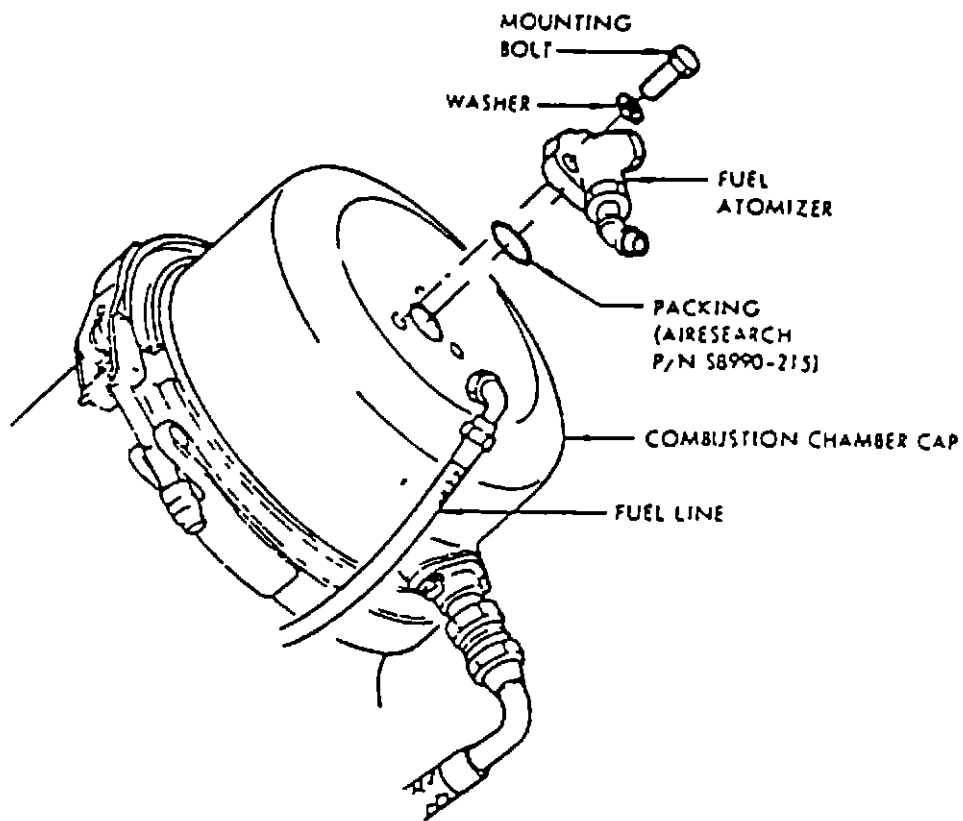
WARNING: THE CURRENT INVOLVED IN THE IGNITION UNIT IS OF VERY HIGH VOLTAGE AND CAN BE FATAL. DO NOT PERFORM NEXT STEP UNTIL AT LEAST 3 MINUTES AFTER PULLING CIRCUIT BREAKER AND DO NOT DISCONNECT THE HIGH TENSION LEAD.

- B. Remove bolts attaching combustion chamber cover.  
C. Lift combustion chamber cover from unit.  
D. Disconnect fuel line from fuel atomizer. (See figure 401.)  
E. Remove fuel atomizer mounting bolts and washers.  
F. Remove fuel atomizer and packing from unit.

#### 2. INSTALL FUEL ATOMIZER

- A. With new packing in place, insert fuel atomizer into combustion chamber cap. (See figure 401.)  
B. Install fuel atomizer mounting bolts with washers. Tighten bolts to a torque range of 20 to 25 pound-inches.  
C. Connect fuel line to fuel atomizer.  
D. Position combustion chamber cover on unit and install bolts.  
E. Close circuit breakers FD1, FD2 and bus feed on Sta. 960 starter relay box.

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Fuel Atomizer Installation  
Figure 401

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## MAINTENANCE MANUAL

### APU SHUTOFF VALVE - INSPECTION/CHECK

#### 1 General

- A. This procedure contains instructions to do a bonding resistance check for the APU shutoff valve.

#### 2. APU Shutoff Valve - Bonding Resistance Check

##### A. References

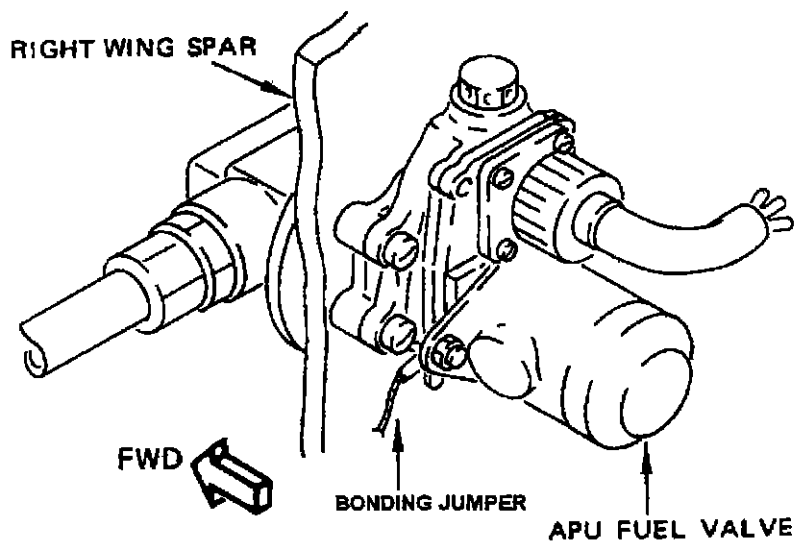
- (1) SWPM 20-20-00, Electrical Bonds and Grounds

##### B. Equipment

- (1) Bonding Meter, Model T477W, Avtron Manufacturing, Cleveland OH  
(2) Maintenance mats, commercially available

##### C. Procedure

- (1) Get access to the APU shutoff valve found on the right wing rear spar (Figure 1).
- (2) Measure the electrical bonding resistance between the bonding jumper terminal and the structure (SWPM 20-20-00).
- (a) Make sure the resistance is 0.005 ohm (5 milliohm) or less.
- (3) Measure the electrical bonding resistance between the APU shut-off valve housing and the structure (SWPM 20-20-00).
- (a) Make sure the resistance is 0.001 ohm (1 milliohm) or less.
- (4) Put the airplane back to a serviceable condition



APU Fuel Valve Actuator  
Figure 1

FUEL ATOMIZER - CLEANING/PAINTING

1. EQUIPMENT AND MATERIALS

A. Cleaning Solvent - Federal Specification P-D-680, or equivalent.

2. CLEAN FUEL ATOMIZER

CAUTION: THE FUEL ATOMIZER IS A PRECISELY ADJUSTED UNIT. MALADJUSTED ATOMIZERS CAN CAUSE DANGEROUSLY HIGH EXHAUST TEMPERATURES OR FLAMING STARTS. DISASSEMBLY AND ASSEMBLY OF THE ATOMIZER IS AN OVERHAUL PROCEDURE REQUIRING SPECIAL EQUIPMENT. UNDER NO CIRCUMSTANCE MUST THE ATOMIZER BE DISASSEMBLED DURING MAINTENANCE, EXCEPT AS SHOWN BELOW. IF THE ATOMIZER IS FOUND TO BE DEFECTIVE, IT MUST BE REPLACED AND REMOVED UNIT SENT TO OVERHAUL.

A. Remove fuel atomizer. Refer to Fuel Atomizer - Removal/Installation.

B. Remove elbow from fuel atomizer. (See figure 701.)

C. Remove fuel screen by unscrewing with screwdriver.

CAUTION: EXERCISE CARE WHEN REMOVING FUEL SCREEN TO PREVENT DAMAGE TO ATOMIZER HOUSING THREADS OR SCREEN.

D. Place fuel atomizer in solvent and allow to soak thoroughly. Dry thoroughly with filtered compressed air.

WARNING: SOLVENT IS HIGHLY TOXIC. USE IN WELL VENTILATED AREAS.

CAUTION: DO NOT USE SANDPAPER OR OTHER ABRASIVES TO CLEAN ATOMIZER HEAD. ALTERATION OF FUEL SPRAY PATTERN MAY RESULT.

E. Wash fuel screen in solvent and dry with filtered compressed air.

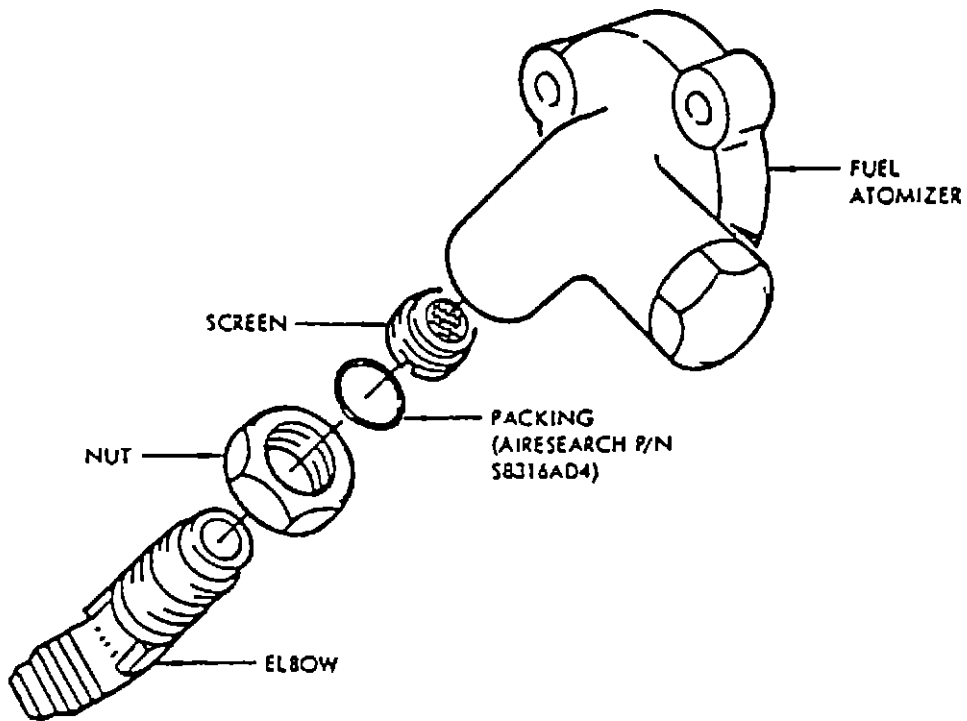
F. Install fuel screen in fuel atomizer.

G. Using new gasket, install elbow in atomizer. (See figure 701.)

H. Install fuel atomizer. Refer to Fuel Atomizer - Removal/Installation.

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Fuel Atomizer  
Figure 701

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**FUEL ATOMIZER - REMOVAL/INSTALLATION**

EFFECTIVITY RTCA LX-N19997 LX-N20000

**1 REMOVE FUEL ATOMIZER**

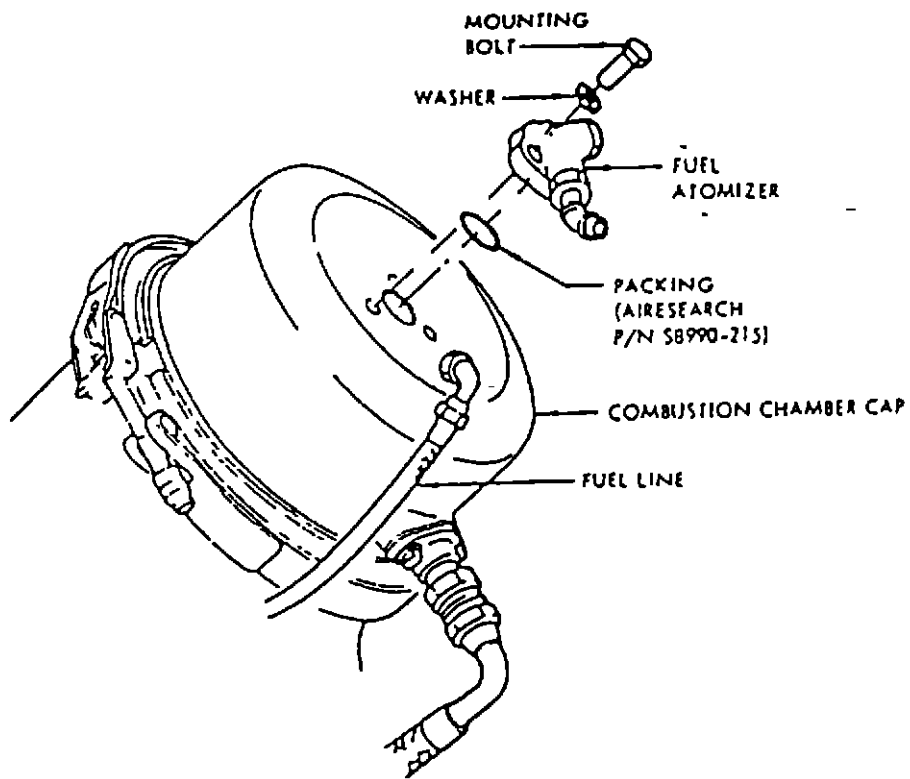
- A Open circuit breakers FD1, FD2, and bus feed on Sta 960 Starter Relay Box

**WARNING** THE CURRENT INVOLVED IN THE IGNITION UNIT IS OF VERY HIGH VOLTAGE AND CAN BE FATAL DO NOT PERFORM NEXT STEP UNTIL AT LEAST 3 MINUTES AFTER PULLING CIRCUIT BREAKER AND DO NOT DISCONNECT THE HIGH TENSION LEAD

- B Remove bolts attaching combustion chamber cover  
C Lift combustion chamber cover from unit  
D Disconnect fuel line from fuel atomizer (See Figure 401 )  
E Remove fuel atomizer mounting bolts and washers  
F Remove fuel atomizer and packing from unit

**2 INSTALL FUEL ATOMIZER**

- A With new packing in place, insert fuel atomizer into combustion chamber cap (See Figure 401)  
B Install fuel atomizer mounting bolts with washers Tighten bolts to a torque range of 20 to 25 pound-inches  
C Connect fuel line to fuel atomizer.  
D Position combustion chamber cover on unit and install bolts  
E Close circuit breakers FD1, FD2 and bus feed on Sta 960 starter relay box



**FUEL ATOMIZER INSTALLATION**  
**FIGURE 401**

Ref : MM STEWARD-DAVIS



## MAINTENANCE MANUAL

EFFECTIVITY TCA LX-N20198 LX-N20199

### FUEL PUMP AND CONTROL UNIT - SERVICING

#### 1. EQUIPMENT AND MATERIALS

- A. Cleaning Solvent - Federal Specification P-D-680, or equivalent.

#### 2. REPLACE FUEL FILTER ELEMENT

- A. Remove accessory section cover from APU housing. Refer to 49-11-01, APU Housing Accessory Section Cover - Removal/Installation.
- B. Unscrew filter cap from fuel pump and control unit. (See figure 301.)
- C. Remove filter element, spring, and packing.

CAUTION: EXERCISE EXTREME CARE TO PREVENT ANY DIRT FROM ENTERING FUEL PUMP AND CONTROL UNIT.

- D. Clean filter cap and spring in solvent and dry thoroughly.

WARNING: SOLVENT IS HIGHLY TOXIC. USE IN WELL VENTILATED ARE.

- E. Install new packing on filter guide.
- F. Place new filter element, spring and new filter cap packing in place; install filter cap in fuel pump and lockwire.
- F. Install accessory section cover on APU housing. Refer to 49-11-01 APU Accessory Section Cover - Removal/Installation.

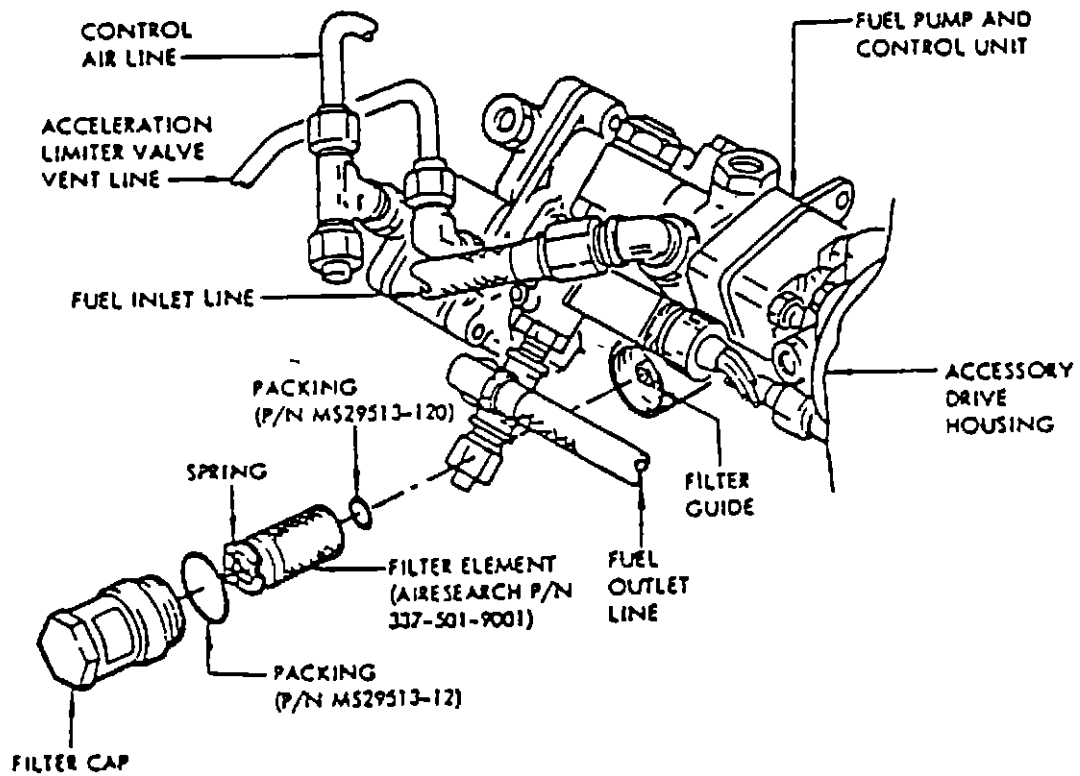
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BOEING *707*  
*Intercontinental*  
MAINTENANCE MANUAL



Fuel Pump and Control Unit Servicing  
Figure 301

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FUEL PUMP AND CONTROL UNIT - REMOVAL/INSTALLATION

1. REMOVE FUEL PUMP AND CONTROL UNIT

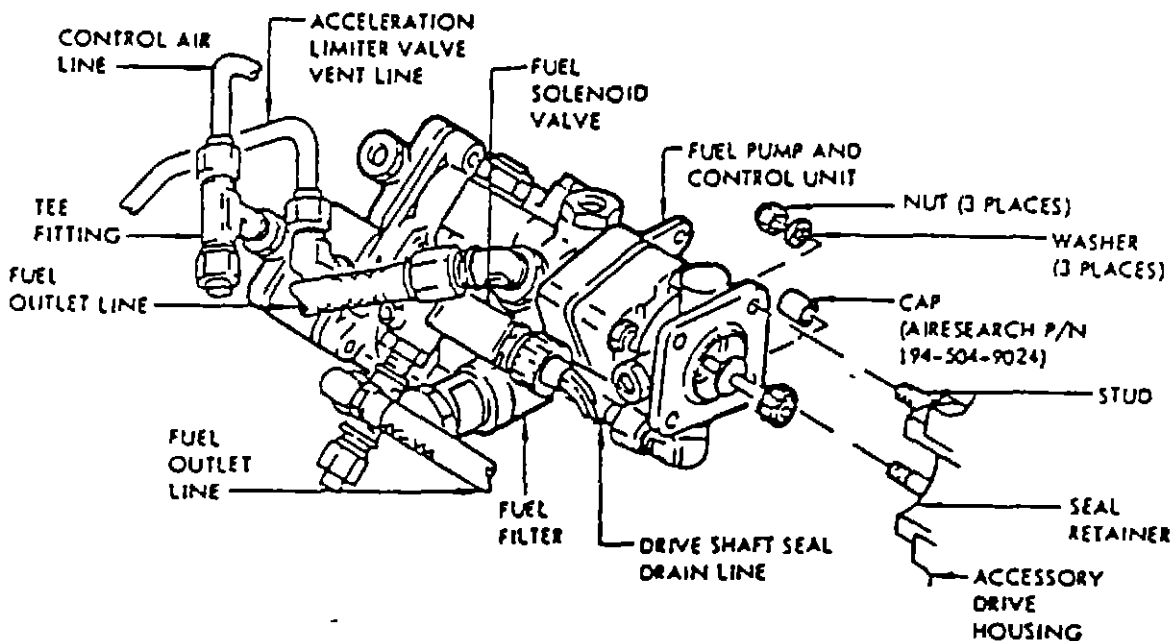
- A. Open FD1, FD2 and bus feed circuit breakers on Sta. 960 starter relay box.
- B. Remove accessory cover from APU housing. Refer to 49-11-01, APU Accessory Section Cover - Removal/Installation.
- C. Remove fuel solenoid valve. Refer to 49-32-11, Fuel Solenoid Valve - Removal/Installation.
- D. Disconnect control air line from tee fitting. (See figure 401.)
- E. Disconnect drive shaft seal drain line and acceleration limited valve vent line from fuel pump and control unit.
- F. Remove protective cap from fuel pump and control unit mounting stud.
- G. Remove attaching nuts and washers.
- H. Carefully remove fuel pump and control unit.
- I. Remove fuel inlet line from fuel pump and control unit and save for installation.

2. INSTALL FUEL PUMP AND CONTROL

- A. Connect fuel inlet line to fuel pump and control unit. (See figure 401.)
- B. Position fuel pump and control unit on mounting studs. Make sure that drive shaft of fuel pump and control unit engages with gear shaft on accessory drive.
- C. Install washers and attaching nuts. Tighten nuts to a torque range of 50 to 70 pound-inches.
- D. Install protective cap on stud.
- E. Connect drive shaft seal drain line and acceleration limited valve vent line to fuel pump and control unit.
- F. Connect control air line to tee fitting.
- G. Install fuel solenoid valve. Refer to 49-32-11, Fuel Solenoid Valve - Removal/Installation.

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- H. Install accessory cover on APU Housing. Refer to 49-11-01, APU Accessory Section Cover - Removal/Installation.
- I. Close FD1, FD2 and bus feed circuit breakers on Sta. 960 starter relay box.
- J. Bleed fuel system. Refer to 49-00, Auxiliary Power Unit - Maintenance Practices.
- K. Adjust fuel pump and control unit. Refer to Fuel Pump and Control Unit - Adjustment/Test.



Fuel Pump and Control Unit Installation  
 Figure 401

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FUEL PUMP AND CONTROL UNIT - ADJUSTMENT/TEST

1. EQUIPMENT AND MATERIALS

- A. Pressure Gage - 0 to 50 PSIG.
- B. APU Tester - AiResearch No. 290122-400, AiResearch Manufacturing Company, Phoenix, Arizona, or equivalent.
- C. Tester Cable Assembly - AiResearch No. 290128-1-1, AiResearch Manufacturing Company, Phoenix, Arizona, or equivalent.
- D. Establish interphone line between F/E station and aft cargo compartment.

ADJUST ACCELERATION LIMITED VALVE

- A. Open circuit breakers FD1, FD2 and bus feed on Sta. 960 starter relay box.

WARNING - THE CURRENT INVOLVE IN THE IGNITION UNIT IS OF VERY HIGH VOLTAGE AND CAN BE FATAL DO NOT PERFORM NEXT STEP UNTIL AT LEAST THREE MINUTES AFTER PULLING CIRCUIT BREAKER AND DO NOT DISCONNECT THE HIGH VOLTAGE LEAD.

- B. Remove bolts attaching combustion chamber cover and lift cover from housing.
- C. Disconnect APU harness lead from ignition units.
- D. Remove accessory cover from APU housing. Refer to 49-11-01, APU Accessory Section Cover - Removal/Installation.
- D. Remove accessory cover from APU Housing. Refer to 49-11-01, APU Accessory Section Cover - Removal/Installation.
- E. Disconnect control air line from fuel pump and control unit. (See figure 501.
- F. Disconnect fuel outlet line from fuel solenoid valve tee fitting and install pressure gage on tee fitting.
- G. Close circuit breakers FD1, FD2 and bus feed on Sta. 960 starter relay box.
- H. Actuate APU MASTER switch to ON position (MASTER light on).
- I. Motor unit by momentarily depressing the START switch. (START light on.
- J. Continue motoring until speed levels off (approximately 20% RPM, 8000 to 9000 RPM turbine wheel speed).

J. cont.

CAUTION: DO NOT EXCEED STARTER MOTOR DUTY CYCLE OF ONE MINUTE ON, FOUR MINUTES OFF.

- K. While motoring unit, monitor pressure gage and note and record acceleration limiter valve opening pressure. Pressure should be 34 ( $\pm$  1) PSIG.
- L. Actuate APU MASTER switch to off position as soon as possible. (MASTER light out.)
- M. If opening pressure is not within specified limits, adjust acceleration limiter valve.

NOTE: If no pressure change occurs after two full turns of adjusting screw in either direction, do not adjust further. Refer to 49-00, APU Trouble Shooting for applicable trouble shooting procedure

- (1) If pressure is too low, turn adjusting screw clockwise
- (2) If pressure is too high, turn adjusting screw counterclockwise.

- N. Repeat steps H through M acceleration limited valve is correctly adjusted.
- P. Open FD1, FD2 and bus feed circuit breakers on Sta. 960 starter relay box.
- Q. Remove pressure gage and reconnect fuel outlet line.
- R. Connect control air line to fuel pump and control unit.
- S. Connect APU harness connector to ignition unit.
- T. Place combustion chamber cover on APU housing and install bolts.

### 3. ADJUST GOVERNOR

- A. Connect tester and tester cable assembly to APU. Refer to 49-00, Auxiliary Power Unit - Adjustment/Test. Do not connect hose assemblies to fuel pressure connection, control air connection, and oil pressure connection.
- B. Install tachometer generator on APU.
- C. Close FD1, FD2 and bus feed circuit breakers on Sta. 960 starter relay box.
- D. Actuate APU master switch to ON position. (MASTER light on).

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MAINTENANCE MANUAL

J. cont.

**CAUTION** DO NOT EXCEED STARTER MOTOR DUTY CYCLE OF ONE MINUTE ON, FOUR MINUTES OFF

- K. While motoring unit, monitor pressure gage and note and record acceleration limiter valve opening pressure. Pressure should be 34 ( $\pm$  1) PSIG.
- L. Actuate APU MASTER switch to off position as soon as possible (MASTER light out.)

**NOTE:** When operating the APU unattended for an extended period of time, follow Airplane Maintenance Manual (AMM) instructions regarding necessary fuel quantity based on APU fuel burn rate.

- M. If opening pressure is not within specified limits, adjust acceleration limiter valve.

**NOTE:** If no pressure change occurs after two full turns of adjusting screw in either direction, do not adjust further. Refer to 49-00, APU Trouble Shooting for applicable trouble shooting procedure.

(1) If pressure is too low, turn adjusting screw clockwise.

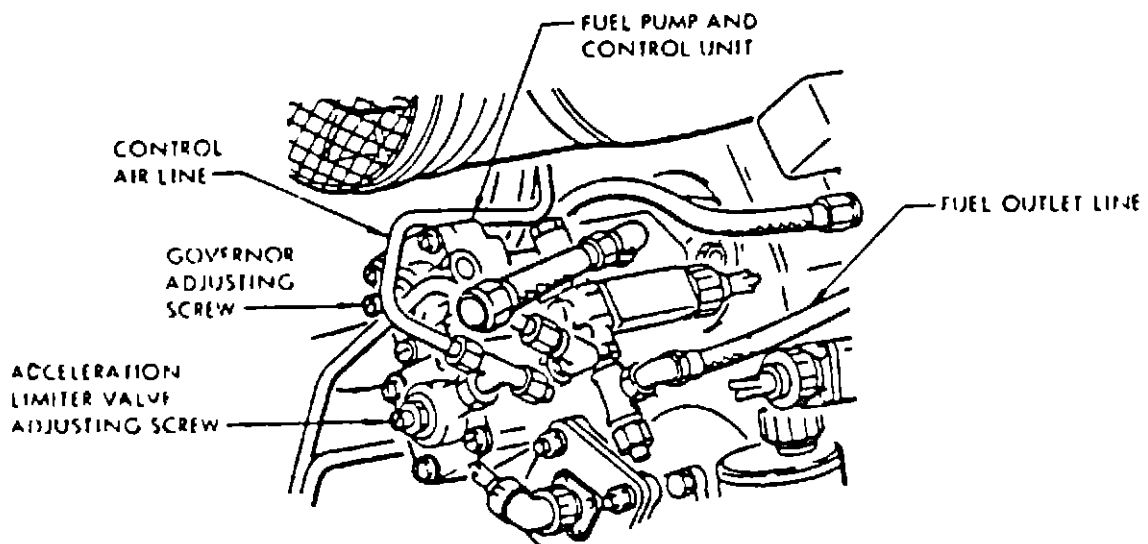
(2) If pressure is too high, turn adjusting screw counterclockwise.

- N. Repeat steps H through M acceleration limited valve is correctly adjusted.
- P. Open FD1 , FD2 and bus feed circuit breakers on Sta. 960 starter relay box.
- Q. Remove pressure gage and reconnect fuel outlet line.
- R. Connect control air line to fuel pump and control unit.
- S. Connect APU harness connector to ignition unit.
- T. Place combustion chamber cover on APU housing and install bolts.

3. Adjust Governor

- A. Connect tester and tester cable assembly to APU. Refer to 49-00, Auxiliary Power Unit - Adjustment/Test. Do not connect hose assemblies to fuel pressure connection, control air connection, and oil pressure connection.
- B. Install tachometer generator on APU.
- C. Close FD1, FD2 and bus feed circuit breakers on Sta. 960 starter relay box.
- D. Actuate APU master switch to ON position. (MASTER light on).

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Fuel Pump and Control Unit Adjustment  
Figure 501

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**MAINTENANCE MANUAL**

- E. Momentarily depress START switch. (Start light on.)
- F. Allow engine to accelerate to no-load governed speed. Allow unit to run at this speed for approximately one minute so that speed is stabilized.
- G. Check no-load governed speed. Speed shall be 41,500 - 41,600 max RPM.
- H. If speed is not correct, adjust governor. (See figure 501.)  
  
NOTE: If proper setting cannot be obtained after one full turn of adjusting screw in either direction, do not attempt further adjustment. Refer to 49-00, APU Trouble Shooting for applicable trouble shooting procedure.
  - (1) If speed is too low, turn adjusting screw clockwise.
  - (2) If speed is too high, turn adjusting screw counterclockwise.
- I. Actuate APU MASTER switch to off position. (MASTER light out.)
- J. Open FD1, FD2 and Bus Feed circuit breakers on Sta. 960 Starter Relay Box
- K. Disconnect tester and tester cable assembly from APU. Refer to 49-00, Auxiliary Power Unit - Adjustment/Test.
- L. Remove tachometer generator from APU.
- M. Install accessory cover on APU housing. Refer to 49-11-01 APU Accessory Section Cover - Removal/Installation.
- N. Close FD1, FD2 and Bus Feed circuit breakers on Sta. 960 Starter Relay Box.

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FUEL PUMP AND CONTROL UNIT - SERVICING

EFFECTIVITY RTCA LX-N19997 LX-N20000

1 EQUIPMENT AND MATERIALS

A. Cleaning Solvent - Federal Specification P-D-680, or equivalent.

2 REPLACE FUEL FILTER ELEMENT

A Remove accessory section cover from APU housing Refer to 49-11-02, APU Housing Accessory Section Cover - Removal/Installation

B Unscrew filter cap from fuel pump and control unit (See Figure 301 )

C Remove filter element, spring, and packing

CAUTION EXERCISE EXTREME CARE TO PREVENT ANY  
DIRT FROM ENTERING FUEL PUMP AND  
CONTROL UNIT

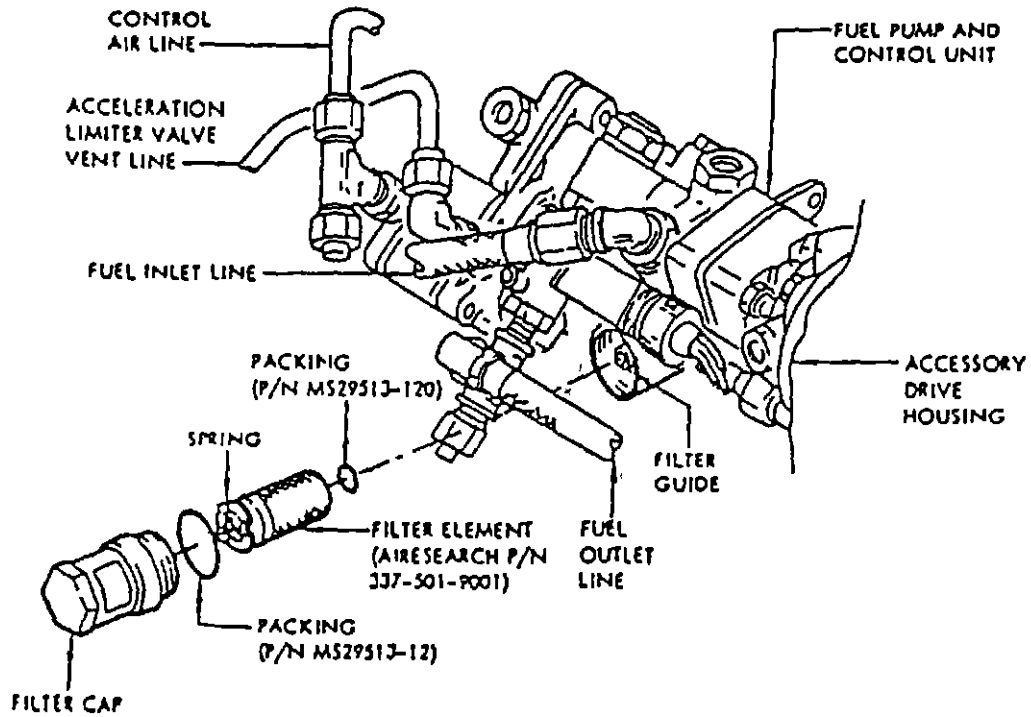
D Clean filter cap and spring in solvent and dry thoroughly

WARNING SOLVENT IS HIGHLY TOXIC USE IN WELL  
VENTILATED AREA

E Install new packing on filter guide

F Place new filter element, spring and new filter cap packing in place, install filter cap in fuel pump and lockwire

G Install accessory section cover on APU housing Refer to 49-11-02 APU Accessory Section Cover - Removal/Installation.



**FUEL PUMP AND CONTROL UNIT SERVICING**  
**FIGURE 301**

Ref MM STEWARD-DAVIS

**FUEL PUMP AND CONTROL UNIT - REMOVAL/INSTALLATION**

EFFECTIVITY RTCA LX-N19997 LX-N20000

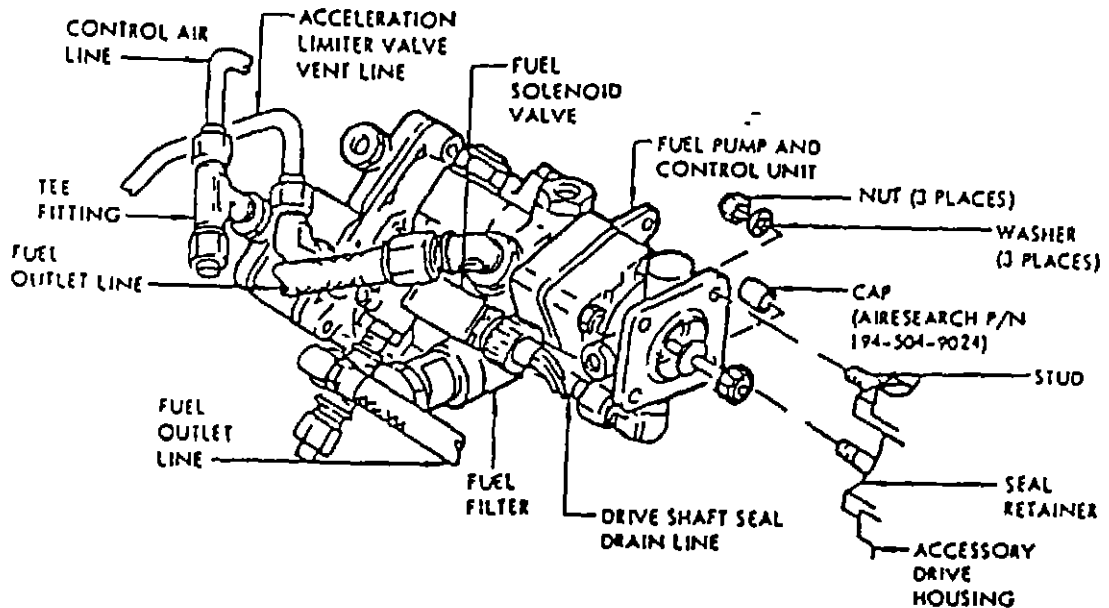
**1 REMOVE FUEL PUMP AND CONTROL UNIT**

- A Open FD1, FD2 and bus feed circuit breakers on Sta 960 starter relay box.
- B Remove accessory cover from APU housing Refer to 49-11-02, APU Accessory Section Cover - Removal/Installation
- C. Remove fuel solenoid valve Refer to 49-32-12, Fuel Solenoid Valve - Removal/Installation
- D Disconnect control Air line from tee fitting (See Figure 401 )
- E Disconnect drive shaft seal drain line and acceleration limited valve vent line from fuel pump and control unit
- F. Remove protective cap from fuel pump and control unit mounting stud
- G Remove attaching nuts and washers
- H Carefully remove fuel pump and control unit.
- I Remove fuel inlet line from fuel pump and control unit and save for installation

**2 INSTALL FUEL PUMP AND CONTROL**

- A Connect fuel inlet line to fuel pump and control unit (See Figure 401.)
- B Position fuel pump and control unit on mounting studs Make sure that drive shaft of fuel pump and control unit engages with gear shaft on accessory drive
- C Install washers and attaching nuts Tighten nuts to a torque range of 50 to 70 pound-inches.
- D. Install protective cap on stud.
- E. Connect drive shaft seal drain line and acceleration limited valve vent line to fuel pump and control unit.
- F Connect control air line to tee fitting.
- G Install fuel solenoid valve. Refer to 49-32-12, Fuel Solenoid Valve - Removal/Installation

- H. Install accessory cover on APU Housing. Refer to 49-11-02, APU Accessory Section Cover - Removal/Installation.
- I. Close FD1, FD2 and bus feed circuit breakers on Sta. 960 starter relay box.
- J. Bleed fuel system Refer to 49-00, Auxiliary Power Unit - Maintenance Practices
- K. Adjust fuel pump and control unit Refer to Fuel Pump and Control Unit - Adjustment/Test



### FUEL PUMP AND CONTROL UNIT INSTALLATION

FIGURE 401

Ref • MM STEWARD-DAVIS

**FUEL PUMP AND CONTROL UNIT - ADJUSTMENT/TEST**

EFFECTIVITY RTCA LX-N19997 LX-N20000

**1 EQUIPMENT AND MATERIALS**

- A Pressure Gage - 0 to 50 PSIG
- B APU Tester - AiResearch No 290122-400, AiResearch Manufacturing Company, Phoenix, Arizona, or equivalent.
- C Tester Cable Assembly - AiResearch No 290128-1-1, AiResearch Manufacturing Company, Phoenix, Arizona, or equivalent
- D. Establish interphone line between F/E station and aft cargo compartment

**2 ADJUST ACCELERATION LIMITED VALVE**

- A. Open circuit breakers FD1, FD2, and bus feed on Sta. 960 starter relay box

**WARNING: THE CURRENT INVOLVE IN THE IGNITION UNIT IS OF VERY HIGH VOLTAGE AND CAN BE FATAL DO NOT PERFORM NEXT STEP UNTIL AT LEAST THREE MINUTES AFTER PULLING CIRCUIT BREAKER AND DO NOT DISCONNECT THE HIGH VOLTAGE LEAD**

- B Remove bolts attaching combustion chamber and lift cover from housing
- C Disconnect APU harness lead from ignition units
- D Remove accessory cover from APU housing Refer 49-11-02, APU Accessory Section Cover - Removal /Installation
- E. Disconnect control air lines from fuel pump and control unit (See Figure 501 )
- F Disconnect fuel outlet line from fuel solenoid valve tee fitting and install pressure gage on tee fitting.
- G Close circuit breakers FD1, FD2 and bus feed on Sta. 960 starter relay box
- H. Actuate APU MASTER switch to ON position (MASTER light on).
- I Motor unit by momentarily depress the START switch (START light on.)
- J Continue motoring until speed levels off (approximately 20% RPM, 8000 to 9000 RPM turbine wheel speed.

**CAUTION: DO NOT EXCEED STARTER MOTOR DUTY CYCLE OF ONE MINUTE ON, FOUR MINUTES OFF**



## MAINTENANCE MANUAL

- K While motoring unit, monitor pressure gage and note and record acceleration limiter valve opening pressure. Pressure should be 34 ( $\pm$  1) PSIG.
- L Actuate APU MASTER switch to off position as soon as possible (MASTER light out)
- M If opening pressure is not within specified limits, adjust acceleration limiter valve

**NOTE** If no pressure change occurs after two full turns of adjusting screw in either direction, do not adjust further Refer to 49-00, APU Trouble Shooting for applicable trouble shooting procedure

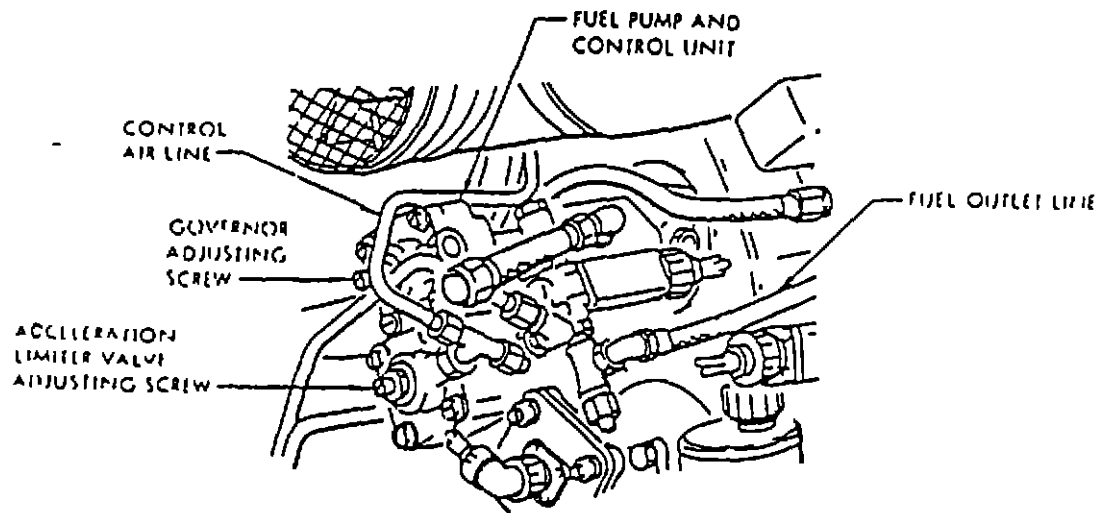
- (1) If pressure is too low, turn adjusting screw clockwise
- (2) If pressure is too high, turn adjusting screw counterclockwise

- N Repeat steps H through M acceleration limited valve is correctly adjusted
- P Open FD1, FD2 and bus feed circuit breakers on Sta 960 starter relay box
- Q Remove pressure gage and reconnect fuel outlet line.
- R Connect control air line to fuel pump and control unit
- S Connect APU harness connector to ignition unit
- T Place combustion chamber cover on APU housing and install bolts

### 3 ADJUST GOVERNOR

- A Connect tester and tester cable assembly to APU Refer to 49-00, Auxiliary Power Unit - Adjustment/Test Do not connect hose assemblies to fuel pressure connection, control air connection, and oil pressure connection
- B Install tachometer generator on APU
- C Close FD1, FD2 and bus feed circuit breakers on Sta 960 starter relay box
- D Actuate APU master switch to ON position (MASTER light on)

Ref MM STEWARD-DAVIS



**FUEL PUMP AND CONTROL UNIT ADJUSTMENT**

**FIGURE 501**

- E. Momentarily depress START switch. (Start light on )
- F. Allow engine to accelerate to no-load governed speed. Allow unit to run at this speed for approximately one minute so that speed is stabilized.
- G. Check no-load governed speed. Speed shall be 41,500 - 41,600 max RPM.
- H. If speed is not correct, adjust governor (See Figure 501)  
NOTE If proper setting cannot be obtained after one full turn of adjusting screw in either direction, do not attempt further adjustment. Refer to 49-00, APU Trouble Shooting for applicable trouble shooting procedure.
  - (1) If speed is too low, turn adjusting screw clockwise
  - (2) If speed is too high, turn adjusting screw counterclockwise
- I. Actuate APU MASTER switch to off position (MASTER light out )
- J. Open FD1, FD2 and Bus Feed circuit breakers on Sta 960 Starter Relay Box
- K. Disconnect tester and tester cable assembly from APU. Refer to 49-00, Auxiliary Power Unit - Adjustment/Test
- L. Remove tachometer generator from APU
- M. Install accessory cover on APU housing. Refer to 49-11-02 APU Accessory Section Cover - Removal/Installation
- N. Close FD1, FD2 and Bus Feed circuit breakers on Sta 960 Starter Relay Box

APU IGNITION AND STARTING SYSTEM

DESCRIPTION AND OPERATION

WARNING: THE CURRENT INVOLVED IN THE IGNITION UNITS IS OF VERY HIGH VOLTAGE AND CAN BE FATAL. BE SURE THAT POWER IS REMOVED FROM THE SYSTEM FOR A MINIMUM OF 3 MINUTES BEFORE MAKING ANY DISCONNECTIONS. AFTER DISCONNECTING A HIGH TENSION LEAD, ENSURE COMPLETE DISCHARGE OF CAPACITORS BY IMMEDIATELY SHORTING EXCITER UNIT TERMINAL TO GROUND.

1. GENERAL

- A. The APU ignition and starting system provides the means of rotating the APU compressor and turbine to starting speed and for igniting the fuel-air mixture in the combustion chamber. The system consists of a starter motor, a starter relay, an ignition unit, an igniter plug, a high voltage lead.
- B. During an APU start the starter motor cranks the APU engine and the ignition unit converts 28 volt DC power into a high voltage current which is conducted to the igniter plug by the high voltage lead, the resultant high energy spark starts combustion of the fuel-air mixture in the combustion chamber. Initiation and terminating of starter operation and ignition unit energization is automatically controlled to occur at the correct time during the starting cycle.

2. STARTER MOTOR

- A. The starter motor is mounted on the APU accessory drive section. It rotates the APU engine compressor and turbine and all engine-driven accessories during an APU start. The starter motor consists of a series-wound electric motor, a spring-loaded friction clutch and a pawl-driven mechanism. When the starter motor is energized, it begins rotating. As its speed increases, centrifugal force throws the pawls into engagement with a ratchet on the accessory drive shaft and the starter rotates the engine and the other accessories. The shock of initial engagement of the pawls is absorbed by the spring-loaded friction clutch. When the starter motor is de-energized, the engine speed exceeds starter motor speed, the pawls ratchet on the shaft until the starter motor speed slows to where the centrifugal force is small enough to allow the springs to retract the pawls.

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### 3. STARTER RELAY

- A. The starter relay is a single coil relay with heavy duty contacts that carry the large electrical load required to operate the starter motor and with auxiliary contacts that are used as follows:
- (1) NC contacts interrupt control power to the APU generator control unit during starter motor operation.
  - (2) NO contacts keep the starter relay coil energized, after the start switch is released, until control power is interrupted when the 35% switch opens.

### 4. IGNITION UNIT

- A. The ignition unit provides the high voltage current required to produce the spark at the igniter plug. The unit consists of a transformer, a vibrator, a rectifier, a booster coil and a series of capacitors all enclosed in a hermetically sealed metal container mounted in the APU housing. When the ignition unit is energized the vibrator converts the 28 volt DC input into a pulsating output. The voltage of this pulsating current is greatly increased by the transformer and booster coil before it is delivered to the igniter plug.

### 5. IGNITER PLUG

- A. The igniter plug provides the high energy spark for igniting the fuel-air mixture in the combustion chamber. It is mounted on the side of the combustion chamber. The principal parts of the igniter plug are the outer casing, a center electrode, and a ceramic insulator. The spark that bridges the non-adjustable annular gap between the center electrode and the outer casing is of sufficient intensity to vaporize and ignite wet fuel.

### 6. HIGH VOLTAGE LEAD

- A. The high voltage lead conducts the output current of the ignition unit to the igniter plug. The lead consists of an insulated electrical conductor encased in a braided metal conduit with insulated, threaded, connectors at each end. The lead and connectors are shielded to prevent radio interference.

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## 7. OPERATION

- A. Once an APU start is initiated, operation of the ignition and starting system is automatically controlled to correctly sequence the energizing and de-energizing of the starter motor and the ignition unit. Momentarily pressing the APU "START" switch energizes the start relay. When the switch is released, the start relay remains energized through a self-locking circuit, the 35% switch of the centrifugal switch assembly and through NC contacts of the lockout relay (LO-2). With the start relay energized, the start light is illuminated and its internal heavyduty contacts complete the circuit to the starter motor which begins to rotate and accelerate the APU engine. As the oil pressure rises to a predetermined value, the sequencing oil pressure switch closes to energize the ignition unit and the fuel solenoid valve.
- B. When the ignition unit is energized, the vibrator is supplied with 28 volt DC power. The vibrator converts the DC input current to a pulsating current. This pulsating current is transmitted into the transformer, where the voltage is greatly increased, then passes through the rectifier unit into the storage capacitors. When the storage capacitors are fully charged, an air gap breaks down. This allows the capacitors to discharge a surge of high intensity current into the primary winding of the booster coil. The secondary winding of the booster coil produces a surge of current, the voltage of which is many times that of the input current in the primary winding, which is transmitted to the center electrode of the igniter plug by the high voltage lead. The voltage of this current is sufficiently high to break down the igniter plug air gap and generate a high energy spark between the igniter plug center electrode and the outer case to ignite the fuel-air mixture in the combustion chamber. The turbine exhaust gases now assist the starter motor to rotate the engine and the engine continues to accelerate.
- C. When the engine has accelerated to approximately 35% of governed speed, the 35% switch in the centrifugal switch assembly opens. The start relay is de-energized. This in turn de-energizes the START light and the starter motor circuit which terminates starter operation. The engine continues to accelerate. At 95% governed speed, the 95% switch in the centrifugal switch opens and breaks the circuit to the ignition unit to terminate operation of the igniter plug.
- D. After a one minute warm-up at governed speed the engine can be loaded as desired, electrically and/or pneumatically.

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## MAINTENANCE MANUAL

### APU IGNITION AND STARTING SYSTEM

#### DESCRIPTION AND OPERATION

EFFECTIVITY RTCA LX-N19997 LX-N20000

**WARNING** THE CURRENT INVOLVED IN THE IGNITION UNITS IS OF VERY HIGH VOLTAGE AND CAN BE FATAL BE SURE THAT POWER IS REMOVED FROM THE SYSTEM FOR A MINIMUM OF 3 MINUTES BEFORE MAKING ANY DISCONNECTIONS AFTER DISCONNECTING A HIGH TENSION LEAD, ENSURE COMPLETE DISCHARGE OF CAPACITORS BY IMMEDIATELY SHORTING EXCITER UNIT TERMINAL TO GROUND

#### 1. GENERAL

- A The APU ignition and starting system provides the means of rotating the APU compressor and turbine to starting speed and for igniting the fuel-air mixture in the combustion chamber. The system consists of a starter motor, a starter relay, an ignition unit, an igniter plug, a high voltage lead
- B During an APU start the starter motor cranks the APU engine and the ignition unit converts 28 volt DC power into a high voltage current which is conducted to the igniter plug by the high voltage lead, the resultant high energy spark starts combustion of the fuel-air mixture in the combustion chamber Initiation and terminating of starter operation and ignition unit energization is automatically controlled to occur at the correct time during the starting cycle.

#### 2. STARTER MOTOR

- A The starter motor is mounted on the APU accessory drive section It rotates the APU engine compressor and turbine and all engine-driven accessories during an APU start The starter motor consists of a series-wound electric motor, a spring loaded friction clutch and a pawl-driven mechanism. When the starter motor is energized, it begins rotating As its speed increases, centrifugal force throws the pawls into engagement with a ratchet on the accessory drive shaft and the starter rotates the engine and the other accessories The shock of initial engagement of the pawls is absorbed by the spring-loaded friction clutch When the starter motor is de-energized, the engine speed exceeds starter motor speed, the pawls ratchet on the shaft until the starter motor speed slows to where the centrifugal force is small enough to allow the springs to retract the pawls.



## MAINTENANCE MANUAL

### 3 STARTER RELAY

A The starter relay is a single coil relay with heavy duty contacts that carry the large electrical load required to operate the starter motor and with auxiliary contacts that are used as follows:

- (1) NC contacts interrupt control power to the APU generator control unit during starter motor operation.
- (2) NO contacts keep the starter relay coil energized, after the start switch is released, until control power is interrupted when the 35% switch opens.

### 4 IGNITION UNIT

A The ignition unit provides the high voltage current required to produce the spark at the igniter plug. The unit consists of a transformer, a vibrator, a rectifier, a booster coil and a series of capacitors all enclosed in a hermetically sealed metal container mounted in the APU housing. When the ignition unit is energized the vibrator converts the 28 volt DC input into a pulsating output. The voltage of this pulsating current is greatly increased by the transformer and booster coil before it is delivered to the igniter plug.

### 5 IGNITER PLUG

A The igniter plug provides the high energy spark for igniting the fuel-air mixture in the combustion chamber. It is mounted on the side of the combustion chamber. The principal parts of the igniter-plug are the outer casing, a center electrode, and a ceramic insulator. The spark that bridges the non-adjustable annular gap between the center electrode and the outer casing is of sufficient intensity to vaporize and ignite wet fuel.

### 6 HIGH VOLTAGE LEAD

A The high voltage lead conducts the output current of the ignition unit to the igniter plug. The lead consists of an insulated electrical conductor encased in a braided metal conduit with insulated, threaded, connectors at each end. The lead and connectors are shielded to prevent radio interference.

## 7 OPERATION

- A Once an APU start is initiated, operation of the ignition and starting system is automatically controlled to correctly sequence the energizing and de-energizing of the starter motor and the ignition unit. Momentarily pressing the APU "START" switch energizes the start relay. When the switch is released, the start relay remains energized through a self-locking circuit, the 35% switch of the centrifugal switch assembly and through NC contacts of the lockout relay (LO-2). With the start relay energized, the start light is illuminated and its internal heavy duty contacts complete the circuit to the starter motor which begins to rotate and accelerate the APU engine. As the oil pressure begins to rotate and accelerate the APU engine. As the oil pressure rises to a predetermined value, the sequencing oil pressure switch closes to energize the ignition unit and the fuel solenoid valve.
- B When the ignition unit is energized, the vibrator is supplied with 28 volt DC power. The vibrator converts the DC input current to a pulsating current. This pulsating current is transmitted into the transformer, where the voltage is greatly increased, then passes through the rectifier unit into the storage capacitors. When the storage capacitors are fully charged, an air gap breaks down. This allows the capacitors to discharge a surge of high intensity current into the primary winding of the booster coil. The secondary winding of the booster coil produces a surge of current, the voltage of which is many times that of the input current in the primary winding, which is transmitted to the center electrode of the igniter plug by the high voltage lead. The voltage of this current is sufficiently high to break down the igniter plug air gap and generate a high energy spark between the igniter plug center electrode and the outer case to ignite the fuel-air mixture in the combustion chamber. The turbine exhaust gases now assist the starter motor to rotate the engine and the engine continues to accelerate.
- C When the engine has accelerated to approximately 35% of governed speed, the 35% switch in the centrifugal switch assembly opens. The start relay is de-energized. This in turn de-energizes the START light and the starter motor circuit which terminates starter operation. The engine continues to accelerate. At 95% governed speed, the 95 switch in the centrifugal switch opens and breaks the circuit to the ignition unit terminate operation of the igniter plug.
- D After a one minute warm-up at governed speed the engine can be loaded as desired, electrically and/or pneumatically.



## MAINTENANCE MANUAL

EFFECTIVITY TCA LX-N20198 LX-N20199

### IGNITER PLUG - REMOVAL/INSTALLATION

#### 1. REMOVE IGNITER PLUG

- A. Open FD1, FD2 and Bus Feed circuit breaker on Sta. 960 starter relay box.
- B. Remove combustion chamber cover attaching bolts and lift cover from housing.

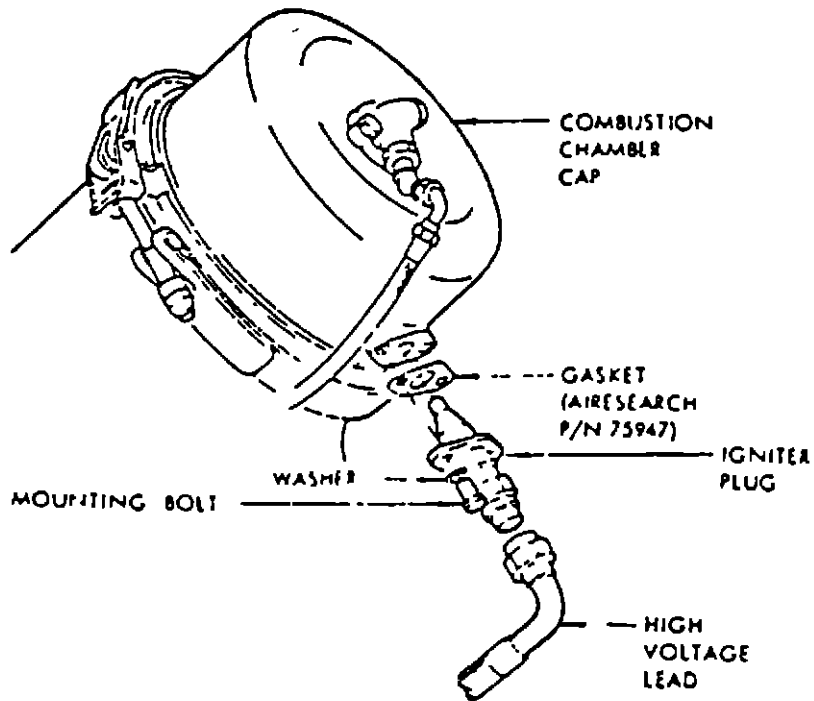
WARNING: THE CURRENT INVOLVED IN THE IGNITION UNIT IS OF VERY HIGH VOLTAGE AND CAN BE FATAL. BE SURE THAT POWER IS REMOVED FROM THE UNIT FOR A MINIMUM OF 3 MINUTES BEFORE MAKING ANY DISCONNECTIONS. AFTER DISCONNECTING A HIGH VOLTAGE LEAD, INSURE COMPLETE DISCHARGE OF CAPACITORS BY IMMEDIATELY SHORTING EXCITER UNIT TERMINAL TO GROUND.

- C. Disconnect high voltage lead from igniter plug. (See figure 401)
- D. Remove igniter plug mounting bolts and washers.
- E. Withdraw igniter plug from combustion chamber cap.
- F. Remove and discard old gasket.

#### 2. INSTALL IGNITER PLUG

- A. Place new gasket on igniter plug. (See figure 401.)
- B. Insert igniter plug into combustion chamber cap.
- C. Install igniter plug mounting bolts with washers. Tighten bolts to a torque range of 50 to 70 pound-inches. Lockwire bolts.
- D. Connect high voltage lead to igniter plug.
- E. Position combustion chamber cover on housing and install bolts.
- F. Close FD1, FD2 and Bus Feed circuit breakers on Sta. 960 starter relay box.

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Igniter Plug Installation  
Figure 401

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EFFECTIVITY TCA LX-N20198 LX-N20199

IGNITER PLUG - ADJUSTMENT/TEST

1. EQUIPMENT AND MATERIALS

- A. Establish interphone communication between F/E station and aft cargo compartment.

2. TEST IGNITER PLUG

- A. Remove accessory section cover. Refer to 49-11-11, APU Accessory Section Cover - Removal/Installation.
- B. Disconnect electrical connector from fuel solenoid valve.
- C. Close BUS FEED, BATT switch, CONTROL FEEDS 1 and 2 circuit breakers on Sta 960 starter relay box
- D. Actuate APU MASTER switch to ON position (MASTER light on.)
- E. PRESS START switch.
- F. Listen for sound of igniter plug sparking, then actuate MASTER switch to OFF position (MASTER light out.)

CAUTION: DO NOT EXCEED STARTER MOTOR DUTY CYCLE OF ONE MINUTE ON, FOUR MINUTES OFF.

- G. Open BUS FEED, BATT switch, CONTROL FEEDS 1 and 2 circuit breakers on Sta. 960 starter relay box
- H. Connect electrical connector to fuel solenoid valve.
- I. Install accessory section cover. Refer to 49-11-11, APU Accessory Section Cover - Removal/Installation.

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IGNITER PLUG - INSPECTION/CHECK

1. CHECK IGNITER PLUG

- A. Remove igniter plug from APU. Refer to Igniter Plug - Removal/Installation.
- B. Check igniter plug for cracks or chipping of ceramic insulator or body.
- C. Check electrodes for excessive burning, erosion of material or other damage.
- D. Check that electrode extends beyond ceramic insulator a minimum of 1/16 inch.
- E. Install igniter plug on APU. Refer to Igniter Plug - Removal/Installation.

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IGNITER PLUG - CLEANING/PAINTING

1. EQUIPMENT AND MATERIALS

- A. Solvent - Federal Specification P-D-680, or equivalent.
- B. Soft Grit Blasting Equipment or Brass Bristle Brush.

NOTE: Suitable soft blasting materials are ground corn, apricot or peach pits, walnut shells, clover seeds, or cracked wheat.

2. CLEAN IGNITER PLUG

- A. Remove igniter plug from APU. Refer to Igniter Plug - Removal/Installation.
- B. Clean igniter plug with solvent and blow dry with clean compressed air.
- C. Clean all deposits from igniter plug by blasting or brushing.
- D. Blow off all loosened material with clean, dry compressed air.

CAUTION: DO NOT USE HARD GRIT BLASTING OR STEEL BRISTLE BRUSH AS THESE MATERIALS CAN SERIOUSLY DAMAGE IGNITER PLUG.

- E. Install igniter plug on APU. Refer to Igniter Plug - Removal/Installation.

**IGNITER PLUG - REMOVAL/INSTALLATION**

EFFECTIVITY RTCA LX-N19997 LX-N20000

**1 REMOVE IGNITER PLUG**

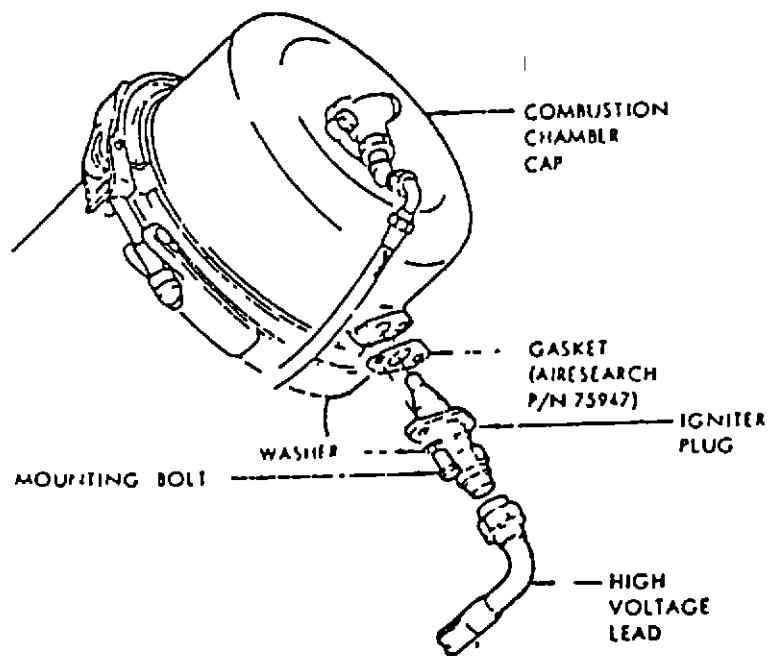
- A Open FD1, FD2 and Bus Feed circuit breaker on Sta 960 starter relay box
- B Remove combustion chamber cover attaching bolts and list cover from housing

**WARNING** THE CURRENT INVOLVED IN THE IGNITION UNIT IS OF VERY HIGH VOLTAGE AND CAN BE FATAL BE SURE THAT POWER IS REMOVED FROM THE UNIT FOR A MINIMUM OF 3 MINUTES BEFORE MAKING ANY DISCONNECTIONS AFTER DISCONNECTING A HIGH VOLTAGE LEAD, INSURE COMPLETE DISCHARGE OF CAPACITORS BY IMMEDIATELY SHORTING EXCITER UNIT TERMINAL TO GROUND

- C Disconnect high voltage lead from igniter plug (See Figure 401)
- D Remove igniter plug mounting bolts and washers
- E Withdraw igniter plug from combustion chamber cap
- F Remove and discard old gasket

**2 INSTALL IGNITER PLUG**

- A Place new gasket on igniter plug (See Figure 401)
- B Insert igniter plug into combustion chamber cap
- C Install igniter plug mounting bolts with washers Tighten bolts to a torque range of 50 to 70 pound-inches Lockwire bolts
- D Connect high voltage lead to igniter plug
- E Position combustion chamber cover on housing and install bolts
- F Close FD1, FD2 and Bus Feed circuit breakers on Sta 960 starter relay box



**IGNITER PLUG INSTALLATION**  
**FIGURE 401**

Ref • MM STEWARD-DAVIS

IGNITER PLUG - ADJUSTMENT/TEST

EFFECTIVITY RTCA LX-N19997 LX-N20000

1 EQUIPMENT AND MATERIALS

A Establish interphone communication between F/E station and aft cargo compartment

2 TEST IGNITER PLUG

A Remove accessory section cover Refer to 49-11-12, APU Accessory Section Cover - Removal/Installation.

B Disconnect electrical connector from fuel solenoid valve

C. Close BUS FEED, BATT switch, CONTROL FEEDS 1 and 2 circuit breakers on Sta 960 starter relay box

D Actuate APU MASTER switch to ON position (MASTER light on.)

E. PRESS START switch

F Listen for sound of igniter plug sparking, then actuate MASTER switch to OFF position. MASTER light out )

CAUTION DO NOT EXCEED STARTER MOTOR DUTY CYCLE  
OF ONE MINUTE ON, FOUR MINUTES OFF

G Open BUS FEED, BATT switch, CONTROL FEEDS 1 and 2 circuit breakers on Sta 960 starter relay box

H Connect electrical connector to fuel solenoid valve

I Install accessory section cover Refer to 49-11-12, APU Accessory Section Cover - Removal/Installation



**IGNITER PLUG - INSPECTION/CHECK**

EFFECTIVITY RTCA LX-N19997 LX-N20000

1 **CHECK IGNITER PLUG**

- A Remove igniter plug from APU Refer to Igniter Plug - Removal/Installation
- B Check igniter plug for cracks or chipping of ceramic insulator or body
- C Check electrodes for excessive burning, EROSION of material or other damage
- D Check that electrode extends beyond ceramic insulator a minimum of 1/16 inch
- E Install igniter plug on APU Refer to Igniter Plug - Removal/Installation

IGNITER PLUG - CLEANING/PAINTING

EFFECTIVITY RTCA LX-N19997 LX-N20000

1 EQUIPMENT AND MATERIALS

- A Solvent - Federal Specification P-D-680, or equivalent
- B. Soft Grit Blasting Equipment or Brass Bristle Brush

NOTE Suitable soft blasting materials are ground corn, apricot or peach pits, walnut shells, clover seeds or cracked wheat

2 CLEAN IGNITER PLUG

- A Remove igniter plug from APU Refer to Igniter Plug - Removal/Installation
- B Clean igniter plug with solvent and blow dry with clean compressed air
- C Clean all deposits from igniter plug by blasting or brushing
- D Blow off all loosened material with clean, dry compressed air

CAUTION· DO NOT USE HARD GRIT BLASTING OR STEEL BRISTLE BRUSH AS THESE MATERIALS CAN SERIOUSLY DAMAGE IGNITER PLUG

- E Install igniter plug on APU Refer to Igniter plug - Removal/Installation

STARTER MOTOR - REMOVAL/INSTALLATION

1. REMOVE STARTER MOTOR

- A. Open all circuit breakers on Sta. 960, starter relay box.
- B. Remove accessory section cover. Refer to 49-11-01, APU Accessory Section Cover - Removal/Installation.
- C. Tag and disconnect electrical leads from starter motor terminals. (See figure 401.)
- D. Remove starter motor attaching nuts and washers.
- E. Carefully withdraw starter motor from mounting studs.

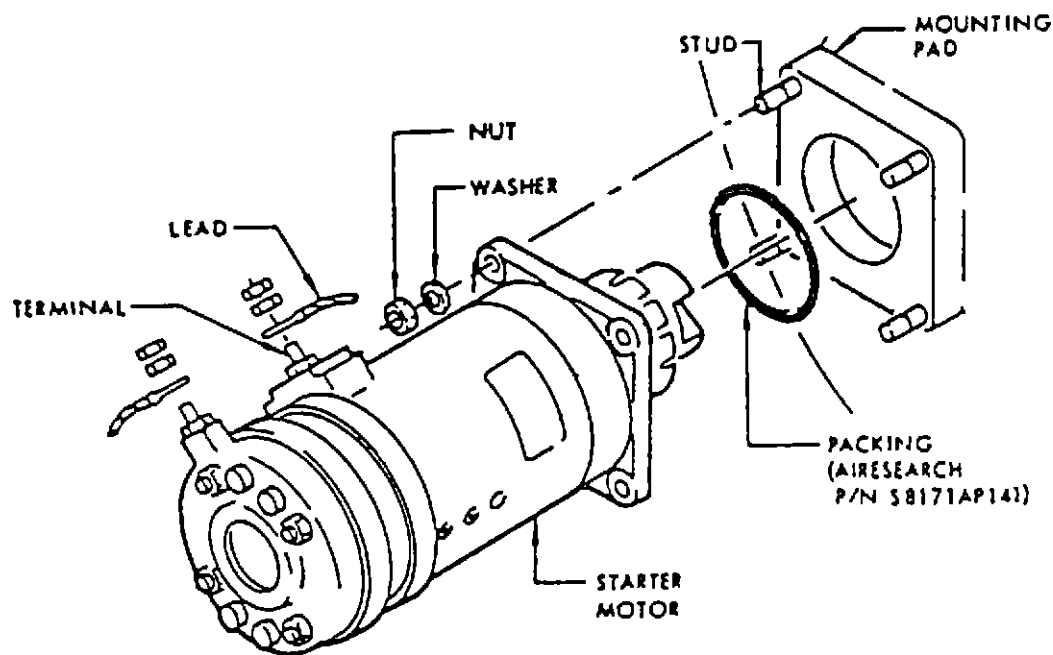
NOTE. When starter is withdrawn from unit, a small amount of oil may drain from the accessory drive case. It is suggested that a rag be placed beneath the starter to catch this oil.

- F. Remove packing from starter motor mounting pad.

2. INSTALL STARTER MOTOR

- A. Install new packing on starter motor mounting pad. (See figure 401.)
- B. Position starter motor on accessory drive, tilt slightly and rotate starter motor shaft until shaft pawls mesh with mating shaft in accessory drive.
- C. Carefully slide starter motor onto mounting studs.
- D. Install starter motor attaching washers and nuts. Tighten nuts to a torqué range of 50 to 70 pound-inches.
- E. Remove tags and connect electrical leads to starter motor terminals.
- F. Install accessory section cover. Refer to 49-11-01, APU Accessory Section Cover - Removal/Installation.
- G. Close all circuit breakers on Sta.960, starter relay box.

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Starter Motor Installation  
Figure 401  
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APU COOLING AIR SYSTEM

DESCRIPTION AND OPERATION

1 GENERAL

A. The APU cooling air system provides the means for cooling the APU housing, engine accessories and the exhaust duct. The system consists of cooling air intake ducting between the R/H main gear wheelwell and the APU module, a cooling air fan, and ducting to distribute and direct the cooling air through the housing. Cooling air is drawn from the main gear wheel well into the housing, where it is circulated through the generator and the oil cooler and around the engine accessories, before being exhausted overboard with the exhaust gases.

2. COOLING AIR INTAKE DUCT

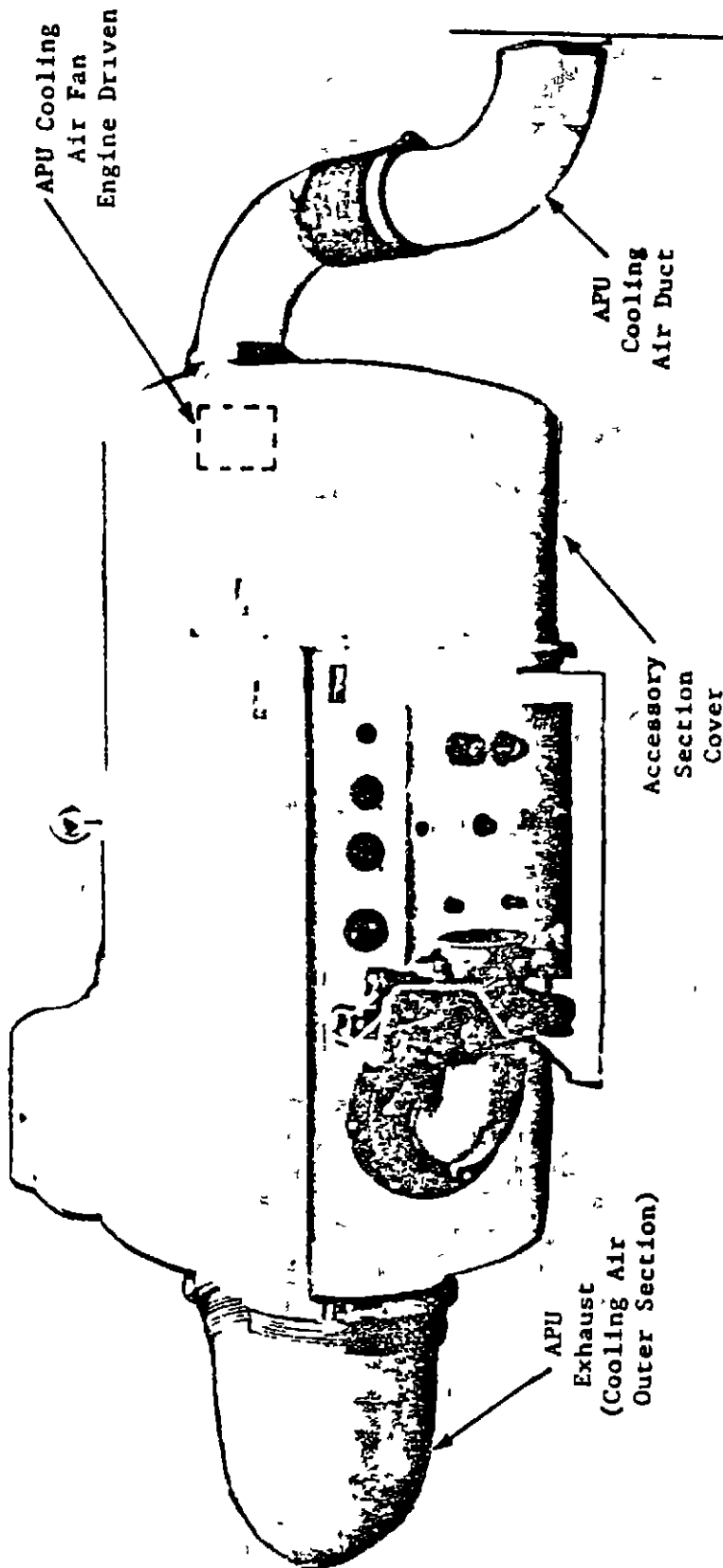
A. The cooling air intake duct carries cooling air from the R/H main gear wheel well through the Sta 960 pressure bulkhead to the APU module housing. The intake to the duct is covered with stainless steel screen, 1/2 inch mesh, to prevent foreign objects entering the cooling air system. The duct, made from 5 inch diameter stainless steel tubing, is clamped to the module housing cooling air inlet, to expedite the installation and removal of the APU module, and attaches to the Sta 960 bulkhead doubler through a bellows assembly, to provide for thermal expansion and contraction of the duct with changes in temperature.

3 COOLING AIR FAN

A. The cooling air fan provides a positive cooling air flow through the oil cooler, the generator and through the module housing. It is an axial flow type fan mounted on the engine accessory section and is driven by the accessory gear train.

4. OPERATION

A. When the APU engine is running the exhaust gases passing through the eductor section of the exhaust system will draw air from the APU module housing, this assists the cooling air fan in drawing cooling air from the main gear wheel well. The ducting within the module housing directs the cooling air through the oil cooler, the generator, and around the engine and engine accessories. The cooling air leaves the module housing through an annular space between the engine exhaust eductor tube (8 inch diameter) and the outer exhaust duct (10 inch diameter), and mixes with the engine exhaust gases downstream from the eductor to reduce the total temperature of the gases exhausted overboard.

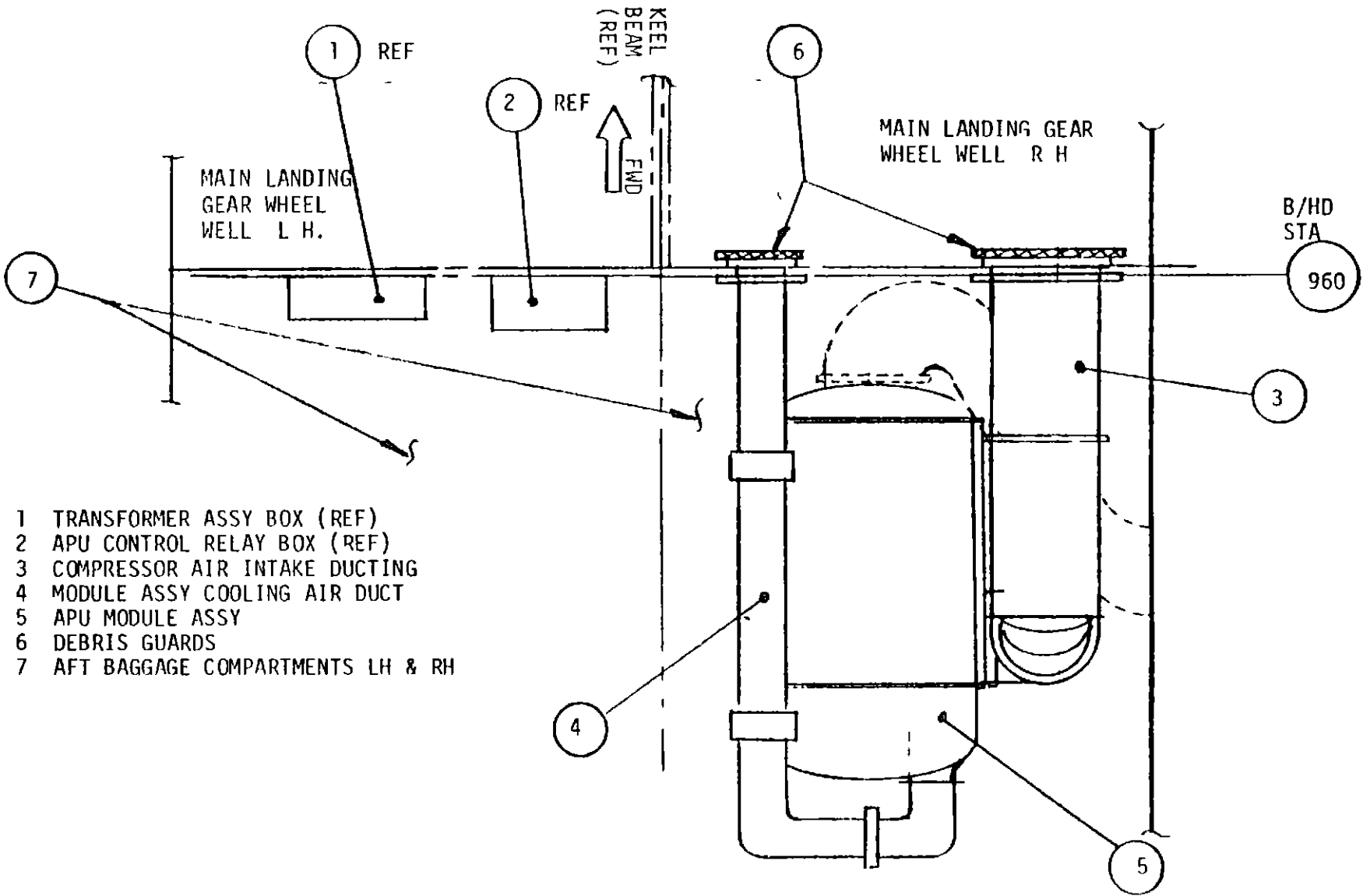


Sta  
960  
BLKHD

APU Cooling Air Intake Duct

FIGURE 1  
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- 1 TRANSFORMER ASSY BOX (REF)
- 2 APU CONTROL RELAY BOX (REF)
- 3 COMPRESSOR AIR INTAKE DUCTING
- 4 MODULE ASSY COOLING AIR DUCT
- 5 APU MODULE ASSY
- 6 DEBRIS GUARDS
- 7 AFT BAGGAGE COMPARTMENTS LH & RH

APU BLEED AIR SYSTEM

DESCRIPTION AND OPERATION

1. GENERAL

- A The APU bleed air system is an automatically controlled source of pneumatic power which is connected to the airplane's pneumatic system. The system consists of APU bleed air control components and ducting from the APU module in the aft cargo compartment of the airplane pneumatic crossover duct.
- B The bleed air control components for the APU installation consist of a pneumatic shutoff (load control) valve, a differential air pressure regulator, a pneumatic thermostat and three-way solenoid valve provided in the APU engine controls, and BLEED AIR selector switch on the APU cockpit control panel.
- C The bleed air ducting manifolds the APU output and carries the compressed air in a five inch, stainless steel duct, installed in the keel beam structure, to the airconditioning bay and through a transition duct into the airplane pneumatic crossover duct. A flapper type check valve on the output of the APU prevents the reverse flow of air. (See Subject 49-00-36, APU Pneumatic System Interface.)
- D The APU bleed air system supplies pneumatic power to the airplane system by bleeding compressed air from the compressor section of the APU engine. The amount of air extracted from the APU is automatically regulated, by the pneumatic thermostat, to provide a maximum amount of air without exceeding APU engine exhaust gas temperature limits. When the APU engine is started and reaches 95% governed speed, the three-way solenoid valve is automatically actuated to transfer the output of the pneumatic thermostat from the acceleration limited valve to the pneumatic shutoff (load control) valve. After a one minute warm-up period at governed speed the APU is ready to accept a pneumatic load.

2. LOAD CONTROL VALVE

- A The load control valve is mounted between the bleed air outlet on the APU housing and the APU bleed air ducting. The valve controls the bleed load by limiting the bleed airflow to below the amount that would cause excessive exhaust gas temperature. The load control valve consists of the main valve, the actuator, the rate control valve, and the switcher valve. The main valve is a normally closed butterfly valve enclosed in a housing having flanges for clamps on each end. The actuator is attached to the main valve housing and

A. cont.

consists of a spring-loaded diaphragm and an actuating linkage contained in a housing which also encloses the switcher valve. The switcher valve is a solenoid-operated two-ball selector valve that directs control air to either side of the actuator diaphragm as required. The rate control valve controls the opening rate of the main valve and consists of a spring-loaded, diaphragm-operated, poppet valve contained in a housing having an adjustable orifice in the control air inlet.

- B. When its solenoid is energized, the switcher valve directs control air to the actuator diaphragm to open the main valve and allow bleed air to flow into the airplane ducting. The rate control valve controls the amount and speed of the initial opening of the main valve.

3. DIFFERENTIAL AIR PRESSURE REGULATOR

- A. The differential air pressure regulator is attached to the load control valve. It provides a constant air pressure under all ambient conditions to the load control valve. The regulator consists of a cover and a main housing. The housing contains a spring-loaded diaphragm assembly, metering valve and an adjustable relief valve. An outlet port is also provided in the main housing. The cover incorporates an inlet port fitting and encloses an air filter. The regulating pressure of the valve is set at approximately 19.2 PSI above ambient.

4. PNEUMATIC THERMOSTAT

- A. The pneumatic thermostat of the APU engine controls is connected by the three-way solenoid valve (See Subject 49-61-0) to the actuator diaphragm chamber of the load control valve when the APU engine accelerates to 95% RPM. The thermostat begins to open between 555° to 565°C (1030° to 1050°F) and bleeds control air from the diaphragm chamber to close the load control valve and reduce the pneumatic load as required to maintain the exhaust gas temperature within limits.

5. PNEUMATIC LOAD SELECTION

- A. Pneumatic loading of an APU is manually selected by actuating the BLEED AIR switch-lite on the APU cockpit control panel. The switch is a push type, alternate action switch-lite.

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- B The BLEED AIR switch-lite, when closed (light on), applies power to energize the switcher (solenoid) valve to move and allow control air to actuate the load control valve to the open position

## 6 OPERATION

- A The APU bleed air system furnishes a regulated supply of compressed air to the airplane pneumatic system and also acts as an overload governor for the APU. The amount of compressed air available is automatically controlled to prevent the APU being overloaded and will therefore vary with the electrical load imposed on the unit.
- B When the APU accelerates to 95% governed speed during the ignition/start sequence, the centrifugal switch closes and actuates the three-way solenoid valve to connect the control signal of the pneumatic thermostat to the load control valve. When BLEED AIR is selected on the APU control panel the switcher valve solenoid is energized causing the load control valve to open and allow air to flow into the APU bleed air ducting to the airplane pneumatic system.
- C When the bleed air solenoid is not energized, the switcher valve directs the control air to the topside of the actuator diaphragm to keep the main valve closed. Control air from upstream of the main valve is directed to both sides of the rate control valve diaphragm and, since the pressure is the same on both sides of the diaphragm, the poppet valve remains closed. Energizing the switcher solenoid opens the primary ball valve in the switcher valve and closes the secondary ball valve. This transfers control air from the bottom to the top of the actuator diaphragm and the main valve opens. When the valve opens, the pressure sensed by the rate control valve drops in proportion to the rate at which air bleeds from the unit. Since the adjustable orifice restricts the bleed off from the top of the rate control diaphragm, the diaphragm will move down and open the poppet valve to bleed some of the control air from the actuator to atmosphere. Reducing the air pressure in the actuator slows down the opening speed of the main valve and the amount it will open, thus preventing a momentary overload of the unit. As the pressure continues to bleed off from the top of the rate control diaphragm the poppet valve gradually closes. As the poppet valve closes, the control air pressure in the actuator increases and opens the main valve further. When the poppet valve is fully closed, the main valve is fully open. The adjustable orifice is normally set so that the main valve will open in between three and six seconds.

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*Intercontinental*   
**MAINTENANCE MANUAL**

- D. During extraction of APU bleed air, the pneumatic thermostat acts as an overload protection for the APU and does not function until an overload condition occurs. If an overload is applied to the APU, the exhaust gas temperature rises. This rise in temperature causes the thermostat to open and allow control air to bleed to atmosphere. Reduction of control air pressure in the load control valve actuator partially closes the valve. This reduces the amount of bleed air extracted from the APU compressor until the overload is removed.

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STARTER MOTOR - REMOVAL/INSTALLATION

EFFECTIVITY RTCA LX-N19997 LX-N20000

1. REMOVE STARTER MOTOR

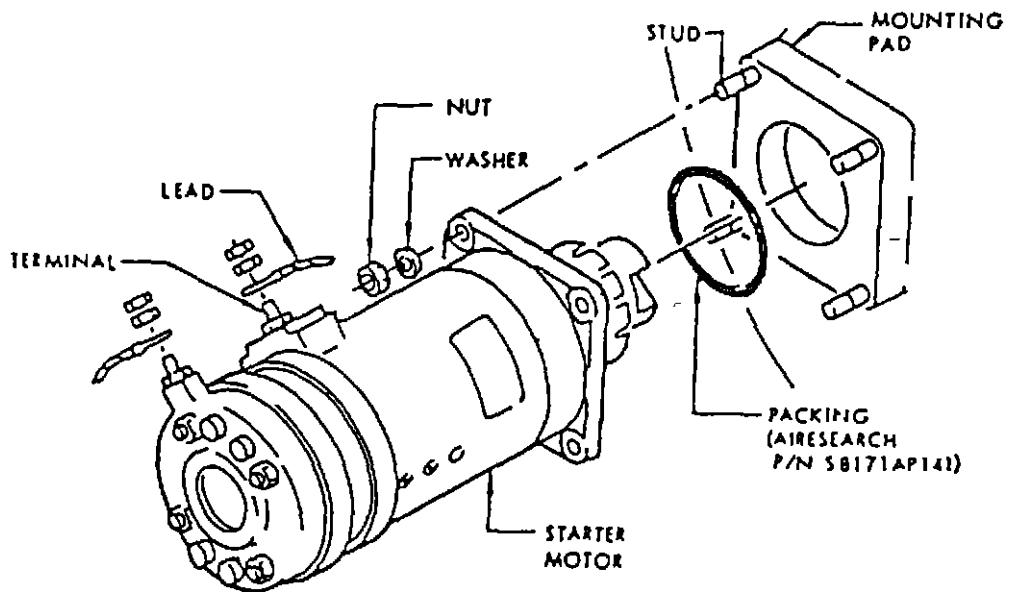
- A Open all circuit breakers on Sta. 960, starter relay box.
- B Remove accessory section cover Refer to 49-11-02, APU Accessory Section Cover - Removal/Installation.
- C Tag and disconnect electrical leads from starter motor terminals (See Figure 401 )
- D Remove starter motor attaching nuts and washers
- E Carefully withdraw starter motor from mounting studs.

NOTE. When starter is withdrawn from unit, a small amount of oil may drain from the accessory drive case It is suggested that a rag be placed beneath the starter to catch this oil

- F. Remove packing from starter motor mounting pad

2. INSTALL STARTER MOTOR

- A Install new packing on starter motor mounting pad (See Figure 401)
- B Position starter motor on accessory drive, tilt slightly and rotate starter motor shaft until shaft pawls mesh with mating shaft in accessory drive.
- C Carefully slide starter motor onto mounting studs
- D Install starter motor attaching washers and nuts Tighten nuts to a torque range of 50 to 70 pound-inches
- E Remove tags and connect electrical leads to starter motor terminals
- F Install accessory section cover Refer to 49-11-02, APU Accessory Section Cover - Removal/Installation.
- G Close all circuit breakers on Sta 960, starter relay box



STARTER MOTOR INSTALLATION

FIGURE 401

Ref MM STEWARD-DAVIS

APU COOLING AIR SYSTEM

DESCRIPTION AND OPERATION

1. GENERAL

- A. The APU cooling air system provides the means for cooling the APU housing, engine accessories and the exhaust duct. The system consists of cooling air intake ducting between the R/H main gear wheelwell and the APU module, a cooling air fan, and ducting to distribute and direct the cooling air through the housing. Cooling air is drawn from the main gear wheel well into the housing, where it is circulated through the generator and the oil cooler and around the engine accessories, before being exhausted overboard with the exhaust gases.

2. COOLING AIR INTAKE DUCT

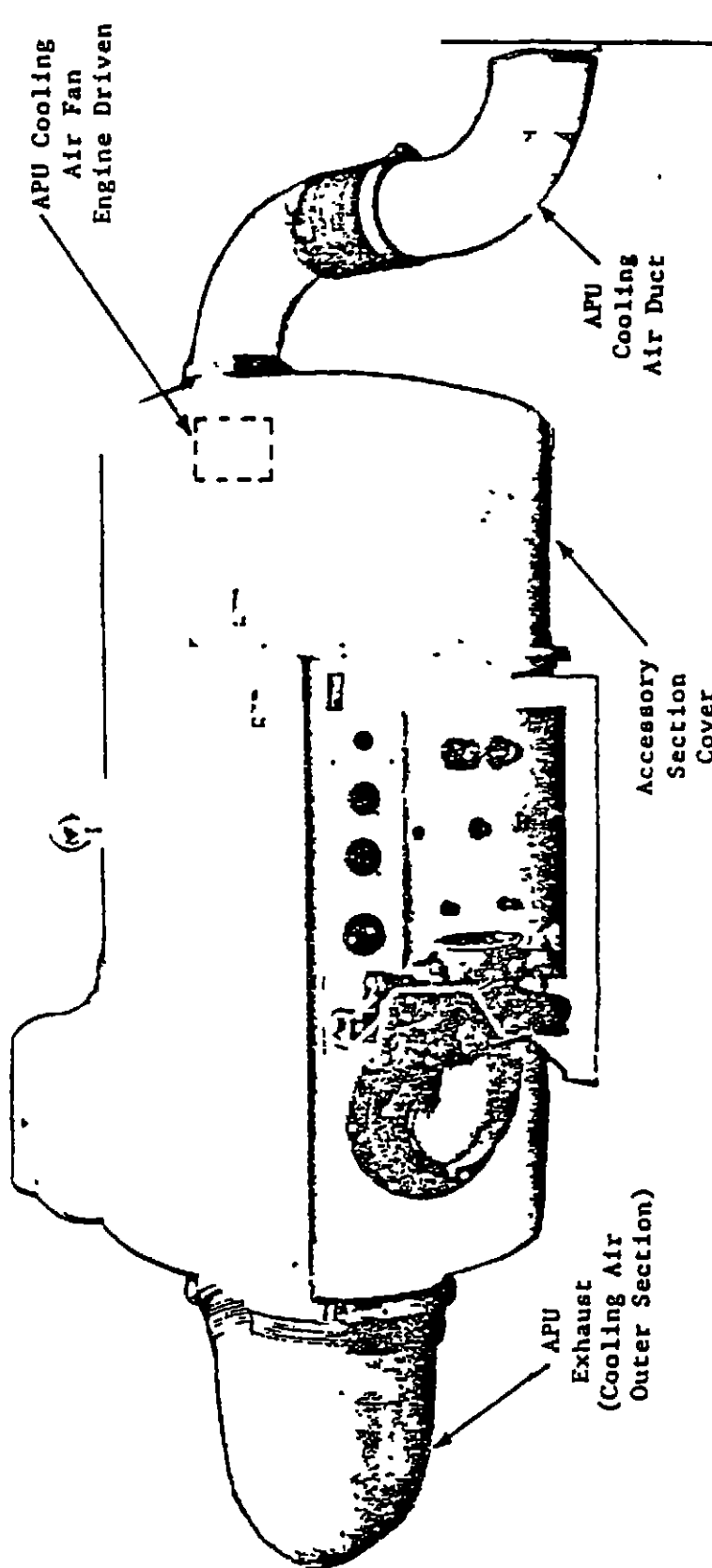
- A. The cooling air intake duct carries cooling air from the R/H main gear wheel well through the Sta. 960 pressure bulkhead to the APU module housing. The intake to the duct is covered with stainless steel screen,  $\frac{1}{8}$  inch mesh, to prevent foreign objects entering the cooling air system. The duct, made from 5 inch diameter stainless steel tubing, is clamped to the module housing cooling air inlet, to expedite the installation and removal of the APU module, and attaches to the Sta. 960 bulkhead doubler through a bellows assembly, to provide for thermal expansion and contraction of the duct with changes in temperature.

3. COOLING AIR FAN

- A. The cooling air fan provides a positive cooling air flow through the oil cooler, the generator and through the module housing. It is an axial flow type fan mounted on the engine accessory section and is driven by the accessory gear train.

4. OPERATION

- A. When the APU engine is running the exhaust gases passing through the eductor section of the exhaust system will draw air from the APU module housing; this assists the cooling air fan in drawing cooling air from the main gear wheel well. The ducting within the module housing directs the cooling air through the oil cooler, the generator, and around the engine and engine accessories. The cooling air leaves the module housing through an annular space between the engine exhaust eductor tube (8 inch diameter) and the outer exhaust duct (10 inch diameter), and mixes with the engine exhaust gases downstream from the eductor to reduce the total temperature of the gases exhausted overboard.



Sta  
960  
BLKID

APU Cooling Air Intake Duct

FIGURE 1  
MM STEWARD DAVIS

**APU COOLING AIR SYSTEM**  
**DESCRIPTION AND OPERATION**

EFFECTIVITY RTCA LX-N19997 LX-N20000

**1 GENERAL**

- A The APU cooling air system provides the means for cooling the APU housing, engine accessories and the exhaust duct. The system consists of cooling air intake ducting between the R/H main gear wheelwell and the APU module, a cooling air fan, and ducting to distribute and direct the cooling air through the housing. Cooling air is drawn from the main gear wheel well into the housing, where it is circulated through the generator and the oil cooler and around the engine accessories, before being exhausted overboard with the exhaust gases.

**2 COOLING AIR INTAKE DUCT**

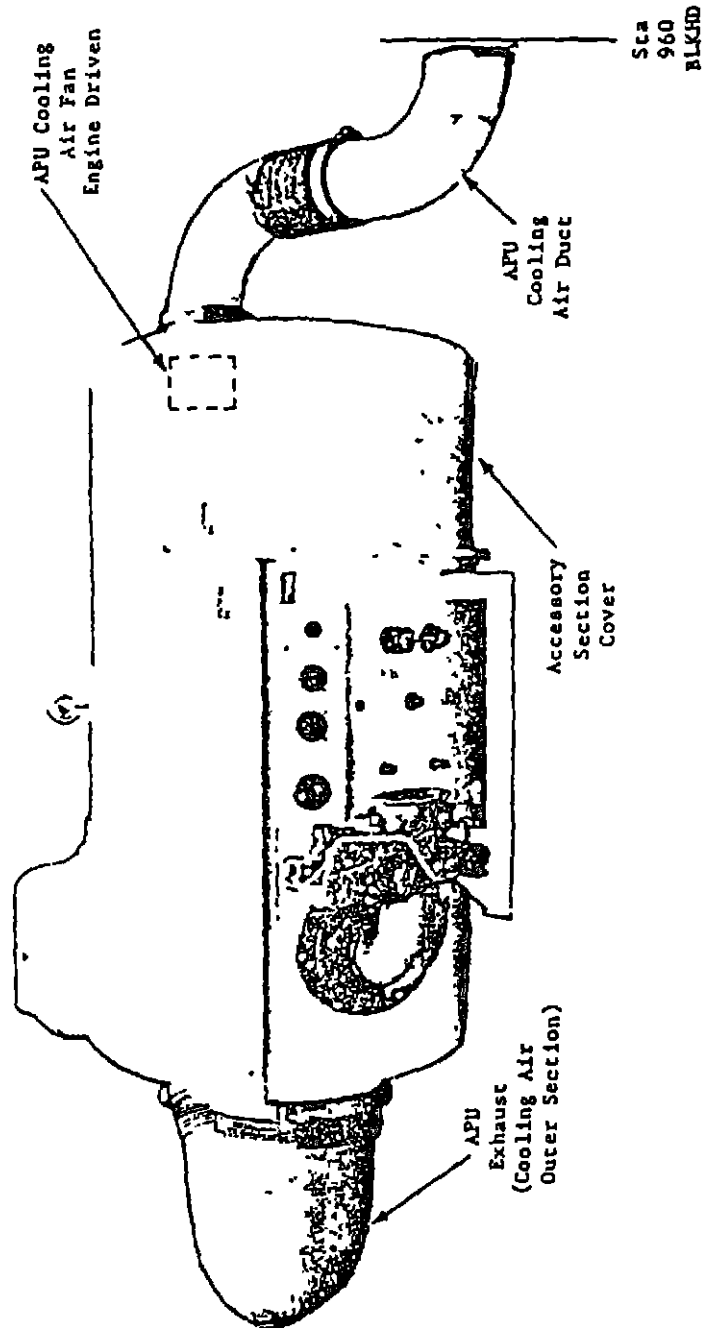
- A The cooling air intake duct carries cooling air from the R/H main gear wheel well through the Sta. 960 pressure bulkhead to the APU module housing. The intake to the duct is covered with stainless steel screen, 1/4 inch mesh, to prevent foreign objects entering the cooling air system. The duct, made from 5 inch diameter stainless steel tubing, is clamped to the module housing cooling air inlet, to expedite the installation and removal of the APU module, and attaches to the Sta. 960 bulkhead doubler through a bellows assembly, to provide for thermal expansion and contraction of the duct with changes in temperature.

**3 COOLING AIR FAN**

- A The cooling air fan provides a positive cooling air flow through the oil cooler, the generator and through the module housing. It is an axial flow type fan mounted on the engine accessory section and is driven by the accessory gear train.

**4 OPERATION**

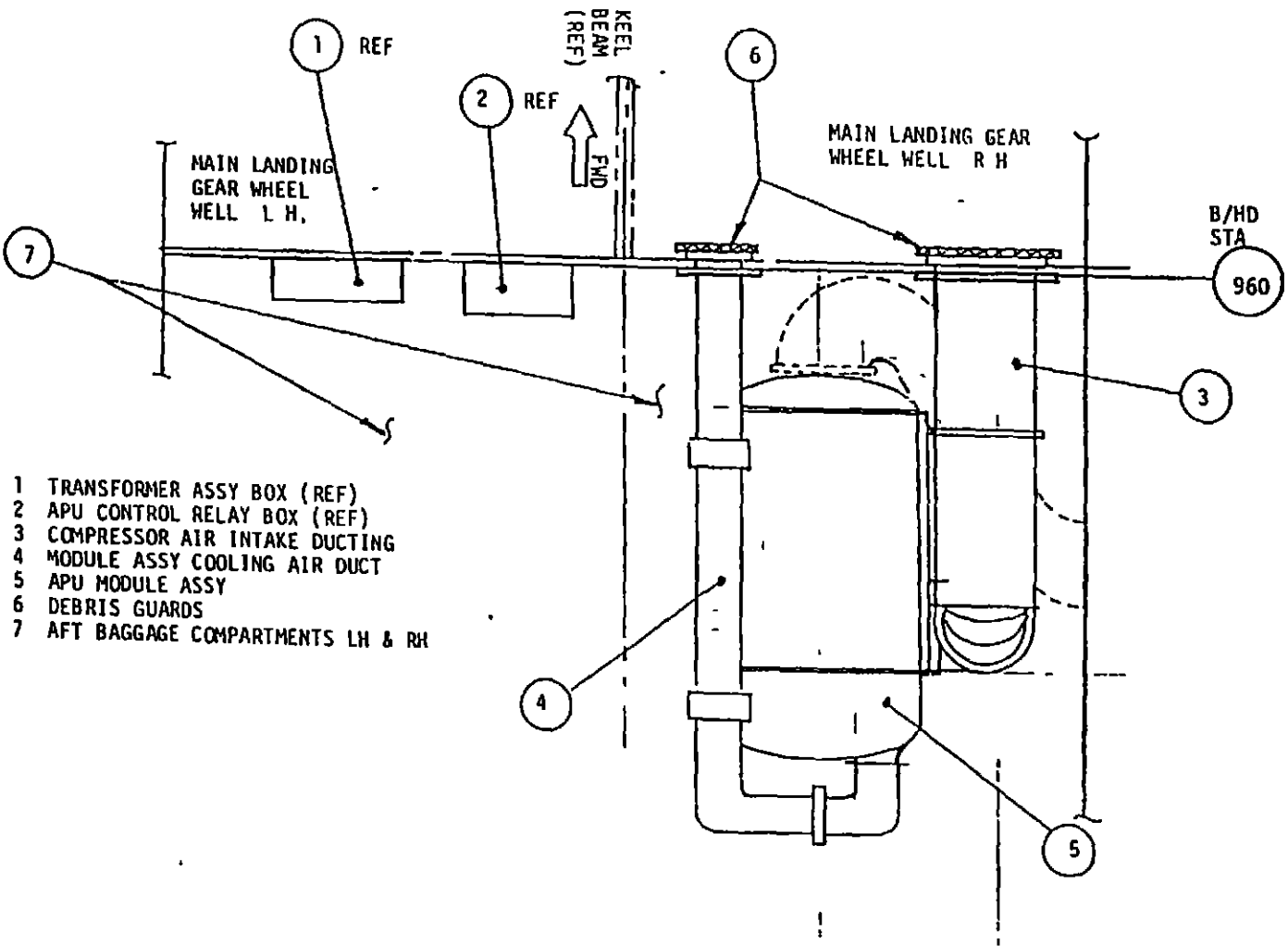
- A. When the APU engine is running the exhaust gases passing through the eductor section of the exhaust system will draw air from the APU module housing, thus assists the cooling air fan in drawing cooling air from the main gear wheel well. The ducting within the module housing directs the cooling air through the oil cooler, the generator, and around the engine and engine accessories. The cooling air leaves the module housing through an annular space between the engine exhaust eductor tube (8 inch diameter) and the outer exhaust duct (10 inch diameter), and mixes with the engine exhaust gases downstream from the eductor to reduce the total temperature of the gases exhausted overboard.



APU COOLING AIR INTAKE DUCT

FIGURE 1

Ref MM STEWARD-DAVIS



- 1 TRANSFORMER ASSY BOX (REF)
- 2 APU CONTROL RELAY BOX (REF)
- 3 COMPRESSOR AIR INTAKE DUCTING
- 4 MODULE ASSY COOLING AIR DUCT
- 5 APU MODULE ASSY
- 6 DEBRIS GUARDS
- 7 AFT BAGGAGE COMPARTMENTS LH & RH

APU BLEED AIR SYSTEM

DESCRIPTION AND OPERATION

1. GENERAL

- A. The APU bleed air system is an automatically controlled source of pneumatic power which is connected to the airplane's pneumatic system. The system consists of APU bleed air control components and ducting from the APU module in the aft cargo compartment of the airplane pneumatic crossover duct.
- B. The bleed air control components for the APU installation consist of a pneumatic shutoff (load control) valve, a differential air pressure regulator, a pneumatic thermostat and three-way solenoid valve provided in the APU engine controls, and BLEED AIR selector switch on the APU cockpit control panel
- C. The bleed air ducting manifolds the APU output and carries the compressed air in a five inch, stainless steel duct, installed in the keel beam structure, to the airconditioning bay and through a transition duct into the airplane pneumatic crossover duct. A flapper type check valve on the output of the APU prevents the reverse flow of air. (See Subject 49-00-36, APU Pneumatic System Interface.)
- D. The APU bleed air system supplies pneumatic power to the airplane system by bleeding compressed air from the compressor section of the APU engine. The amount of air extracted from the APU is automatically regulated, by the pneumatic thermostat, to provide a maximum amount of air without exceeding APU engine exhaust gas temperature limits. When the APU engine is started and reaches 95% governed speed, the three-way solenoid valve is automatically actuated to transfer the output of the pneumatic thermostat from the acceleration limited valve to the pneumatic shutoff (load control) valve. After a one minute warm-up period at governed speed the APU is ready to accept a pneumatic load

2. LOAD CONTROL VALVE

- A. The load control valve is mounted between the bleed air outlet on the APU housing and the APU bleed air ducting. The valve controls the bleed load by limiting the bleed airflow to below the amount that would cause excessive exhaust gas temperature. The load control valve consists of the main valve, the actuator, the rate control valve, and the switcher valve. The main valve is a normally closed butterfly valve enclosed in a housing having flanges for clamps on each end. The actuator is attached to the main valve housing and

A. cont.

consists of a spring-loaded diaphragm and an actuating linkage contained in a housing which also encloses the switcher valve. The switcher valve is a solenoid-operated two-ball selector valve that directs control air to either side of the actuator diaphragm as required. The rate control valve controls the opening rate of the main valve and consists of a spring-loaded, diaphragm-operated, poppet valve contained in a housing having an adjustable orifice in the control air inlet.

- B. When its solenoid is energized, the switcher valve directs control air to the actuator diaphragm to open the main valve and allow bleed air to flow into the airplane ducting. The rate control valve controls the amount and speed of the initial opening of the main valve.

3. DIFFERENTIAL AIR PRESSURE REGULATOR

- A. The differential air pressure regulator is attached to the load control valve. It provides a constant air pressure under all ambient conditions to the load control valve. The regulator consists of a cover and a main housing. The housing contains a spring-loaded diaphragm assembly, metering valve and an adjustable relief valve. An outlet port is also provided in the main housing. The cover incorporates an inlet port fitting and encloses an air filter. The regulating pressure of the valve is set at approximately 19.2 PSI above ambient.

4. PNEUMATIC THERMOSTAT

- A. The pneumatic thermostat of the APU engine controls is connected by the three-way solenoid valve (See Subject 49-61-0) to the actuator diaphragm chamber of the load control valve when the APU engine accelerates to 95% RPM. The thermostat begins to open between 555° to 565°C (1030° to 1050°F) and bleeds control air from the diaphragm chamber to close the load control valve and reduce the pneumatic load as required to maintain the exhaust gas temperature within limits.

5. PNEUMATIC LOAD SELECTION

- A. Pneumatic loading of an APU is manually selected by actuating the BLEED AIR switch-lite on the APU cockpit control panel. The switch is a push type, alternate action switch-lite.

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## APU BLEED AIR SYSTEM

### DESCRIPTION AND OPERATION

EFFECTIVITY RTCA LX-N19997 LX-N20000

#### 1 GENERAL

- A. The APU bleed air system is an automatically controlled source of pneumatic power which is connected to the airplane's pneumatic system. The system consists of APU bleed air control components and ducting from the APU module in the aft cargo compartment to the airplane pneumatic crossover duct
- B. The bleed air control components for the APU installation consist of a pneumatic shutoff (load control) valve, a differential air pressure regulator, a pneumatic thermostat and three-way solenoid valve provided in the APU engine controls, and BLEED AIR selector switch on the APU cockpit control panel
- C. The bleed air ducting manifolds the APU output and carries the compressed air in a five inch, stainless steel duct, installed in the keel beam structure, to the airconditioning bay and through a transition duct into the airplane pneumatic crossover duct. A flapper type check valve on the output of the APU prevents the reverse flow of air (See Subject 49-00-37, APU Pneumatic System Interface )
- D. The APU bleed air system supplies pneumatic power to the airplane system by bleeding compressed air from the compressor section of the APU engine. The amount of air extracted from the APU is automatically regulated, by the pneumatic thermostat, to provide a maximum amount of air without exceeding APU engine exhaust gas temperature limits. When the APU engine is started and reaches 95% governed speed, the three-way solenoid valve is automatically actuated to transfer the output of the pneumatic thermostat from the acceleration limited valve to the pneumatic shutoff (load control) valve. After a one minute warm-up period at governed speed the APU is ready to accept a pneumatic load.

#### 2 LOAD CONTROL VALVE

- A. The load control valve is mounted between the bleed air outlet on the APU housing and the APU bleed air ducting. The valve controls the bleed load by limiting the bleed airflow to below the amount that would cause excessive exhaust gas temperature. The load control valve consists of the main valve, the actuator. The rate control valve, and the switcher valve. The main valve is a normally closed butterfly valve enclosed in a housing having flanges for clamps on each end. The actuator is attached to the main valve housing and consists of a spring-loaded diaphragm and an actuating linkage.

## 2 LOAD CONTROL VALVE (CONTINUED)

### A (CONTINUED)

contained in a housing which also encloses the switcher valve. The switcher valve is a solenoid-operated two-ball selector valve that directs control air to either side of the actuator diaphragm as required. The rate control valve controls the opening rate of the main valve and consists of a spring-loaded, diaphragm-operated, poppet valve contained in a housing having an adjustable orifice in the control air inlet.

- B When its solenoid is energized, the switcher valve directs control air to the actuator diaphragm to open the main valve and allow bleed air to flow into the airplane ducting. The rate control valve controls the amount and speed of the initial opening of the main valve.

## 3 DIFFERENTIAL AIR PRESSURE REGULATOR

- A The differential air pressure regulator is attached to the load control valve. It provides a constant air pressure under all ambient conditions to the load control valve. The regulator consists of a cover and a main housing. The housing contains a spring-loaded diaphragm assembly, metering valve and an adjustable relief valve. An outlet port is also provided in the main housing. The cover incorporates an inlet port fitting and encloses an air filter. The regulating pressure of the valve is set at approximately 19.2 PSI above ambient.

## 4 PNEUMATIC THERMOSTAT

- A The pneumatic thermostat of the APU engine controls is connected by the three-way solenoid valve (See Subject 49-61-1) to the actuator diaphragm chamber of the load control valve when the APU engine accelerates to 95% RPM. The thermostat begins to open between 555° to 565°C (1030° to 1050°F) and bleeds control air from the diaphragm chamber to close the load control valve and reduce the pneumatic load as required to maintain the exhaust gas temperature within limits.

## 5 PNEUMATIC LOAD SELECTION

- A Pneumatic loading of an APU is manually selected by actuating the BLEED AIR switch-lite on the APU cockpit control panel. The switch is a push type, alternate action switch-lite.



## MAINTENANCE MANUAL

- B The BLEED AIR switch-lite, when closed (light on), applies power to energize the switcher (solenoid) valve to move and allow control air to actuate the load control valve to the open position.

### 6. OPERATION

- A The APU bleed air system furnishes a regulated supply of compressed air to the airplane pneumatic system and also acts as an overload governor for the APU. The amount of compressed air available is automatically controlled to prevent the APU being overloaded and will therefore vary with the electrical load imposed on the unit.
- B When the APU accelerates to 95% governed speed during the ignition/start sequence, the centrifugal switch closes and actuates the threeway solenoid valve to connect the control signal of the pneumatic thermostat to the load control valve. When BLEED AIR is selected on the APU control panel the switcher valve solenoid is energized causing the load control valve to open and allow air to flow into the APU bleed air ducting to the airplane pneumatic system.
- C When the bleed air solenoid is not energized, the switcher valve directs the control air to the topside of the actuator diaphragm to keep the main valve closed. Control air from upstream of the main valve is directed to both sides of the rate control valve diaphragm and, since the pressure is the same on both sides of the diaphragm, the poppet valve remains closed. Energizing the switcher solenoid opens the primary ball valve in the switcher valve and closes the secondary ball valve. This transfers control air from the bottom to the top of the actuator diaphragm and the main valve opens. When the valve opens, the pressure sensed by the rate control valve drops in proportion to the rate at which air bleeds from the unit. Since the adjustable orifice restricts the bleed off from the top of the rate control diaphragm, the diaphragm will move down and open the poppet valve to bleed some of the control air from the actuator to atmosphere. Reducing the air pressure in the actuator slows down the opening speed of the main valve and the amount it will open, thus preventing a momentary overload of the unit. As the pressure continues to bleed off from the top of the rate control diaphragm the poppet valve gradually closes. As the poppet valve closes, the control air pressure in the actuator increases and opens the main valve further. When the poppet valve is fully closed, the main valve is fully open. The adjustable orifice is normally set so that the main valve will open in between three and six seconds.

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**MAINTENANCE MANUAL**

- D During extraction of APU bleed air, the pneumatic thermostat acts as an overload protection for the APU and does not function until an overload condition occurs. If an overload is applied to the APU, the exhaust gas temperature rises. This rise in temperature causes the thermostat to open and allow control air to bleed to atmosphere. Reduction of control air pressure in the load control valve actuator partially closes the valve. This reduces the amount of bleed air extracted from the APU compressor until the overload is removed.

Ref MM STEWARD-DAVIS

APU ENGINE CONTROL

DESCRIPTION AND OPERATION

1. GENERAL

- A. The APU engine control system provides for the manual selection and the automatic control of the operation and loading of the APU engine. The system consists of an APU control panel, engine control components and engine control circuits.
- B. The APU control panel provides switches for selecting the APU operational mode and loading configuration, and instrumentation to monitor the electrical loading and the performance of the engine.
- C. The APU engine control components monitor the operation of the APU engine to provide electrical and pneumatic signals used to sequence and control the start, ignition and acceleration of the engine to governed speed, to control the pneumatic load on the APU engine and to shutdown the engine. See APU Engine Control Components, Subject 49-61-0.
- D. The engine control circuits provide for the manual selection and the automatic control of the operation and loading of the APU engine. See APU Engine Control Circuits, Subject 49-62-0.

2. APU COCKPIT CONTROL PANEL

- A. The APU control panel consists of a control module, an APU battery switch, an APU generator contactor control switch, an overspeed test switch, engine and electrical instrumentation and instrument lighting.
- B. The control module provides switches for energizing the APU engine control circuits, for starting the APU engine and for activating and testing the APU's fire extinguishing and fire detection system. Switch lights, annunciator lights and warning lights in the control module provide visual references of the operational status and the loading configuration of the engine. The module consists of a mounting rack with nine pushbutton switch-lite and three annunciator light assemblies.
  - (1) The mounting rack is itself a modular assembly that provides terminal blocks for quick installation and removal of the pushbutton switch-lite and annunciator lite assemblies. A hole in the terminal block mates with a large post on the terminal end of the switch-lite and annunciator lite units to assure proper orientation of the units when they are installed. Dividers in the mounting rack extend out to form a natural barrier between units. To actuate a particular switch-lite, the switch-plate (lens) must be depressed below the level of the barrier. If two adjacent units are accidentally depressed simultaneously

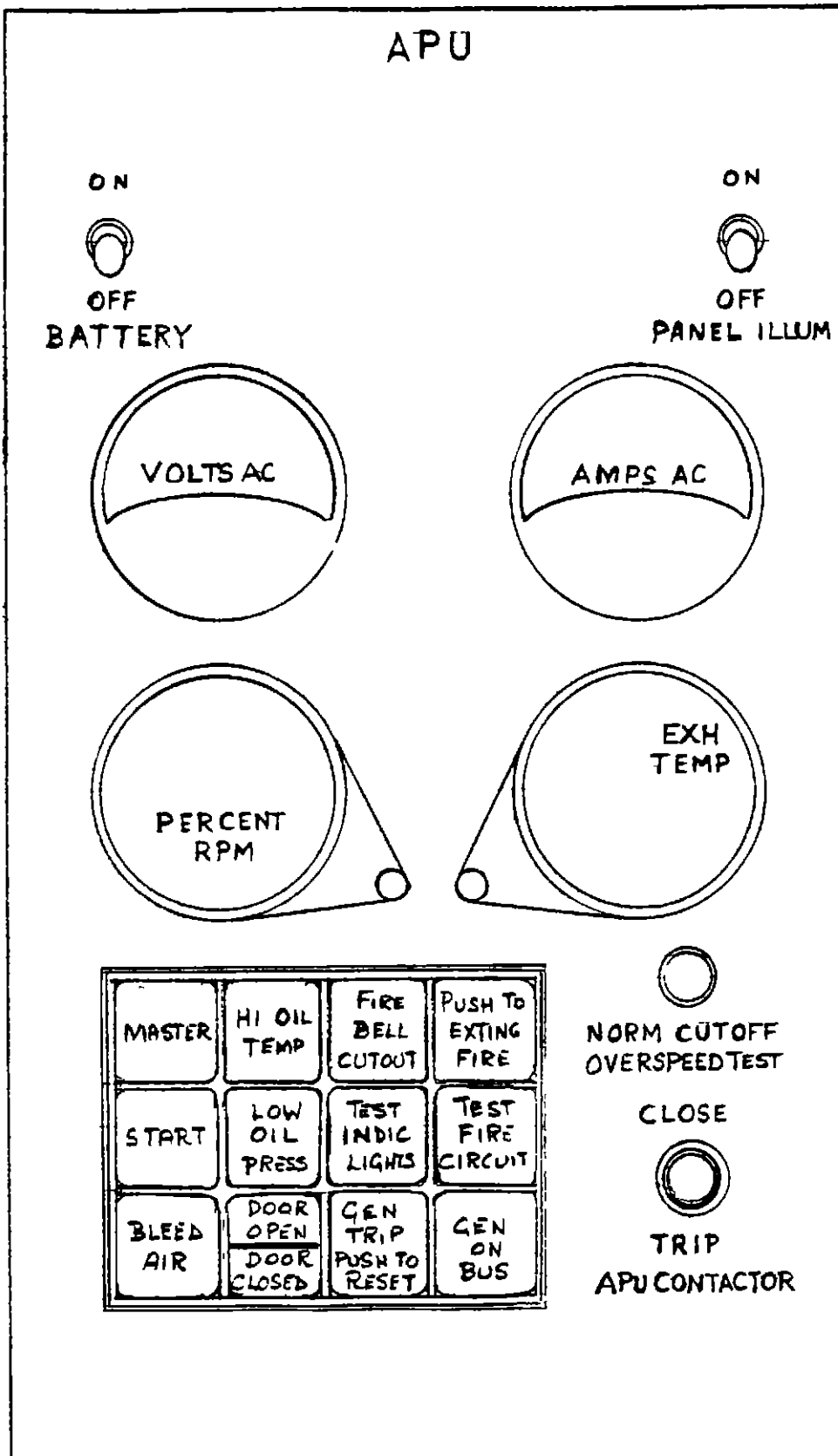
*BOEING* **707**  
*Intercontinental*  
**MAINTENANCE MANUAL**

(1) cont.

with one finger, the barrier will prevent actuation. The mounting rack is mounted in the APU control panel through a single panel cutout. Mounting fasteners are slipped into slots on the rack frame and tightened against the back of the control panel to secure the entire control module to the panel.

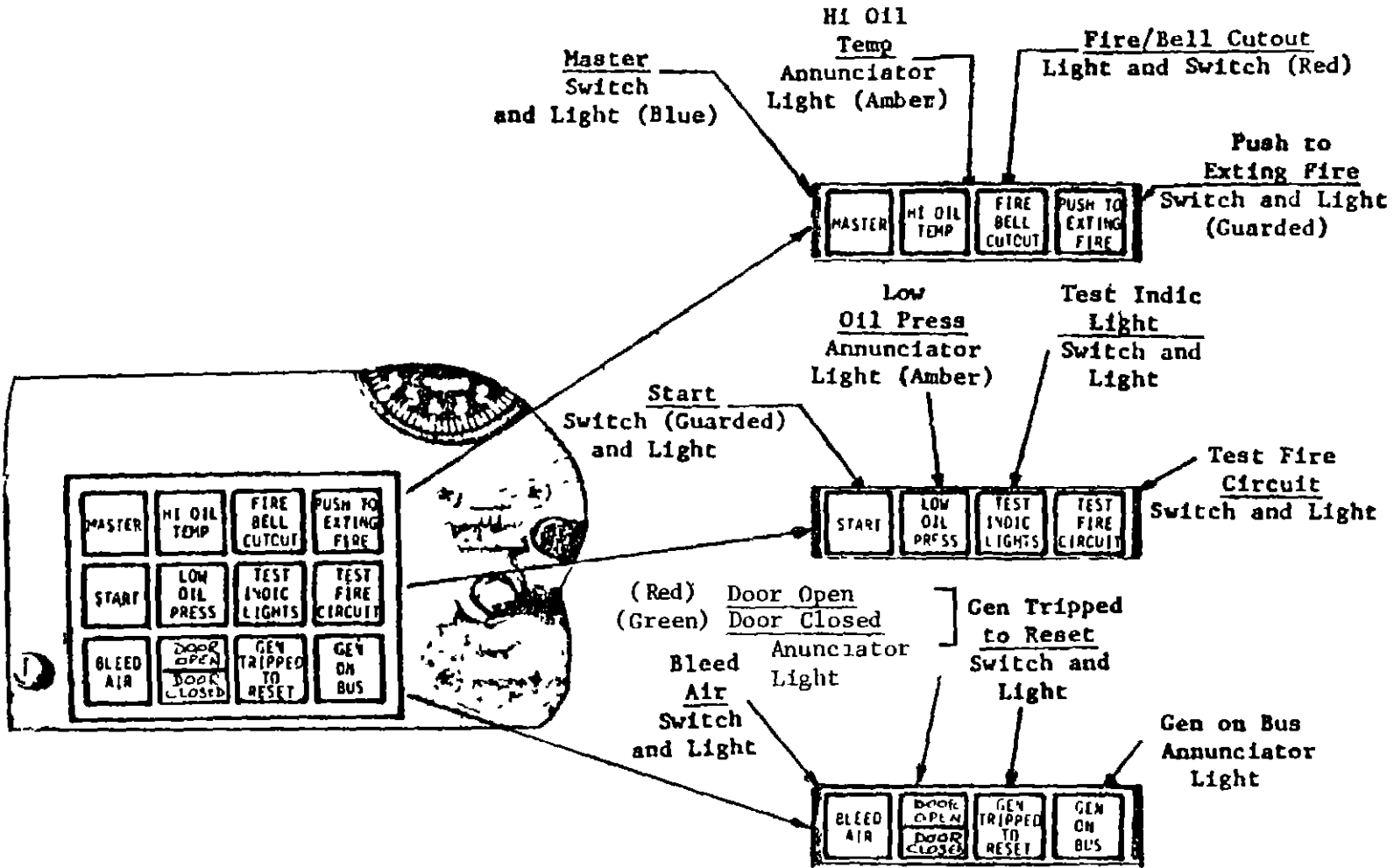
(2) The pushbutton switch-lite assemblies are alternate or momentary actuation switches with indicator lights mounted beneath their switch-plate (lens). A color filter below the lens of each switch-lite (and annunciator lite) provides color coding in relationship to the significance of the information that the light provides: safe/acceptable (blue or green); advisory information, on/energized, etc., (amber or yellow); warning, unsafe (red). The following switch-lites are provided in the control module:

- (a) **MASTER** - An alternate action switch that applies control power to the master relay and the APU generator control relay circuits. Its indicator light comes on (blue color filter) when control power is available to the master relay.
- (b) **START** - A guarded, momentary action switch that applies power to the start-ignition/fuel circuit. Its indicator light comes on (yellow color filter) when the switch is depressed and control power is applied to the starter relay. When the starter relay actuates, closes, the indicator light will remain on (after the start switch is released) until the relay opens.
- (c) **BLEED AIR** - An alternate action switch that applies power to energize the control circuit of the load control valve in the engine bleed air system. Its indicator light comes on (blue color filter) when its switch contacts are in the closed position.



APU COCKPIT CONTROL PANEL  
 Figure 1

APU Control Module  
Figure 2  
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 737-400  
 MAINTENANCE MANUAL



## MAINTENANCE MANUAL

- (e) GEN TRIPPED- A momentary action switch that applies power to the close circuit of the generator field control relay. Its indicator light comes on (Red color filter) when the generator control unit has automatically tripped the field control relay to protect the generator or AC power system. (See Subject 24-13-0, AC Power System - APU)
  - (f) TEST INDIC LIGHTS- A momentary action switch that applies power to check all indicator and annunciator lights in the control module. Its indicator light comes on (Amber color filter) when its switch contacts close and power is available to the light test circuit.
  - (g) PUSH TO EXTING FIRE- A guarded, momentary action switch that applies power to the fire extinguisher detonator circuit. Its indicator light comes on (Yellow color filter) when its switch contacts close or when the fire extinguisher circuit is energized automatically by the fire warning or test fire circuits. (See APU Fire Protection, Subject 49-00-26 )
  - (h) TEST FIRE CIRCUIT- A momentary action switch that applies power to the (fire) test relay. Its indicator light comes on (Amber color filter), and remains on when the (fire) test relay is in the closed position.
  - (i) FIRE/HORN CUTOUT- A momentary action switch that cuts out the fire warning horn, but does not extinguish the indicator light (Red color filter). The light remains on until the fire detector cools off or until the fire warning test relay opens.
- (3) The annunciator lights provide information concerning APU shut-down and of its electrical loading configuration. The annunciator lights are identical to the switch-lights except that they do not contain switch contacts. The following annunciator lights are provided in the control module:
- (a) GEN ON BUS- Its light illuminates (Green color filter) when the APU generator is in the closed position to show that the APU generator output is connected to the synchronous bus.
  - (b) HI OIL TEMP- Its light illuminates (Red color filter) when the APU engine is automatically shut down due to excessive engine oil temperature. The light remains on until the master relay is opened (MASTER switch open, light out) to remove power from the self-locking circuit of the high oil temperature relay.

- (c) LOW OIL PRESS - Its light illuminates (red color filter) when the APU engine is automatically shut down due to low engine oil pressure. Its light remains on until the master relay is opened (MASTER switch open, light out) to remove power from the self-locking circuit of the low oil pressure relay.
  - (d) DOOR CLOSED - Its light illuminates when APU exhaust door is fully closed.
  - (e) DOOR OPEN - Its light illuminates when APU exhaust door is fully open.
- C. The generator contactor selector switch, APU CONTACTOR, is a lever actuated switch that is spring loaded and locked to the center, OFF position. When the switch actuating lever is lifted and moved to the CLOSE or TRIP position, power is applied to the related control circuit of the APU generator contactor. (See Subject 24-13-0, AC Power System - APU.) When the actuating lever is released, the lever returns to and locks in the center position. The switch is adjacent to the control module, slightly above the GEN ON BUS annunciator light that indicates the position of the generator breaker.
- D. The OVERSPEED TEST switch is a momentary contact, press to actuate switch that provides for normal shutdown of the APU engine. When actuated, its contacts close and apply power to energize the pneumatic (shutoff) solenoid valve to shut down the engine through actuation of the 110% contacts of the centrifugal switch assembly. The switch is located above the control module between the engine instruments.
- E. The engine instrumentation provided on the APU control panel consists of a tachometer and an exhaust gas temperature indicator. The tachometer indicates the engine's rotational speed in percent of governed speed (% RPM) to provide a visual indication that the engine fuel and control system is maintaining the engine speed with prescribed limits. The exhaust gas temperature indicator displays the engine's exhaust gas temperature in degrees centigrade (EGT, °C) to provide a visual indication that the pneumatic thermostat is maintaining the engine exhaust gas temperature within allowable limits.
- F. The electrical instrumentation on the APU cockpit control panel is provided to monitor the electrical load on the APU engine. The AC ammeter (AC AMPS) indicates the APU generator output (one phase) as a measure of the engine's electrical load. AC voltmeter indicating the voltage level of the APUs AC output voltage supply to the aircraft's electrical system.

The AC voltmeter indicates the voltage level that the APU generator is supplying to the aircraft's electrical system.

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APU ENGINE CONTROL  
DESCRIPTION AND OPERATION

EFFECTIVITY RTCA LX-N19997 LX-N20000

1 GENERAL

- A The APU engine control system provides for the manual selection and the automatic control of the operation and loading of the APU engine. The system consists of an APU control panel, engine control components and engine control circuits.
- B The APU control panel provides switches for selecting the APU operational mode and loading configuration, and instrumentation to monitor the electrical loading and the performance of the engine
- C The APU engine control components monitor the operation of the APU engine to provide electrical and pneumatic signals used to sequence and control the start, ignition and acceleration of the engine to governed speed, to control the pneumatic load on the APU engine and to shutdown the engine See APU Engine Control Components, Subject 49-61-1
- D. The engine control circuits provide for the manual selection and the automatic control of the operation and loading of the APU engine. See APU Engine Control Circuits, Subject 49-62-1.

2 APU COCKPIT CONTROL PANEL

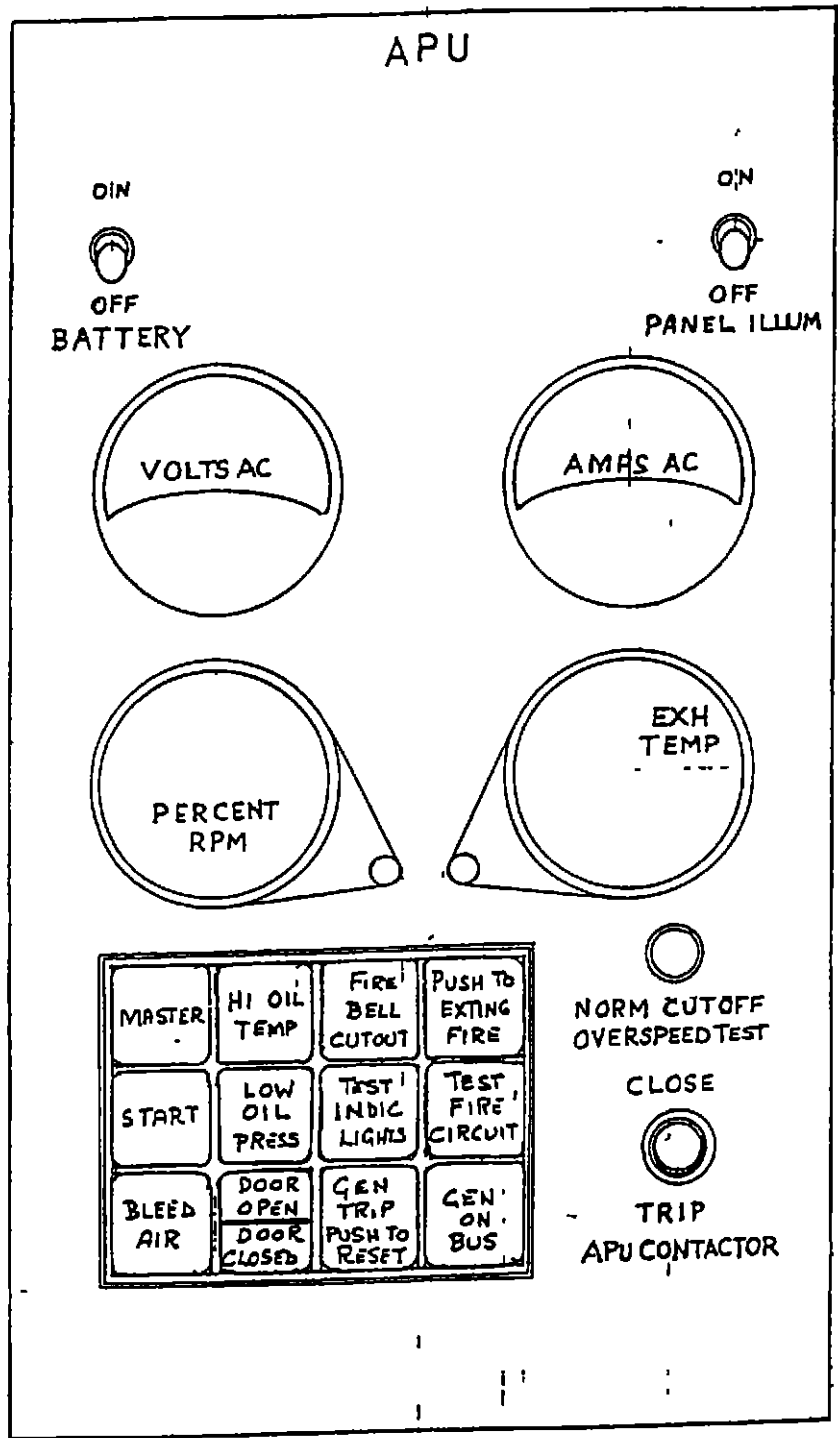
- A The APU control panel consists of a control module, an APU battery switch, an APU generator contactor control switch, an overspeed test switch, engine and electrical instrumentation and instrument lighting
- B The control module provides switches for energizing the APU engine control circuits, for starting the APU engine and for activating and testing the APU's fire extinguishing and fire detection system Switch lights, annunciator lights and warning lights in the control module provide visual references of the operational status and the loading configuration of the engine. The module consists of a mounting rack with nine pushbutton switch-lite and three annunciator light assemblies.
  - (1) The mounting rack is itself a modular assembly that provides terminal blocks for quick installation and removal of the pushbutton switch-lite and annunciator lite assemblies. A hole in the terminal block mates with a large post on the terminal end of the switch-lite and annunciator lite units to assure proper orientation of the units when they are installed. Dividers in the mounting rack extend out to form a natural barrier between units. To actuate a particular switch-lite, the switch-plate (lens) must be depressed below the level of the barrier If two adjacent units are accidentally depressed

(1) (Continued)

simultaneously with one finger, the barrier will prevent actuation. The mounting rack is mounted in the APU control panel through a single panel cutout. Mounting fasteners are slipped into slots on the rack frame and tightened against the back of the control panel to secure the entire control module to the panel.

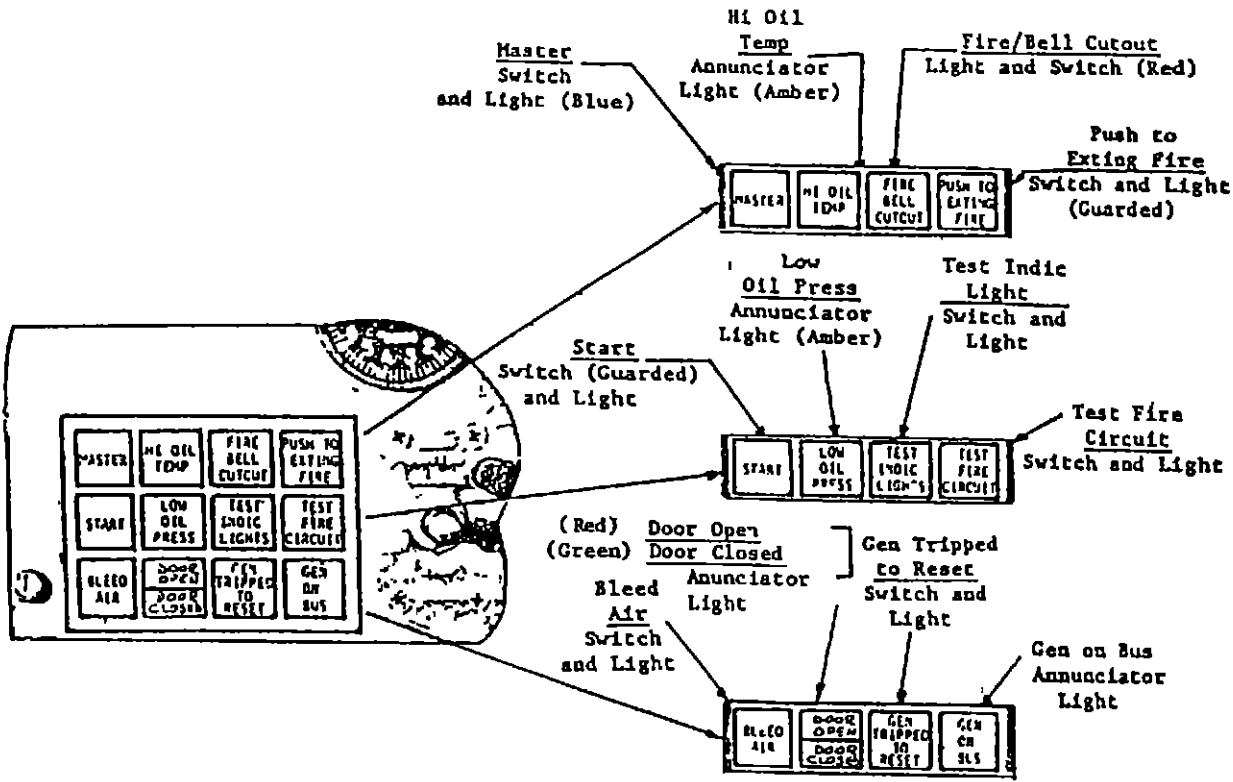
(2) The pushbutton switch-lite assemblies are alternate or momentary actuation switches with indicator lights mounted beneath their switch-plate (lens). A color filter below the lens of each switch-lite (and annunciator lite) provides color coding in relationship to the significance of the information that the light provides: safe/acceptable (blue or green), advisory information, on/energized, etc., (amber or yellow), warning, unsafe (red). The following switch-lites are provided in the control module:

- (a) **MASTER** - An alternate action switch that applies control power to the master relay and the APU generator control relay circuits. Its indicator light comes on (blue color filter) when control power is available to the master relay.
- (b) **START** - A guarded, momentary action switch that applies power to the start-ignition/fuel circuit. Its indicator light comes on (yellow color filter) when the switch is depressed and control power is applied to the starter relay. When the starter relay actuates, closes, the indicator light will remain on (after the start switch is released) until the relay opens.
- (c) **BLEED AIR** - An alternate action switch that applies power to energize the control circuit of the load control valve in the engine bleed air system. Its indicator light comes on (blue color filter) when its switch contacts are in the closed position.



**APU COCKPIT CONTROL PANEL**

**FIGURE 1**



APU CONTROL MODULE  
 FIGURE 2

Ref MM STEWARD-DAVIS

- (e) **GEN TRIPPED** - A momentary action switch that applies power to the close circuit of the generator field control relay. Its indicator light comes on (Red color filter) when the generator control unit has automatically tripped the field control relay to protect the generator or AC power system. (See Subject 24-49-0, AC Power System - APU).
  - (f) **TEST INDIC LIGHTS** - A momentary action switch that applies power to check all indicator and annunciator lights in the control module. Its indicator light comes on (Amber color filter) when its switch contacts close and power is available to the light test circuit.
  - (g) **PUSH TO EXTING FIRE** - A guarded, momentary action switch that applies power to the fire extinguisher detonator circuit. Its indicator light comes on (Yellow color filter) when its switch contacts close or when the fire extinguisher circuit is energized automatically by the fire warning or test fire circuits. (See APU Fire Protection, Subject 49-00-27)
  - (h) **TEST FIRE CIRCUIT** - A momentary action switch that applies power to the (fire) test relay. Its indicator light comes on (Amber color filter), and remains on when the (fire) test relay is in the closed position.
  - (i) **FIRE/HORN CUTOFF** - A momentary action switch that cuts out the fire warning horn, but does not extinguish the indicator light (Red color filter). The light remains on until the fire detector cools off or until the fire warning test relay opens.
- (3) The annunciator lights provide information concerning APU shutdown and of its electrical loading configuration. The annunciator lights are identical to the switch-lights except that they do not contain switch contacts. The following annunciator lights are provided in the control module:
- (a) **GEN ON BUS** - Its light illuminates (Green color filter) when the APU generator is in the closed position to show that the APU generator output is connected to the synchronous bus.
  - (b) **HI OIL TEMP** - Its light illuminates (Red color filter) when the APU engine is automatically shut down due to excessive engine oil temperature. The light remains on until the master relay is opened (MASTER switch open, light out) to remove power from the self-locking circuit of the high oil temperature relay.

- (c) LOW OIL PRESS - Its light illuminates (red color filter) when the APU engine is automatically shut down due to low engine oil pressure. Its light remains on until the master relay is opened (MASTER switch open, light out) to remove power from the self-locking circuit of the low oil pressure relay.
  - (d) DOOR CLOSED - Its light illuminates when APU exhaust door is full closed.
  - (e) DOOR OPEN - Its light illuminates when APU exhaust door is fully open.
- C The generator contactor selector switch, APU CONTACTOR, is a lever actuated switch that is spring loaded and locked to the center, OFF position. When the switch actuating lever is lifted and moved to the CLOSE or TRIP position, power is applied to the related control circuit of the APU generator contactor (See Subject 24-49-0, AC Power System - APU ) When the actuating lever is released, the lever returns to and locks in the center position. The switch is adjacent to the control module, slightly above the GEN ON BUS annunciator light that indicates the position of the generator breaker.
- D The OVERSPEED TEST switch is a momentary contact, press to actuate switch that provides for normal shutdown of the APU engine. When actuated, its contacts close and apply power to energize the pneumatic (shutoff) solenoid valve to shut down the engine through actuation of the 110% contacts of the centrifugal switch assembly. The switch is located above the control module between the engine instruments.
- E The engine instrumentation provided on the APU control panel consists of a tachometer and an exhaust gas temperature indicator. The tachometer indicates the engine's rotational speed in percent of governed speed (% RPM) to provide a visual indication that the engine fuel and control system is maintaining the engine speed with prescribed limits. The exhaust gas temperature in degrees centigrade (EGT, °C) to provide a visual indication that the pneumatic thermostat is maintaining the engine exhaust gas temperature within allowable limits.
- F The electrical instrumentation on the APU cockpit control panel is provided to monitor the electrical load on the APU engine. The AC ammeter (AC AMPS) indicates the APU generator output (one phase) as a measure of the engine's electrical load. AC voltmeter indicating the voltage level of the APUs AC output voltage supply to the aircraft's electrical system.

The AC voltmeter indicates the voltage level that the APU generator is supply to the aircraft's electrical system.



## MAINTENANCE MANUAL

EFFECTIVITY TCA LX-N20198 LX-N20199

### APU ENGINE CONTROL COMPONENTS

#### DESCRIPTION AND OPERATION

#### 1. GENERAL

- A. The APU engine control components provide speed (RPM), temperature (EGT, and Oil) and pressure (Oil) information used to start, to control the loading, and to shut down the APU engine. The engine controls consist of a sequencing oil pressure switch, a centrifugal switch assembly, a pneumatic thermostat, a three-way solenoid valve, a pneumatic (shutoff) solenoid valve and a low oil pressure switch, all of which are mounted on the APU engine, and a high oil temperature switch inserted in the return line to the oil tank.
- B. The sequencing oil pressure switch, mounted on the engine oil pump assembly flange, senses oil pressure at the oil pump outlet at a very low APU engine RPM. Closure of the switch assures that there is lubrication oil for the engine and that airflow (engine rotation) is available for combustion. The switch is used in the start/ignition circuit to control the opening of the fuel solenoid valve and the initiation of the ignition unit.
- C. The centrifugal switch assembly, mounted on the engine accessory gear case, provides information concerning engine speed to the engine control circuits. Switches within the assembly close at 35%, 95% and 110% of governed engine RPM.
- D. The pneumatic thermostat, mounted in the turbine exhaust flange of the engine, senses exhaust gas temperature and controls pneumatically actuated valves to limit fuel flow (acceleration limiter valve) or air bleed (load control valve) as required to maintain the engine exhaust gas temperature within established limits.
- E. The three-way (solenoid) valve connects the pneumatic thermostat's control output to the acceleration limiter valve, in the engine fuel and control system, during the engine start/ignition cycle; and when energized by actuation of the 95% switch in the centrifugal switch assembly, it transfers the pneumatic thermostat's control output to the load control valve in the engine bleed air system.
- F. The pneumatic (shutoff) solenoid valve is a normally closed valve that, when energized by actuation of the overspeed test switch or engine protection circuits, allows compressed air to flow into the centrifugal switch assembly to actuate the 110% (overspeed) switch and shut down the engine.

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- G. The low oil pressure switch, mounted with the sequencing oil pressure switch is used in the engine protection circuits to shut down the engine and illuminate an annunciator light on the APU control panel if engine oil pressure falls below 45 PSIG.
- H. The high oil temperature switch, mounted in the oil return line to the oil tank, is used in the engine protection circuits to shut down the engine and illuminate an annunciator light on the APU control panel if engine oil temperature rises above  $255 \pm 10^{\circ}\text{F}$ .

## 2. SEQUENCING OIL PRESSURE SWITCH

- A. The sequencing oil pressure switch consists of a housing containing a diaphragm-operated snap-action switch having connections for an oil pressure line and an electrical connector. When the lubricating oil pressure rises to approximately 3 PSIG the switch will be actuated to close. The switch controls power to the fuel solenoid valve, the ignition unit and to the APU loading circuits.

## 3. CENTRIFUGAL SWITCH ASSEMBLY

- A. The centrifugal switch assembly consists of a mechanical flyweight type governor, an actuating lever, three spring-loaded pushrods and three snap-action switches
- B. As the APU engine accelerates, the flyweights in the switch act against the actuating lever to move it in proportion to engine speed. The spring-loaded pushrods oppose the flyweight force on the lever to decrease the flyweight movement as necessary to ensure that the three switches are actuated in sequence and at the correct engine speed. The switches are mechanically actuated at approximately 35%, 95% and 110% of governed engine speed. In addition, an air-operated override provision will operate the 110% switch when the pneumatic solenoid is energized.

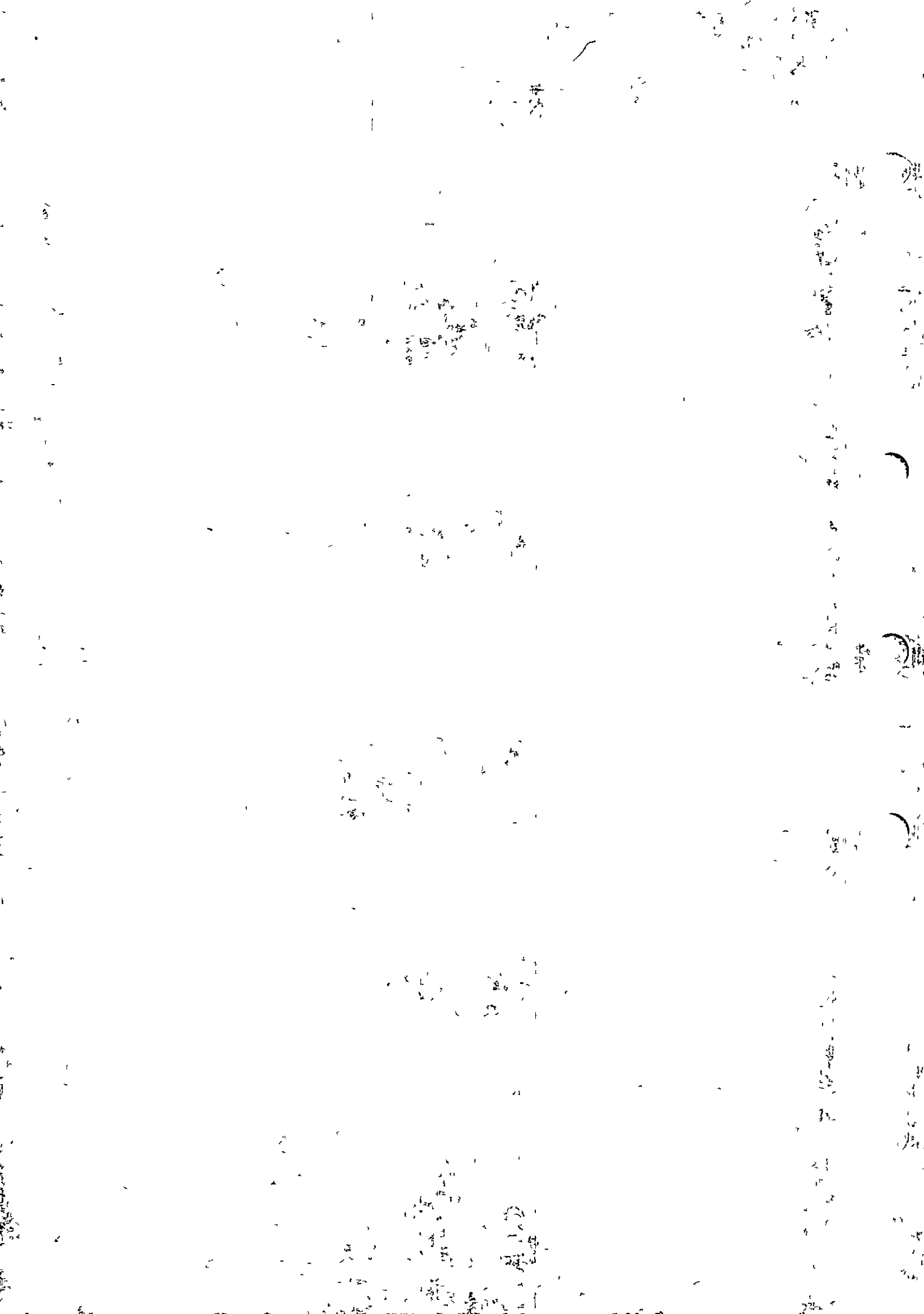
## 4. PNEUMATIC THERMOSTAT

- A. The pneumatic thermostat projects into the turbine exhaust duct. It consists of an alloy steel housing, spring-loaded ball valve, thermostatic core, and connection for a pneumatic line. The thermostat functions as a temperature controlled orifice over a range of turbine exhaust gas temperatures. It is connected by pneumatic line to the three-way solenoid valve which applies its control signal to the acceleration limiter valve during engine start and transfers its signal to the pneumatic shutoff (load control) valve when the engine reaches 95% governed speed. The thermostat is closed when cold and begins to open between  $555^{\circ}$  to  $565^{\circ}\text{C}$  ( $1030^{\circ}$  to  $1050^{\circ}\text{F}$ ) when it will bleed control air from one side of a diaphragm in the acceleration limiter valve during engine start, to control the fuel bypass valve or the pneumatic shutoff (load control) valve after governed speed is reached, to control air bleed as required to maintain the exhaust gas temperature within limits.

5. OPERATION

- A. The APU engine controls are actuated by the rotational speed (RPM), the lubricating oil pressure and temperature, and the exhaust gas temperature of the engine. When the lubricating oil pressure increases to approximately 3 PSIG as the engine is rotated by the starter motor, the sequencing oil pressure switch is actuated to close, as the engine accelerates during the ignition/start cycle, the centrifugal switch 35% contacts open and the 95% contacts close. Transfer of each switch is used in the engine control circuitry to automatically sequence the start/ignition cycle, to transfer the pneumatic thermostat control to the (bleed air) load control valve, and to provide control power to the APU loading circuits. The 110% contacts of the centrifugal switch provide overspeed protection of the engine and, in addition, are actuated by compressed air through action of the pneumatic solenoid valve for normal (overspeed test) and protective shutdown of the engine.

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APU ENGINE CONTROL COMPONENTS

DESCRIPTION AND OPERATION

EFFECTIVITY RTCA LX-N19997 LX-N20000

1 GENERAL

- A The APU engine control components provide speed (RPM), temperature (EGT, and Oil) and pressure (Oil) information used start, to control the loading, and to shut down the APU engine. The engine controls consists of a sequencing oil pressure switch, a centrifugal switch assembly, a pneumatic thermostat, a three-way solenoid valve, a pneumatic (shutoff) solenoid valve and a low oil pressure switch, all of which are mounted on the APU engine, and a high oil temperature switch inserted in the return line to the oil tank
- B The sequencing oil pressure switch, mounted on the engine oil pump assembly flange, senses oil pressure at the oil pump outlet at a very low APU engine RPM. Closure of the switch assures that there is lubrication oil for the engine and that airflow (engine rotation) is available for combustion. The switch is used in the start/ignition circuit to control the opening of the fuel solenoid valve and the initiation of the ignition unit.
- C The centrifugal switch assembly, mounted on the engine accessory gear case, provides information concerning engine speed to the engine control circuits. Switches within the assembly close at 35%, 95% and 110% of governed engine RPM.
- D The pneumatic thermostat, mounted in the turbine exhaust flange of the engine, senses exhaust gas temperature and controls pneumatically actuated valves to limit fuel flow (acceleration limiter valve) or air bleed (load control valve) as required to maintain the engine exhaust gas temperature within established limits.
- E The three-way (solenoid) valve connects the pneumatic thermostat's control output to the acceleration limiter valve, in the engine fuel and control system, during the engine start/ignition cycle; and when energized by actuation of the 95% switch in the centrifugal switch assembly, it transfers the pneumatic thermostat's control output to the load control valve in the engine bleed air system.
- F The pneumatic shutoff solenoid valve is a normally closed valve that, when energized by actuation of the overspeed test switch or engine protection circuits, allows compressed air to flow into the centrifugal switch assembly to actuate the 110% (overspeed) switch and shut down the engine.



## MAINTENANCE MANUAL

- G The low oil pressure switch, mounted with the sequencing oil pressure switch is used in the engine protection circuits to shut down the engine and illuminate an annunciator light on the APU control panel if engine oil pressure falls below 45 PSIG
- H The high oil temperature switch, mounted in the oil return line to the oil tank, is used in the engine protection circuits to shut down the engine and illuminate an annunciator light on the APU control panel if engine oil temperature rises above  $255 \pm 10^{\circ}\text{F}$ .

### 2 SEQUENCING OIL PRESSURE SWITCH

- A The sequencing oil pressure switch consists of a housing containing a diaphragm-operated snap-action switch having connections for an oil pressure line and an electrical connector. When the lubricating oil pressure rises to approximately 3 PSIG the switch will be actuated to close. The switch controls power to the fuel solenoid valve, the ignition unit and to the APU loading circuits

### 3 CENTRIFUGAL SWITCH ASSEMBLY

- A The centrifugal switch assembly consists of a mechanical flyweight type governor, an actuating lever, three spring-loaded pushrods and three snap-action switches
- B As the APU engine accelerates, the flyweights in the switch act against the actuating lever to move it in proportion to engine speed. The spring-loaded pushrods oppose the flyweight force on the lever to decrease the flyweight movement as necessary to ensure that the three switches are actuated in sequence and at the correct engine speed. The switches are mechanically actuated at approximately 35%, 95% and 110% of governed engine speed. In addition, an air-operated override provision will operate the 100% switch when the pneumatic solenoid is energized

### 4 PNEUMATIC THERMOSTAT

- A The pneumatic thermostat projects into the turbine exhaust duct. It consists of an alloy steel housing, spring-loaded ball valve, thermostatic core, and connection for a pneumatic line. The thermostat functions as a temperature controlled orifice over a range of turbine exhaust gas temperatures. It is connected by pneumatic line to the three-way solenoid valve which applies its control signal to the acceleration limiter valve during engine start and transfers its signal to the pneumatic shutoff (load control) valve when the engine reaches 95% governed speed. The thermostat is closed when cold and begins to open between  $555^{\circ}$  to  $565^{\circ}\text{C}$  ( $1030^{\circ}$  to  $1050^{\circ}\text{F}$ ) when it will bleed control air from one side of a diaphragm in the acceleration limiter valve during engine start, to control the fuel bypass valve or the pneumatic shutoff (load control) valve after governed speed is reached, to control air bleed as required to maintain the exhaust gas temperature within limits

## 5 OPERATION

- A The APU engine controls are actuated by the rotational speed (RPM), the lubricating oil pressure and temperature, and the exhaust gas temperature of the engine. When the lubricating oil pressure increases to approximately 3 PSIG as the engine is rotated by the starter motor, the sequencing oil pressure switch is actuated to close, as the engine accelerates during the ignition/start cycle, the centrifugal switch 35% contacts open and the 95% contacts close. Transfer of each switch is used in the engine control circuitry to automatically sequence the start/ignition cycle, to transfer the pneumatic thermostat control to the bleed air load control valve, and to provide control power to the APU loading circuits. The 110% contacts of the centrifugal switch provide overspeed protection of the engine and, in addition, are actuated by compressed air through action of the pneumatic solenoid valve for normal (overspeed test) and protective shutdown of the engine.

APU ENGINE CONTROL CIRCUITS

DESCRIPTION AND OPERATION

EFFECTIVITY TCA LX-N20198 LX-N20199

1. GENERAL

- A. The APU engine control circuits control power to the APU fuel supply system, the APU battery charger and generator control unit, the APU exhaust door actuator, and to components of the APU engine start, ignition and bleed air systems. Relays and sensors are provided in the circuits to monitor the conditions required for safe operation of the APU engine and to interconnect the selector switches on the APU control panel with the engine, fuel and electrical control components as required to automatically sequence the start, loading and shutdown (normal and protective) of the APU engine. The circuit consists of a master power circuit, engine start circuits, pneumatic and electric loading circuits and engine shutdown circuits, plus the fire detection/fire test circuits of the APU fire protection system. (See Subject 49-00-26.) The engine control circuits require 28 VDC power to actuate the components and relays controlled by the circuits.
- B. The master power circuits controls power to the generator control unit, the APU fuel supply system, the APU exhaust door actuator and to the engine start, pneumatic and electric loading and engine shutdown circuits.
- C. The engine start circuit provides control of the start and loading of the APU engine. The circuit interconnects engine control components and control relays as required to automatically sequence the operation of the starter motor, fuel solenoid valve and engine ignition unit as required to initiate engine rotation and combustion, to accelerate the engine to governed speed quickly and safely, and to energize an APU loading circuit when governed speed is reached.
- D. The pneumatic loading circuits provide for loading the APU engine pneumatically and for limiting the electrical load on the engine when maximum pneumatic power is desired.
- E. The APU engine shutdown circuits provide for the manual selection of engine shutdown (normal) and for automatic shutdown of the engine through engine protection circuits.
- F. The APU engine control circuits require 28 VDC power to actuate the engine control components and the control relays provided in the circuits. Control power is available to the master power circuit when the APU BATTERY switch is in the ON position.

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## 2. MASTER POWER CIRCUIT

- A. The master power circuit consists of a master switch and a master relay circuit. Control power is available to the circuit from the APU DC bus through a 15A BUS FEED circuit breaker on the starter relay junction box (Sta. 960L) when the APU BATTERY switch is placed in the ON position.
- (1) The MASTER switch is a push type, alternate action switch-lite located on the APU control panel. When actuated to the closed position, the switch applies power from the CONTROL FEED #1 circuit breaker to the master relay circuit.
  - (2) The master relay circuit provides and controls a master relay that, in turn, controls power to the APU exhaust door actuator, to the APU fuel supply system, and to the engine start, pneumatic and electrical loading and engine shutdown circuits. The circuit monitors the airplane landing gear and APU fire protection system to assure that conditions are safe for APU engine operation before the master relay closes. The circuit illuminates the MASTER switch-lite on the APU control panel when control power is available to the master relay.
- B. The master relay circuit consists of a master relay, master relay (MR) actuating circuit, and master relay power circuits.
- (1) The master relay is a single coil, multiple contact relay that requires 28 VDC power and an electrical ground to actuate to the closed position. The contacts of the master relay control power to the master relay power circuits. The master relay is contained in the APU control relay box on Sta. 960L in the aft baggage compartment.
  - (2) The MR actuating circuit consists of a power circuit and an electrical ground circuit.

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APU ENGINE CONTROL CIRCUITS

DESCRIPTION AND OPERATION

1 GENERAL

- A The APU engine control circuits control power to the APU fuel supply system, the APU battery charger and generator control unit, the APU exhaust door actuator, and to components of the APU engine start, ignition and bleed air systems. Relays and sensors are provided in the circuits to monitor the conditions required for safe operation of the APU engine and to interconnect the selector switches on the APU control panel with the engine, fuel and electrical control components as required to automatically sequence the start, loading and shutdown (normal and protective) of the APU engine. The circuit consists of a master power circuit, engine start circuits, pneumatic and electric loading circuits and engine shutdown circuits, plus the fire detection/fire test circuits of the APU fire protection system. (See Subject 49-00-26 ) The engine control circuits require 28 VDC power to actuate the components and relays controlled by the circuits.
- B The master power circuits controls power to the generator control unit, the APU fuel supply system, the APU exhaust door actuator and to the engine start, pneumatic and electric loading and engine shutdown circuits.
- C The engine start circuit provides control of the start and loading of the APU engine. The circuit interconnects engine control components and control relays as required to automatically sequence the operation of the starter motor, fuel solenoid valve and engine ignition unit as required to initiate engine rotation and combustion, to accelerate the engine to governed speed quickly and safely, and to energize an APU loading circuit when governed speed is reached.
- D The pneumatic loading circuits provide for loading the APU engine pneumatically and for limiting the electrical load on the engine when maximum pneumatic power is desired.
- E. The APU engine shutdown circuits provide for the manual selection of engine shutdown (normal) and for automatic shutdown of the engine through engine protection circuits.
- F The APU engine control circuits require 28 VDC power to actuate the engine control components and the control relays provided in the circuits. Control power is available to the master power circuit when the APU BATTERY switch is in the ON position.

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## 2 MASTER POWER CIRCUIT

- A. The master power circuit consists of a master switch and a master relay circuit. Control power is available to the circuit from the APU DC bus through a 15A BUS FEED circuit breaker on the starter relay junction box (Sta 960L) when the APU BATTERY switch is placed in the ON position.
- (1) The MASTER switch is a push type, alternate action switch-lite located on the APU control panel. When actuated to the closed position, the switch applies power from the CONTROL FEED #1 circuit breaker to the master relay circuit.
  - (2) The master relay circuit provides and controls a master relay that, in turn, controls power to the APU exhaust door actuator, to the APU fuel supply system, and to the engine start, pneumatic and electrical loading and engine shutdown circuits. The circuit monitors the airplane landing gear and APU fire protection system to assure that conditions are safe for APU engine operation before the master relay closes. The circuit illuminates the MASTER switch-lite on the APU control panel when control power is available to the master relay.
- B. The master relay circuit consists of a master relay, master relay (MR) actuating circuit, and master relay power circuits.
- (1) The master relay is a single coil, multiple contact relay that requires 28 VDC power and an electrical ground to actuate to the closed position. The contacts of the master relay control power to the master relay power circuits. The master relay is contained in the APU control relay box on Sta 960L in the aft baggage compartment.
  - (2) The MR actuating circuit consists of a power circuit and an electrical ground circuit.

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- (a) The power circuit connects power from the MASTER switch through normally closed contacts of the fire lockout relay to the MR control coil in parallel with the MASTER light circuit. When the fire lock relay is in the tripped position (no APU engine fire) control power from the master switch is available to energize the MR coil and to illuminate the MASTER light.
  - (b) The electrical ground circuit connects a ground to the master relay control coil through normally closed contacts of an aircraft safety relay. When the oleo strut of the airplane's right hand landing gear is compressed, airplane on the ground, the safety relay is actuated to provide an electrical ground for the MR coil.
- (3) The master relay power circuits control power from the CONTROL FEED 2 and DOOR MOTOR circuit breakers on the APU starter control relay junction box at Sta 960L
- (a) Power from the CONTROL FEED 1 circuit breaker is controlled through normally open contacts of the master relay to actuate the boost pump relay and to make control power available to the engine start, pneumatic loading and engine shutdown circuits.
    - 1) The boost pump relay (BPR) is a single coil, multiple contact relay that requires 28 VDC power to actuate to the closed position. The contacts of the relay apply power from the BOOST PUMP circuit breaker on the APU starter relay box at Sta 960L to the fuel boost pump and to the fuel supply shutoff valve. The BPR is contained in the APU control relay box at Sta 960L.
  - (b) Power from the DOOR MOTOR circuit breaker is connected to the control circuits, ED open and ED close, of the APU exhaust door actuator through normally open and normally closed contacts of the master relay.
    - 1) Normally open contacts of the relay apply power to the ED open circuit when the master relay actuates to the closed position.
    - 2) Normally closed contacts of the relay apply power to the ED close circuit when the master relay trips.

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D Operation

- (1) Control power is available to the master power circuit through the BUS FEED circuit breaker when the APU BATTERY switch on the APU control panel is placed in the ON position. The master relay circuit energized when the MASTER switch is actuated to the closed position.
  - (a) The MASTER light will illuminate and control power will be available to the control coil of the master relay if the fire lockout is tripped (no APU engine fire in progress). The master relay will actuate if an electrical ground is available to its control coil through contacts of the aircraft safety relay (airplane on the ground).
- (2) When the master relay actuates to the closed position, APU DC bus power is applied as follows:
  - (a) Power from the DOOR MOTOR circuit breaker is applied to the ED open circuit of the APU exhaust door actuator to open the exhaust door.
  - (b) Power from the CONTROL FEED 2 circuit breaker is applied to the control coil of the fuel boost relay. When the relay actuates (closes), power from the APU bus is applied to the fuel supply shutoff valve and to the fuel boost pump to make the airplane main tank fuel available for the APU engine operation.

- (c) Control power from the CONTROL FEED 2 circuit breaker is made available to the engine start, pneumatic loading and engine shutdown circuits
- (3) When the master relay is de-energized, tripped, by actuating the MASTER switch to the open position, by action of the fire lockout relay (APU engine fire) or by action of the safety relay (landing gear oleos extending at airplane lift-off) the following events occur
  - (a) Power is applied to the ED close circuit of the APU exhaust door actuator to close the exhaust door.
  - (b) Power is removed from the control coil of the fuel boost relay. When the relay trips, power is removed from the fuel supply shutoff valve and the fuel boost pump to shut the valve and to stop the pump
  - (c) Control power is removed from the engine start, pneumatic and electric loading, and engine shutdown circuits

### 3 START CIRCUITS

- A The start circuits consists of a starter relay circuit, a fuel-ignition/loading circuit and a holding relay circuit
  - (1) The starter relay circuit controls the operation of the starter motor opens the battery charger circuit, and monitors the position of the exhaust gas door to assure that the door is open before an engine start can be initiated
  - (2) The fuel-ignition/loading circuits control power to the fuel solenoid valve, to the APU ignition unit and to an APU loading circuit. The circuit monitors engine oil pressure as an indication of the availability of lubrication for the engine and as an indication of engine rotation and airflow to support combustion before fuel is injected and ignition is initiated. In addition, the circuit transfers power from the ignition unit to the APU loading circuit when governed speed is reached
  - (3) The holding relay maintains power to the start circuits on release of the start switch and prevents re-energizing the fuel-ignition circuit and the starter relay as the engine rotational speed spins down after actuation of the 110% switch causes engine shutdown.
- B The starter relay circuit consists of a starter relay, start light and a starter relay and light control circuit.

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- (1) The starter relay is a single coil, 28 VDC power actuated, heavy duty DC power contactor that requires 28 VDC power and an electrical ground to actuate to the closed position. The contacts of the relay apply power from the battery to the starter motor. The starter relay is contained in the starter relay junction box at Sta. 960L.
- (2) The start light illuminates the coverplate (lens) of the START switch-lite on the APU control panel. The light requires 28 VDC power to illuminate. The light is in parallel with the control coil of the starter relay and illuminates when power is available to the coil.
- (3) The starter relay and light control circuit consists of power circuits to the starter relay coil and start light and an electrical ground circuit to the starter relay coil only.
  - (a) The power circuits consist of a start switch circuit and a holding relay circuit.
    - 1) The start switch circuit is a series circuit that connects 28 VDC power from contacts of the master relay to the starter relay coil and start light through the closed contacts of the BLEED AIR switch in the OFF position, the normally closed contacts of the oil pressure sequencing and 35% switches. Therefore, the BLEED AIR switch must be in the OFF position (BLEED AIR light out), the oil pressure sequencing and 35% switches must be closed (engine RPM below 6%), and the START switch must be actuated (pressed) before power from the master relay is available to energize the starter relay coil and to illuminate the start light.

NOTE In this circuit the START light indicates that control power is available to the starter relay.

- 2) The holding relay circuit closes normally open contacts in parallel with the start switch and oil pressure sequence switch contacts maintaining power to itself, the starter relay circuit, and the fuel-ignition/loading circuit.

NOTE When the START switch is released, the START light as powered by this circuit indicates that the starter relay has actuated and that the starter motor should be operating (engine RPM increasing)

- (b) The electrical ground circuit connects a ground to the starter relay coil through normally open contacts of the exhaust door switch 1. Therefore, the exhaust door switch must be actuated to the closed position (exhaust door fully open) before a ground is available to complete the starter relay control circuit.
  - (c) The starter relay and start light circuit is initially energized when the START switch is (momentarily) pressed. Power is retained on the circuit by contacts of the hold relay when the START switch is released. The circuit is de-energized when power to the starter relay coil is interrupted by actuation of the 35% switch when engine rotational speed reaches 35% RPM.
- C. The fuel-ignition/loading circuits consist of a fuel circuit, an ignition circuit and a loading circuit. The fuel circuit controls power to the fuel solenoid valve and to the 95% switch. The 95% switch controls power to the ignition circuit and the loading circuit.
- (1) The fuel circuit consists of the holding relay and a fuel solenoid control circuit
    - (a) The holding relay is a single 28 VDC coil, multiple contact, relay located in the APU control relay box at Sta. 960L.
    - (b) The fuel solenoid control circuit is a series circuit that applies 28 VDC to the holding relay coil initially through the start switch and the normally closed contacts of the oil pressure sequencing and 110% switches, then through closed normally open contacts of the holding relay in series with normally closed contacts of the low oil pressure (LOP) and high oil temperature (HOT) relays and the 110% switch. The power train continues from the 110% switch through normally closed contacts of the lockout relay and normally open contacts of the oil pressure sequencing switch to the 95% switch and the fuel solenoid. The oil pressure sequencing switch contacts close to complete the circuit due to oil pressure build-up as the starter rotates the engine.

- (2) The ignition circuit consists of the ignition unit and igniter plug. The circuit is energized by power from the fuel solenoid control circuit through normally closed contacts of the 95% switch. The circuit is de-energized by actuation of the 95% switch when the engine's rotational speed reaches 95% RPM. This action completes the start cycle and transfers power to the loading circuit.
- (3) The loading circuit applies 28 VDC power to the three-way solenoid valve, the 95% relay and to the hourmeter. The circuit is energized by power from the fuel solenoid control circuit when the normally open contacts of the 95% switch are actuated to close.
  - (a) The three-way solenoid valve is an engine control component mounted on the engine.
  - (b) The 95% relay is a single coil, multiple contact relay that requires 28 VDC power for actuation to the closed position. Normally open contacts of the relay are used in the control circuits to the APU generator protection panel, the bleed air valve and to the low oil pressure relay. This prevents loading of the APU during the start cycle and prevents actuation of the low oil pressure engine protective circuit during normal engine shutdown.
  - (c) The hourmeter is an engine indicating component mounted above the accessory section of the APU engine. (See APU Engine Indicating, Subject 49-70-0)
- (4) The fuel solenoid valve remains open and the loading circuit remains energized until control power to the circuit is interrupted by actuation of the 110% switch or by opening (tripping) the master relay.

NOTE APU engine shutdown should not be initiated by actuating the MASTER switch to the open (MASTER light, out) position.

#### D Operation

- (1) Momentarily pressing the START switch will apply power to the starter relay, START light and to the fuel solenoid control circuit.

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- (a) The START light will come on.
  - (b) The starter relay will actuate (close) if an electrical ground is available through the exhaust door 1 switch
  - (c) The holding relay will close.
- (2) When the holding relay closes, its self-locking (holding) circuit is completed
- (a) The START light remains on after the START switch is released
  - (b) The starter motor is energized to initiate engine rotation.
  - (c) The battery charger control unit in the starter relay box disconnects operating power from the APU battery charger
- (3) As engine oil pressure increases due to engine rotation, the sequencing oil pressure switch closes to complete the fuel solenoid control circuit.
- (a) The fuel solenoid valve opens to supply fuel to the fuel nozzles.
  - (b) The ignition circuit is energized through the normally closed contacts of the 95% switch to ignite the fuel-air mixture and initiate combustion.
- (4) At 35% RPM, the 35% switch actuates to interrupt power in the starter relay and start light circuit.
- (a) The START light goes out.
  - (b) The starter relay trips
    - 1) The starter is de-energized
    - 2) The battery charger control unit connects the APU battery charger to its power source
- (5) At 95% RPM the 95% switch actuates to remove fuel solenoid control circuit power from the ignition circuit and apply it to the load circuit. This completes the start cycle of the APU engine
- (a) The three-way solenoid valve is actuated to transfer the pneumatic thermostat control of engine exhaust gas temperature from the acceleration limiter valve, of the engine fuel and control system, to the load control valve, of the engine bleed air system.

- (b) The 95% relay is actuated to close its contacts in the APU generator control circuit, the low oil pressure relay power circuit and the bleed air (load control) valve circuit.
- (c) The hourmeter is energized to time and totalize APU operation speed.

#### 4. PNEUMATIC LOADING CIRCUIT

- A The pneumatic loading circuit consists of a bleed air circuit.
  - (1) The bleed air circuit provides for pneumatic loading of the APU engine by manual actuation of the BLEED-AIR switch on the APU control panel
  - (2) The pneumatic loading circuit receives 28 VDC power from the APU DC bus through contacts of the master relay
- B. The bleed air circuit connects power from the master relay to the load control valve of the engine bleed air system, and to the light (bulbs) in the BLEED AIR switch-lite on the APU panel
  - (1) The load control valve circuit is a series circuit consisting of normally open contacts of the 95% relay and the BLEED AIR switch. The contacts of the 95% relay prevent actuation of the load control valve before the APU engine reaches 95% RPM and also serve to remove the pneumatic load if the load control valve was not closed prior to engine shutdown
  - (2) The bleed air light is powered through contacts of the BLEED AIR switch only. This provides an indication of the switch position when the MASTER switch is closed so that the switch, if closed, can be actuated to the open position (BLEED AIR light out) before starting the APU engine
  - (3) The switch contacts are closed in both circuits when the BLEED AIR switch is in the AIR position. (BLEED AIR light on)

#### 5. ENGINE SHUTDOWN CIRCUITS

- A The engine shutdown circuits consists of normal and engine protective circuits that control power to the pneumatic solenoid valve on the centrifugal switch assembly of the engine control components. Power is available to the circuits when the master relay closes.

- (1) The normal engine shutdown circuit provides for the manual selection of engine shutdown on the APU control panel
  - (2) The engine protection circuits provide automatic shutdown of the engine if the engine oil temperature or pressure is not within specified limits. Annunciator lights are provided on the APU control panel to indicate the cause of automatic engine shutdown
- B. The normal engine shutdown circuit connects power from the master relay to the pneumatic solenoid valve through the normally open contacts of the OVERSPEED TEST switch on the APU control panel.
- C. The engine protection circuits consist of a high oil temperature circuit and a low oil pressure circuit.
- (1) The high oil temperature circuit consists of a high oil temperature relay (HOT), a HOT switch and an engine high oil temperature (HOT) shutdown circuit.
    - (a) The HOT relay is a single coil, multiple contact relay that requires 28 VDC power and an electrical ground for actuation. Control power is available to the HOT switch when the master relay closes and to the HOT relay and HIGH OIL TEMP annunciator light when the switch closes. The relay is contained in the APU control relay box at Sta. 960L.
    - (b) HOT relay contacts close in parallel with the HOT switch to hold the HOT relay.
    - (c) HOT relay normally closed contacts open the holding loop to the fuel/holding/loading circuit of the APU engine to shut it down.
  - (2) The low oil pressure circuit consists of a low oil pressure relay (LOP), a LOP switch circuit and an engine low oil pressure (LOP) shutdown circuit.
    - (a) The LOP relay is a single coil, multiple contact relay that requires 28 VDC power and an electrical ground for actuation. Control power is available to the LOP switch when the relay coil closes and to the LOP relay and LOW OIL PRESSURE annunciator light when the 95% switch closes. The relay is contained in the APU control relay box at Sta. 960L.
    - (b) LOP relay contacts close in parallel with the LOP switch to hold the LOP relay.

- (c) LOP relay normally closed contacts open the holding loop to the fuel/holding/loading circuit of the APU engine to shut it down.

## 6 OPERATION

A Operation of an APU consists of four steps, preparing to start, starting, loading and shutdown. Each step is manually initiated through selector switches provided on the APU control panel. However, the engine control circuits monitor the conditions required for safe operation of the APU engine before power is applied to actuate start and loading control components.

### B. Preparing to Start APU

- (1) Placing the APU BATTERY switch to the ON position actuates the APU battery relay to connect the battery bus to the APU DC bus (Sta. 960L).
- (2) Actuating the MASTER switch to the on position (MASTER light on) applies power from the APU DC bus to the control circuit of the master relay, and to the MASTER light.

NOTE The MASTER light indicates that the contacts of the master switch and the NC contacts of the fire lockout relay are closed and that power from the APU DC bus is available to the relay. The light does not indicate the position of the master relay.

- (a) The master relay will actuate when control power is applied if an electrical ground is available to its coil through contacts of the safety relay. (The electrical ground is only available when the airplane is on the ground.) When the master relay actuates, control power from the APU DC bus is applied to open the APU exhaust gas door, to actuate the fuel boost relay and to energize the engine control circuits.
  - 1) When the fuel boost relay actuates, control power from the APU bus is applied to open the fuel supply shutoff valve and to run the fuel supply boost pump.
- (3) In summary, with the airplane on the ground, the APU BATTERY switch in the ON position and the MASTER light on, the APU exhaust gas door will open, pressurized fuel will be available to the engine fuel and control system. The engine control circuits will be energized and the APU will be ready to start.

C APU Starting

NOTE The BLEED AIR switch must be in the OFF position (light out) in order to initiate an engine start

- (1) Momentarily pressing the START switch will apply power from the master relay to the starter relay and start light circuits.
  - (a) The START light will illuminate if power is available to the starter relay through the contacts of the start switch, the oil pressure sequence switch and the 35% switch
  - (b) The start relay (SR) will actuate if an electrical ground is available to its coil through the exhaust door 1 switch. When the SR actuates, power from the APU battery bus is applied to the starter motor and power from the master relay is applied to a self-locking circuit to retain power on SR and on the START light after the start switch is released. In addition, power is interrupted to the battery charger. This prevents the APU battery charger from carrying any of the heavy electrical load of the starter operation.
- (2) When the sequencing oil pressure switch closes, power is applied to the fuel solenoid valve and to the ignition unit. This provides fuel and ignition to initiate combustion. When combustion starts, the gases generated assist the starter motor in accelerating the engine.
- (3) When the 35% switch actuates, power is interrupted to the starter relay and start light circuit.
  - (a) The START light will go out.
  - (b) The starter motor will stop.
  - (c) The APU battery charger will be re-activated
- (4) When the 95% switch actuates, power is removed from the ignition unit and applied to the three-way solenoid valve, the 95% relay and to the hourmeter.
  - (a) When the three-way solenoid valve actuates, the pneumatic thermostat's control output is transferred from the acceleration limited valve to the load control valve to control the pneumatic loading of the engine when bleed air is selected.
  - (b) When the 95% relay actuates its contacts close in the APU generator control and bleed air (load control) valve (close) circuits to allow electrical and pneumatic loads to be applied to the engine

- (c) The hourmeter is energized to time and totalize the hours that the engine operates.

NOTE. After a warm-up period of one minute at governed speed the APU engine is ready for loading electrically and/or pneumatically

D APU Loading

(1) Electrical Power Only

- (a) This configuration provides shaft horsepower exceeding normal generator requirement and no pneumatic power. The turbine engine is not loaded to rated capacity (Generator protective devices would function before the engine is overloaded)

(b) Control Selection and Indication

- 1) GEN TRIPPED - If light on (red), push to reset
- 2) ESSENTIAL POWER selector - Position selector to operating APU on Flight Engineer's upper center panel
- 3) APU CONTACTOR SW - Momentarily select the CLOSE position, green GEN ON BUS annunciator light illuminates

(2) Electrical and Pneumatic Power

- (a) This configuration provides electrical power to 75 amps, and pneumatic power as available to load turbine engine to rated capacity

NOTE Should the 75 amp load be exceeded while air bleed is selected, the generator will trip off line

(b) Control Selection and Indication

As in (1-B) above, except the following

BLEED AIR - On - Depress switch momentarily to select bleed air valve to the open position, blue cover plate will illuminate.

(3) Pneumatic Power Only

(a) This configuration provides pneumatic power only and no electrical power. The turbine engine is not loaded to rated capacity.

(b) Control Selection and Indication

1) GEN TRIPPED - If light on (red) push to reset.

NOTE The generator field control relay should be closed, generator tripped light out, during all APU operations

2) APU CONTACTOR SW - Momentarily select the TRIP position, green GEN ON BUS annunciator will extinguish

E. APU Shutdown (Normal)

NOTE Electrical and pneumatic loads should be removed for an engine cool-down period of one minute prior to engine shutdown

CAUTION DO NOT SHUTDOWN ENGINE BY OPENING THE MASTER SWITCH THIS CAUSES EXCESSIVE HEAT BUILD-UP IN THE APU ENGINE AND EXHAUST DUCTS DUE TO CLOSURE OF THE APU EXHAUST DOOR.

(1) OVERSPEED TEST switch - Press momentarily

(a) The pneumatic solenoid valve will open to actuate the 110% switch.

(b) The 110% switch will remove power from the fuel solenoid valve, the APU load circuit and the holding relay

1) Closure of the fuel solenoid valve shuts down the engine due to fuel starvation

2) Dropout of the holding relay removes all power from the APU engine control circuits.

- (c) The starter control circuit will be locked out by the open normally close oil pressure sequencing switch contacts until they close at approximately 6% RPM

CAUTION· DO NOT OPEN MASTER SWITCH UNTIL ENGINE SHUTDOWN IS COMPLETE (RPM NEEDLE AT REST)--IF OPENED INADVERTENTLY, DO NOT CLOSE MASTER SWITCH UNTIL ENGINE SPIN DOWN IS COMPLETE

- (2) MASTER switch - Actuate to open position, MASTER Light out

- (a) Master relay opens

- 1) APU exhaust door closes

- 2) Fuel boost relay opens

- a) Fuel supply shutoff valve closes

- b) Fuel boost pump stops running

- 3) Control power is removed from generator control unit.

- (3) APU Battery switch - OFF

#### F. Protective Shutdown

- (1) If automatic shutdown of the APU engine occurs due to excessive oil temperature or low oil pressure the HI OIL TEMP or LOW OIL PRESS annunciator light will come on and remain on until the master relay is opened to remove power from the holding circuit

- (2) After noting cause of shutdown

- (a) MASTER switch - Actuate to open position, MASTER light out

- (b) APU BATTERY switch - OFF

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**APU ENGINE CONTROL CIRCUITS**

**DESCRIPTION AND OPERATION**

EFFECTIVITY RTCA LX-N19997 LX-N20000

**1 GENERAL**

- A The APU engine control circuits control power to the APU fuel supply system, the APU battery charger and generator control unit, the APU exhaust door actuator, and to components of the APU engine start, ignition and bleed air systems. Relays and sensors are provided in the circuits to monitor the conditions required for safe operation of the APU engine and to interconnect the selector switches on the APU control panel with the engine, fuel and electrical control components as required to automatically sequence the start, loading and shutdown (normal and protective) of the APU engine. The circuit consists of a master power circuit, engine start circuits, pneumatic and electric loading circuits and engine shutdown circuits, plus the fire detection/fire test circuits of the APU fire protection system (See Subject 49-00-27 ) The engine control circuits require 28 VDC power to actuate the components and relays controlled by the circuits
- B The master power circuits controls power to the generator control unit, the APU fuel supply system, the APU exhaust door actuator and to the engine start, pneumatic and electric loading and engine shutdown circuits
- C The engine start circuit provides control of the start and loading of the APU engine. The circuit interconnects engine control components and control relays as required to automatically sequence the operation of the starter motor, fuel solenoid valve and engine ignition unit as required to initiate engine rotation and combustion, to accelerate the engine to governed speed quickly and safely, and to energize an APU loading circuit when governed speed is reached
- D The pneumatic loading circuits provide for loading the APU engine pneumatically and for limiting the electrical load on the engine when maximum pneumatic power is desired
- E The APU engine shutdown circuits provide for the manual selection of engine shutdown (normal) and for automatic shutdown of the engine through engine protection circuits
- F The APU engine control circuits require 28 VDC power to actuate the engine control components and the control relays provided in the circuits. Control power is available to the master power circuit when the APU BATTERY switch is in the ON position

## 2 MASTER POWER CIRCUIT

- A The master power circuit consists of a master switch and a master relay circuit. Control power is available to the circuit from the APU DC bus through a 15A BUS FEED circuit breaker on the starter relay junction box (Sta. 960L) when the APU BATTERY switch is placed in the ON position.
- (1) The MASTER switch is a push type, alternate action switch-lite located on the APU control panel. When actuated to the closed position, the switch applies power from the CONTROL FEED #1 circuit breaker to the master relay circuit.
  - (2) The master relay circuit provides and controls a master relay that, in turn, controls power to the APU exhaust door actuator, to the APU fuel supply system, and to the engine start, pneumatic and electrical loading and engine shutdown circuits. The circuit monitors the airplane landing gear and APU fire protection system to assure that conditions are safe for APU engine operation before the master relay closes. The circuit illuminates the MASTER switch-lite on the APU control panel when control power is available to the master relay.
- B The master relay circuit consists of a master relay, master relay (MR) actuating circuit, and master relay power circuits.
- (1) The master relay is a single coil, multiple contact relay that requires 28 VDC power and an electrical ground to actuate to the closes position. The contacts of the master relay control power to the master relay power circuits. The master relay is contained in the APU control relay box on Sta. 960L in the aft baggage compartment.
  - (2) The MR actuating circuit consists of a power circuit and an electrical ground circuit.



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- (a) The power circuit connects power from the MASTER switch through normally closed contacts of the fire lockout relay to the MR control coil in parallel with the MASTER light circuit. When the fire lockout relay is in the tripped position (no APU engine fire) control power from the master switch is available to energize the MR coil and to illuminate the MASTER light.
  - (b) The electrical ground circuit connects a ground to the master relay control coil through normally closed contacts of an aircraft safety relay. When the oleo strut of the airplane's right hand landing gear is compressed, airplane on the ground, the safety relay is actuated to provide an electrical ground for the MR coil.
- (3) The master relay power circuits control power from the CONTROL FEED 2 and DOOR MOTOR circuit breakers on the APU starter control relay junction box at Sta 960L
- (a) Power from the CONTROL FEED 1 circuit breaker is controlled through normally open contacts of the master relay to actuate the boost pump relay and to make control power available to the engine start, pneumatic loading and engine shutdown circuits
    - 1) The boost pump relay (BPR) is a single coil, multiple contact relay that requires 28 VDC power to actuate to the closed position. The contacts of the relay apply power from the BOOST PUMP circuit breaker on the APU starter relay box at Sta 960L to the fuel boost pump and to the fuel supply shutoff valve. The BPR is contained in the APU control relay box at Sta 960L.
  - (b) Power from the DOOR MOTOR circuit breaker is connected to the control circuits, ED open and ED close, of the APU exhaust door actuator through normally open and normally closed contacts of the master relay
    - 1) Normally open contacts of the relay apply power to the ED open circuit when the master relay actuates to the closed position.
    - 2) Normally closed contacts of the relay apply power to the ED close circuit when the master relay trips.



#### D Operation

- (1) Control power is available to the master power circuit through the BUS FEED circuit breaker when the APU BATTERY switch on the APU control panel is placed in the ON position. The master relay circuit energized when the MASTER switch is actuated to the closed position
  - (a) The MASTER light will illuminate and control power will be available to the control coil of the master relay if the fire lockout is tripped (no APU engine fire in progress) The master relay will actuate if an electrical ground is available to its control coil through contacts of the aircraft safety relay (airplane on the ground)
- (2) When the master relay actuates to the closed position, APU DC bus power is applied as follows.
  - (a) Power from the DOOR MOTOR circuit breaker is applied to the ED open circuit of the APU exhaust door actuator to open the exhaust door
  - (b) Power from the CONTROL FEED 2 circuit breaker is applied to the control coil of the fuel boost relay When the relay actuates (closes), power from the APU bus is applied to the fuel supply shutoff valve and to the fuel boost pump to make the airplane main tank fuel available for the APU engine operation

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- (c) Control power from the CONTROL FEED 2 circuit breaker is made available to the engine start, pneumatic loading and engine shutdown circuits.
- (3) When the master relay is de-energized, tripped, by actuating the MASTER switch to the open position, by action of the fire lockout relay (APU engine fire) or by action of the safety relay (landing gear oleos extending at airplane lift-off) the following events occur.
  - (a) Power is applied to the ED close circuit of the APU exhaust door actuator to close the exhaust door.
  - (b) Power is removed from the control coil of the fuel boost relay. When the relay trips, power is removed from the fuel supply shutoff valve and the fuel boost pump to shut the valve and to stop the pump.
  - (c) Control power is removed from the engine start, pneumatic and electric loading, and engine shutdown circuits.

### 3. START CIRCUITS

- A The start circuits consists of a starter relay circuit, a fuel-ignition/loading circuit and a holding relay circuit
  - (1) The starter relay circuit controls the operation of the starter motor opens the battery charger circuit, and monitors the position of the exhaust gas door to assure that the door is open before an engine start can be initiated.
  - (2) The fuel-ignition/loading circuits control power to the fuel solenoid valve, to the APU ignition unit and to an APU loading circuit. The circuit monitors engine oil pressure as an indication of the availability of lubrication for the engine and as an indication of engine rotation and airflow to support combustion before fuel is injected and ignition is initiated. In addition, the circuit transfers power from the ignition unit to the APU loading circuit when governed speed is reached.
  - (3) The holding relay maintains power to the start circuits on release of the start switch and prevents re-energizing the fuel-ignition circuit and the starter relay as the engine rotational speed spins down after actuation of the 110% switch causes engine shutdown.
- B The starter relay circuit consists of a starter relay, start light and a starter relay and light control circuit.

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- (1) The starter relay is a single coil, 28 VDC power actuated, heavy duty DC power contactor that requires 28 VDC power and an electrical ground to actuate to the closed position. The contacts of the relay apply power from the battery to the starter motor. The starter relay is contained in the starter relay junction box at Sta. 960L.
- (2) The start light illuminates the coverplate (lens) of the START switch-lite on the APU control panel. The light requires 28 VDC power to illuminate. The light is in parallel with the control coil of the starter relay and illuminates when power is available to the coil.
- (3) The starter relay and light control circuit consists of power circuits to the starter relay coil and start light and an electrical ground circuit to the starter relay coil only.
  - (a) The power circuits consist of a start switch circuit and a holding relay circuit.
    - 1) The start switch circuit is a series circuit that connects 28 VDC power from contacts of the master relay to the starter relay coil and start light through the closed contacts of the BLEED AIR switch in the OFF position, the normally closed contacts of the oil pressure sequencing and 35% switches. Therefore, the BLEED AIR switch must be in the OFF position (BLEED AIR light out), the oil pressure sequencing and 35% switches must be closed (engine RPM below 6%), and the START switch must be actuated (pressed) before power from the master relay is available to energize the starter relay coil and to illuminate the start light.

NOTE. In this circuit the START light indicates that control power is available to the starter relay
    - 2) The holding relay circuit closes normally open contacts in parallel with the start switch and oil pressure sequence switch contacts maintaining power to itself, the starter relay circuit, and the fuel-ignition/loading circuit

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**NOTE** When the START switch is released, the START light as powered by this circuit indicates that the starter relay has actuated and that the starter motor should be operating (engine RPM increasing)

- (b) The electrical ground circuit connects a ground to the starter relay coil through normally open contacts of the exhaust door switch 1. Therefore, the exhaust door switch must be actuated to the closed position (exhaust door fully open) before a ground is available to complete the starter relay control circuit.
  - (c) The starter relay and start light circuit is initially energized when the START switch is (momentarily) pressed. Power is retained on the circuit by contacts of the hold relay when the START switch is released. The circuit is de-energized when power to the starter relay coil is interrupted by actuation of the 35% switch when engine rotational speed reaches 35% RPM.
- C** The fuel-ignition/loading circuits consist of a fuel circuit, an ignition circuit and a loading circuit. The fuel circuit controls power to the fuel solenoid valve and to the 95% switch. The 95% switch controls power to the ignition circuit and the loading circuit.
- (1) The fuel circuit consists of the holding relay and a fuel solenoid control circuit.
    - (a) The holding relay is a single 28 VDC coil, multiple contact, relay located in the APU control relay box at Sta 960L.
    - (b) The fuel solenoid control circuit is a series circuit that applies 28 VDC to the holding relay coil initially through the start switch and the normally closed contacts of the oil pressure sequencing and 110% switches, then through closed normally open contacts of the holding relay in series with normally closed contacts of the low oil pressure (LOP) and high oil temperature (HOT) relays and the 110% switch. The power train continues from the 110% switch through normally closed contacts of the lockout relay and normally open contacts of the oil pressure sequencing switch to the 95% switch and the fuel solenoid. The oil pressure sequencing switch contacts close to complete the circuit due to oil pressure build-up as the starter rotates the engine.

- (2) The ignition circuit consists of the ignition unit and igniter plug. The circuit is energized by power from the fuel solenoid control circuit through normally closed contacts of the 95% switch. The circuit is de-energized by actuation of the 95% switch when the engine's rotational speed reaches 95% RPM. This action completes the start cycle and transfers power to the loading circuit.
- (3) The loading circuit applies 28 VDC power to the three-way solenoid valve, the 95% relay and to the hourmeter. The circuit is energized by power from the fuel solenoid control circuit when the normally open contacts of the 95% switch are actuated to close.
  - (a) The three-way solenoid valve is an engine control component mounted on the engine.
  - (b) The 95% relay is a single coil, multiple contact relay that requires 28 VDC power for actuation to the closed position. Normally open contacts of the relay are used in the control circuits to the APU generator protection panel, the bleed air valve and to the low oil pressure relay. This prevents loading of the APU during the start cycle and prevents actuation of the low oil pressure engine protective circuit during normal engine shutdown.
  - (c) The hourmeter is an engine indicating component mounted above the accessory section of the APU engine. (See APU Engine Indicating, Subject 49-70-02.)
- (4) The fuel solenoid valve remains open and the loading circuit remains energized until control power to the circuit is interrupted by actuation of the 110% switch or by opening (tripping) the master relay.

**NOTE** APU engine shutdown should not be initiated by actuating the MASTER switch to the open (MASTER light, out) position.

#### D Operation

- (1) Momentarily pressing the START switch will apply power to the starter relay, START light and to the fuel solenoid control circuit.



- (a) The START light will come on
  - (b) The starter relay will actuate (close) if an electrical ground is available through the exhaust door 1 switch
  - (c) The holding relay will close.
- (2) When the holding relay closes, its self-locking (holding) circuit is completed.
- (a) The START light remains on after the START switch released
  - (b) The starter motor is energized to initiate engine rotation
  - (c) The battery charger control unit in the starter relay box disconnects operating power from the APU battery charger
- (3) As engine oil pressure increases due to engine rotation, the sequencing oil pressure switch closes to complete the fuel solenoid control circuit
- (a) The fuel solenoid valve opens to supply fuel to the fuel nozzles
  - (b) The ignition circuit is energized through the normally closed contacts of the 95% switch to ignite the fuel-air mixture and initiate combustion
- (4) At 35% RPM, the 35% switch actuates to interrupt power in the starter relay and start light circuit.
- (a) The START light goes out
  - (b) The starter relay trips
    - 1) The starter is de-energized
    - 2) The battery charger control unit connects the APU battery charger to its power source
- (5) At 95% RPM the 95% switch actuates to remove fuel solenoid control circuit power from the ignition circuit and apply it to the load circuit. This completes the start cycle of the APU engine
- (a) The three-way solenoid valve is actuated to transfer the pneumatic thermostat control of engine exhaust gas temperature from the acceleration limiter valve, of the engine fuel and control system, to the load control valve, of the engine bleed air system.



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- (b) The 95% relay is actuated to close its contacts in the APU generator control circuit, the low oil pressure relay power circuit and the bleed air (load control) valve circuit.
- (c) The hourmeter is energized to time and totalize APU operation speed.

### 4 PNEUMATIC LOADING CIRCUIT

- A The pneumatic loading circuit consists of a bleed air circuit
  - (1) The bleed air circuit provides for pneumatic loading of the APU engine by manual actuation of the BLEED-AIR switch on the APU control panel.
  - (2) The pneumatic loading circuit receives 28 VDC power from the APU DC bus through contacts of the master relay
- B The bleed air circuit connects power from the master relay to the load control valve of the engine bleed air system, and to the light (bulbs) in the BLEED AIR switch-lite on the APU panel
  - (1) The load control valve circuit is a series circuit consisting of normally open contacts of the 95% relay and the BLEED AIR switch. The contact of the 95% relay prevent actuation of the load control valve before the APU engine reaches 95% RPM and also serve to remove the pneumatic load if the load control valve was not closed prior to engine shutdown
  - (2) The bleed air light is power through contacts of the BLEED AIR switch only. This provides an indication of the switch position when the MASTER switch is closed so that the switch, if closed, can be actuated to the open position (BLEED AIR light out) before starting the APU engine.
  - (3) The switch contacts are closed in both circuits when the BLEED AIR switch is in the AIR position (BLEED AIR light on):

### 5 ENGINE SHUTDOWN CIRCUITS

- A The engine shutdown circuits consists of normal and engine protective circuits that control power to the pneumatic solenoid valve on the centrifugal switch assembly of the engine control components. Power is available to the circuits when the master relay closes

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- (1) The normal engine shutdown circuit provides the manual selection of engine shutdown on the APU control panel.
  - (2) The engine protection circuits provide automatic shutdown of the engine if the engine oil temperature or pressure is not within specific limits. Annunciator lights are provided on the APU control panel to indicate the cause of automatic engine shutdown.
- B. The normal engine shutdown circuit connects power from the master relay to the pneumatic solenoid valve through the normally open contacts of the OVERSPEED TEST switch on the APU control panel.
- C. The engine protection circuits consist of high oil temperature circuit and a low oil pressure circuit.
- (1) The high oil temperature circuit consists of a high oil temperature relay (HOT), a HOT switch and an engine high oil temperature (HOT) shutdown circuit.
    - (a) The HOT relay is a single coil, multiple contact relay that requires 28 VDC power and an electrical ground for actuation. Control power is available to the HOT switch when the master relay closes and to the HOT relay and HIGH OIL TEMP annunciator light when the switch closes. The relay is contained in the APU control relay box at Sta 960L.
    - (b) HOT relay contacts close in parallel with the HOT switch to hold the HOT relay.
    - (c) HOT relay normally closes contacts open the holding loop to the fuel/holding/loading circuit of the APU engine to shut it down.
  - (2) The low oil pressure circuit consists of a low oil pressure relay (LOP), a LOP switch circuit and an engine low oil pressure (LOP) shutdown circuit.
    - (a) The LOP relay is a single coil, multiple contact relay that requires 28 VDC power and an electrical ground for actuation. Control power is available to the LOP switch when the relay coil closes and to the LOP relay and LOW OIL PRESSURE annunciator light when the 95% switch closes. The relay is contained in the APU control relay box at Sta 960L.
    - (b) LOP relay contacts close in parallel with the LOP switch to hold the LOP relay.

- (c) LOP relay normally closed contacts open the holding loop to the fuel/holding loading circuit of the APU engine to shut it down.

## 6 OPERATION

A. Operation of an APU consists of four steps, preparing to start, starting, loading and shutdown. Each step is manually initiated through selector switches provided on the APU control panel. However, the engine control circuits monitor the conditions required for safe operation of the APU engine before power is applied to actuate start and loading control components.

### B Preparing to Start APU

- (1) Placing the APU BATTERY switch to the ON position actuates the APU battery relay to connect the battery bus to the APU DC bus (Sta 960L).
- (2) Actuating the MASTER switch to the ON position (MASTER light on) applies power from the APU DC bus to the control circuit of the master relay, and to the MASTER light.

NOTE. The MASTER light indicates that the contacts of the master switch and the NC contacts of the fire lockout relay are closed and that power from the APU DC bus is available to the relay. The light does not indicate the position of the master relay.

- (a) The master relay will actuate when control power is applied if an electrical ground is available to its coil through contacts of the safety relay. (The electrical ground is only available when the airplane is on the ground.) When the master relay actuates, control power from the APU DC bus is applied to open the APU exhaust gas door, to actuate the fuel boost relay and to energize the engine control circuits.
  - 1) When the fuel boost relay actuates, control power from the APU bus is applied to open the fuel supply shutoff valve and to run the fuel supply boost pump.
- (3) In summary, with the airplane on the ground, the APU BATTERY switch in the ON position and the MASTER light on, the APU exhaust gas door will open, pressurized fuel will be available to the engine fuel and control system. The engine control circuits will be energized and the APU will be ready to start.

### C. APU Starting

**NOTE.** The BLEED AIR switch must be in the OFF position (Light out in order to initiate an engine start.

- (1) Momentarily pressing the START switch will apply power from the master relay to the starter relay and start light circuits
  - (a) The START light will illuminate if power is available to the starter relay through the contacts of the start switch, the oil pressure sequence switch and the 35% switch
  - (b) The start relay (SR) will actuate if an electrical ground is available to its coil through the exhaust door 1 switch. When the SR actuates, power from the APU battery bus is applied to the starter motor and power from the master relay is applied to a self-locking circuit to retain power on SR and the START light after the start switch is released. In addition, power is interrupted to the battery charger. This prevents the APU battery charger from carrying any of the heavy electrical load of the starter operation.
- (2) When the sequencing oil pressure switch closes, power is applied to the fuel solenoid valve and to the ignition unit. This provides fuel and ignition to initiate combustion. When combustion starts, the gases generated assist the starter motor in accelerating the engine.
- (3) When the 35% switch actuates, power is interrupted to the starter relay and start light circuit
  - (a) The START light will go out.
  - (b) The starter motor will stop
  - (c) The APU battery charger will be re-activated
- (4) When the 95% switch actuates, power is removed from the ignition unit and applied to the three-way solenoid valve, the 95% relay and to the hourmeter
  - (a) When the three-way solenoid valve actuates, the pneumatic thermostat's control output is transferred from the acceleration limited valve to the load control valve to control the pneumatic loading of the engine when bleed air is selected
  - (b) When the 95% relay actuates its contacts close in the APU generator control and bleed air (load control) valve (close) circuits to allow electrical and pneumatic loads to be applied to the engine

- (c) The hourmeter is energized to time and totalize the hours that the engine operates

NOTE. After a warm-up period of one minute of governed speed the APU is ready for loading electrically and/or pneumatically

#### D APU Loading

##### (1) Electrical Power Only

- (a) This configuration provides shaft horsepower exceeding normal generator requirement and no pneumatic power. The turbine engine is not loaded to rated capacity. (Generator protective devices would function before the engine is overloaded.)

##### (b) Control Selection and Indication

- (1) GEM TRIPPED - If light on (red), push to reset
- (2) ESSENTIAL POWER SELECTOR - Position selector to operating APU on Flight Engineer's upper center panel
- (3) APU CONTACTOR SW - Momentarily select the CLOSE position, green GEN ON BUS annunciator light illuminates

##### (2) Electrical and Pneumatic Power

- (a) This configuration provides electrical power to 75 amps, and pneumatic power as available to load turbine engine to rated capacity

NOTE Should the 75 amp load be exceeded while air bleed is selected, the generator will trip off line

(b) Control Selection and Indication

As in (1-B) above, except the following

**BLEED AIR - ON** - Depress switch momentarily to select bleed air valve to the open position, blue cover plate will illuminate.

(3) Pneumatic Power Only

(a) This configuration provides pneumatic power only and no electrical power. The turbine engine is not loaded to rated capacity.

(b) Control Selection and Indication

(1) **GEN TRIPPED** - If light on (red) push to reset

**NOTE** The generator field control relay should be closed, generator tripped light out, during all APU operations

(2) **APU CONTACTOR SW** - Momentarily select the TRIP position, green GEN ON BUS annunciator will extinguish.

E APU Shutdown (Normal)

**NOTE** Electrical and pneumatic loads should be removed for an engine cool-down period of one minute prior to engine shutdown

**CAUTION** DO NOT SHUTDOWN ENGINE BY OPENING THE MASTER SWITCH. THIS CAUSES EXCESSIVE HEAT BUILD-UP IN THE APU ENGINE AND EXHAUST DUCTS DUE TO CLOSURE OF THE APU EXHAUST DOOR.

(1) OVERSPEED TEST switch - Press momentarily

(a) The pneumatic solenoid valve will open to actuate the 110% switch.

(b) The 110% switch will remove power from the fuel solenoid valve, the APU load circuit and the holding relay

(1) Closure of the fuel solenoid valve shuts down the engine due to fuel starvation

(2) Dropout of the holding relay removes all power from the APU engine control circuits.

- (c) The starter control circuit will be locked out by the open normally close oil pressure sequencing switch contacts until they close at approximately 6% RPM

**CAUTION** DO NOT OPEN MASTER SWITCH UNTIL ENGINE SHUTDOWN IS COMPLETE (RPM NEEDLE AT REST)—IF OPENED INADVERTENTLY, DO NOT CLOSE MASTER SWITCH UNTIL ENGINE SPIN DOWN IS COMPLETE

- (2) MASTER SWITCH - Actuate to open position, MASTER Light out
  - (a) Master relay opens
    - (1) APU exhaust door closes
    - (2) Fuel boost relay opens
      - (a) Fuel supply shutoff valve closes
      - (b) Fuel boost pump stops running
    - (3) Control power is removed from generator control unit
  - (3) APU Battery switch - OFF

F Protective Shutdown

- (1) If automatic shutdown of the APU engine occurs due to excessive oil temperature or low oil pressure the HI OIL TEMP or LOW OIL PRESS annunciator light will come on and remain on until the master relay is opened to remove power from the holding circuit
- (2) After noting cause of shutdown
  - (a) MASTER SWITCH - Actuate to open position, MASTER light out
  - (b) APU BATTERY SWITCH - OFF.

EFFECTIVITY TCA LX-N20198 LX-N20199

APU ENGINE INDICATING SYSTEM

DESCRIPTION AND OPERATION

1. GENERAL

- A. The APU engine indicating systems provide the information necessary to monitor the starting and operation of the unit. The indications provided on the APU control panel are door closed and door open lights, exhaust gas temperature, engine RPM, and a start light. In addition, an APU exhaust door open light is provided on the first officer's door annunciator panel and an hourmeter is mounted in the accessory section of the engine.

NOTE: This section covers only the APU engine indicating systems. For APU generator indicators see Subject 24-13-0, and for fire warning indicators see Subject 49-00-26.

2. EXHAUST GAS TEMPERATURE INDICATING SYSTEM

- A. The APU exhaust gas temperature (EGT) indicating system measures the APU engine exhaust gas temperature and displays the temperature value on the EGT indicator on the APU control panel.
- B. A thermocouple probe, projecting into the exhaust gas stream, is mounted in the exhaust nozzle ring. Chromel and alumel wiring connects the probe to the engine harness connector. A variable resistor is included in the engine circuit to allow the total resistance of the system to be adjusted during maintenance.

3. APU ENGINE RPM (TACHOMETER) SYSTEM

- A. The APU tachometer system provides an indication of the rotary speed of the APU turbine. A tachometer generator supplies a three-phase signal to drive the indicator.
- B. The tachometer generator is mounted on the accessory section of the engine and is driven by the accessory gearcase train. It is a standard tachometer generator consisting of a stator and rotor. The rotor rotates inside the stator coils and generates a three-phase alternating signal with a frequency that varies with the turbine speed. This generated signal is fed to the tachometer indicator by a two-wire conductor, the third phase is completed through ground connections.

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- C. The tachometer indicator, mounted on the APU control panel, receives the signal from the tachometer generator and converts it to a visual indication of APU engine speed, % RPM (percent of governed speed). The indicator consists of a three-phase synchro-motor driving an induction drag cup mechanism. The speed of the synchro-motor varies with the input frequency and is therefore always rotating at the same speed as the generator. A pointer moves across the graduated dial, on the face of the indicator, by an amount proportional to the speed of the synchro-motor, to provide the indication of APU engine speed.
4. APU START LIGHT
- A. The APU start light, contained within the start switch-light on the APU control panel, indicates when the starter relay is energized. The light comes on and the start relay is energized when the start circuit keeps the relay energized and the start light on, after the start switch is released, until the 35% switch opens to interrupt power to the relay coil and to the light. Therefore, the start light provides a multiple indication, it indicates starter relay energization, starter relay operation, 35% switch operation and starter relay de-energization during a start cycle.
5. DOOR CLOSED LIGHT
- A. The APU DOOR CLOSED light on the APU control panel indicates that the APU exhaust door is fully closed. A ground is provided for the light through normally open contacts of the Exhaust Door Switch #2.
6. DOOR OPEN LIGHT
- A. The APU DOOR OPEN light on the APU control panel indicates that the APU exhaust door is fully open. A ground is provided for the light through normally open contacts of the Exhaust Door Switch #1.
7. APU EXHAUST DOOR OPEN LIGHT
- A. The APU exhaust door open light on the first officer's door annunciator panel indicates that the APU exhaust door is not in the fully closed position. A ground is provided for the light through the NC contacts of the Exhaust Door Switch #2.
8. APU HOURMETER
- A. The hourmeter is energized when the 95% switch transfers power from the ignition unit to the APU loading circuits. Therefore, it records throughout the APU operating periods to give a visual indication of the number of hours that the APU has been operated since the meter was reset to zero. The meter is basically an electric clock with a digital indicating dial that shows the total operating time in hours and tenths of hours. The meter is mounted on a shock absorbing bracket in the accessory section of the APU engine.



MAINTENANCE MANUAL

EFFECTIVITY TCA LX-N20198 LX-N20199

EXHAUST GAS TEMPERATURE THERMOCOUPLE - MAINTENANCE PRACTICES

1. Removal/Installation

Table 201. Materials and Compounds

---

Material or Compound

Manufacturer

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NOTE: Equivalent substitutes may be used for listed item.

High temperature compound  
(Felt-Pro C-5A)

Felt-Pro Inc, Division of Felt Products  
Mfg Co, 7450 North McCormick Blvd.  
Skokie, IL 60076

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A Remove Exhaust Gas Temperature Thermocouple

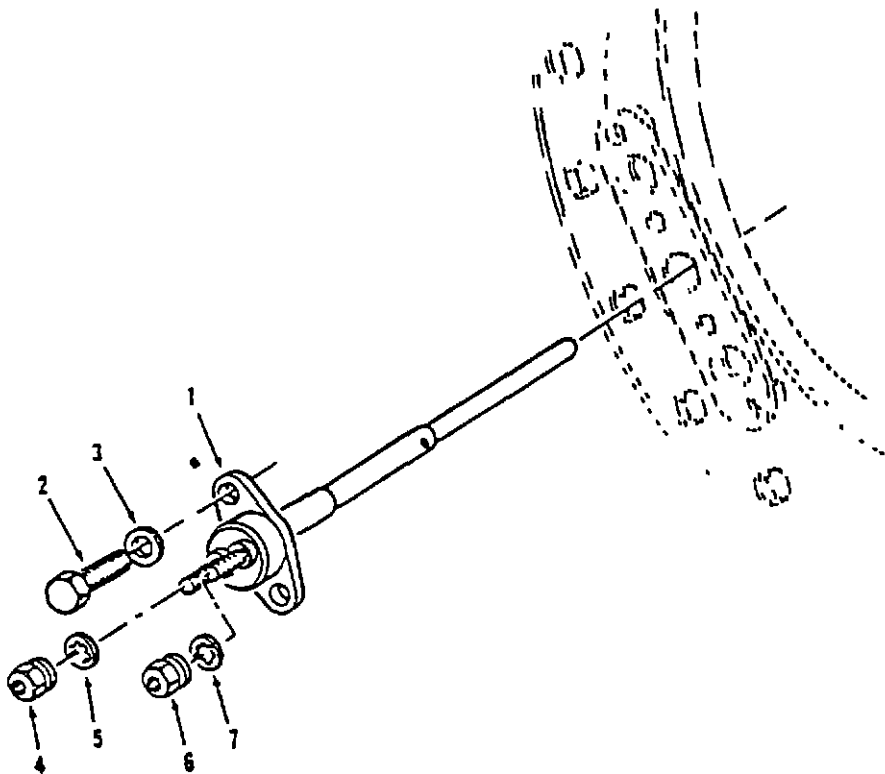
CAUTION EXERCISE CARE WHEN REMOVING LOCKNUTS  
TO PREVENT DAMAGE TO THERMOCOUPLE.

- (1) Remove locknuts and harness assembly leads from terminals of exhaust gas temperature thermocouple
- (2) Remove attaching bolts and washers (See figure 201.)
- (3) Carefully withdraw exhaust gas temperature thermocouple from exhaust duct flange assembly.

B. Install Exhaust Gas Temperature Thermocouple

- (1) Install exhaust gas temperature thermocouple in exhaust duct flange assembly (See figure 201.)
- (2) Coat threads of attaching bolts with high temperature compound (table 201).
- (3) Secure exhaust gas temperature thermocouple with washers and bolts.
- (4) Tighten bolts to torque value of 50 to 70 inch-pounds.

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- |                       |            |
|-----------------------|------------|
| 1. THERMOCOUPLE (ECT) | 5. WASHER  |
| 2. BOLT               | 6. LOCKNUT |
| 3. WASHER             | 7. WASHER  |
| 4. LOCKNUT            |            |

Exhaust Gas Temperature Thermocouple Removal/Installation  
Figure 201

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- (5) Reconnect harness assembly leads to exhaust gas temperature thermocouple terminals, matching Chromel lead to CR and Alumel lead to AL marked terminals.

CAUTION DO NOT EXCEED 25 INCH-POUNDS  
TIGHTENING TORQUE AT AL TERMINAL  
AND 15 INCH-POUNDS TIGHTENING  
TORQUE AT CR TERMINAL WHEN TIGHT-  
ENING LOCKNUTS.

- (6) Install locknuts to secure harness assembly leads.

## 2. Inspection/Check

### A. Check Exhaust Gas Temperature Thermocouple

- (1) Check exhaust gas temperature thermocouple if special facilities are available.
- (2) Provide a surrounding temperature of 677C (1250F), exhaust gas temperature thermocouple shall register 28.00 to 28.30 millivolts.
- (3) If special facilities are not available, place thermocouple in a holder.
- (4) Connect a millivoltmeter (register to 1.6 volts dc full scale deflection) to terminal connections on thermocouple.
- (5) Apply heat to thermocouple in area of sensing holes. As heat is applied millivoltmeter shall register increase. If increase is noted, thermocouple is acceptable. If no increase is noted, thermocouple is defective and shall be replaced.
- (6) Using a multimeter, measure resistance from each stud to body. Resistance shall be 20,000 ohms minimum at 20C (68F) or 10,000 ohms minimum at 649C (1200F).

**APU ENGINE INDICATING SYSTEM**  
**DESCRIPTION AND OPERATION**

EFFECTIVITY RTCA LX-N19997 LX-N20000

**1 GENERAL**

- A The APU engine indicating systems provide the information necessary to monitor the starting and operating of the unit. The indications provided on the APU control panel are door closed and door open lights, exhaust gas temperature, engine RPM, and a start light. In addition, an APU exhaust door open light is provided on the first officer's door annunciator panel and an hourmeter is mounted in the accessory section of the engine.

**NOTE:** This section covers only the APU engine indicating systems. For APU generator indicators see Subject 24-49-0, and for fire warning indicators see Subject 49-00-27.

**2. EXHAUST GAS TEMPERATURE INDICATING SYSTEM**

- A. The APU exhaust gas temperature (EGT) indicating system measures the APU engine exhaust gas temperature and displays the temperature value on the EGT indicator on the APU control panel.
- B A thermocouple probe, projecting into the exhaust gas stream, is mounted in the exhaust nozzle ring. Chromel and alumel wiring connects the probe to the engine harness connector. A variable resistor is included in the engine circuit to allow the total resistance of the system to be adjusted during maintenance.

**3 APU ENGINE RPM (TACHOMETER) SYSTEM**

- A The APU tachometer system provides an indication of the rotary speed of the APU turbine. A tachometer generator supplies a three-phase signal to drive the indicator.
- B The tachometer generator is mounted on the accessory section of the engine and is driven by the accessory gearcase train. It is a standard tachometer generator consisting of a stator and rotor. The rotor rotates inside the stator coils and generates a three-phase alternating signal with a frequency that varies with the turbine speed. This generated signal is fed to the tachometer indicator by a two-wire conductor, the third phase is completed through ground connections.

C The tachometer indicator, mounted on the APU control panel, receives the signal from the tachometer generator and converts it to a visual indication of APU engine speed, % RPM (percent of governed speed). The indicator consists of a three-phase synchro-motor driving an induction drag cup mechanism. The speed of the synchro-motor varies with the input frequency and is therefore always rotating at the same speed as the generator. A pointer moves across the graduated dial, on the face of the indicator, by an amount proportional to the speed of the synchro-motor, to provide the indication of APU engine speed.

#### 4 APU START LIGHT

A The APU start light, contained within the start switch-light on the APU control panel, indicates when the starter relay is energized. The light comes on and the start relay is energized when the start circuit keeps the relay energized and the start light on, after the start switch is released, until the 35% switch opens to interrupt power to the relay coil and to the light. Therefore, the start light provides a multiple indication, it indicates starter relay energization, starter relay operation, 35% switch operation and starter relay de-energization during a start cycle.

#### 5 DOOR CLOSED LIGHT

A The APU DOOR CLOSED light on the APU control panel indicates that the APU exhaust door is fully closed. A ground is provided for the light through normally open contacts of the Exhaust Door Switch #2.

#### 6 DOOR OPEN LIGHT

A The APU DOOR OPEN light on the APU control panel indicates that the APU exhaust door is fully open. A ground is provided for the light through normally open contacts of the Exhaust Door Switch #1.

#### 7 APU EXHAUST DOOR OPEN LIGHT

A The APU exhaust door open light on the first officer's door annunciator panel indicates that the APU exhaust door is not in the fully closed position. A ground is provided for the light through the NC contacts of the Exhaust Door Switch #1.

#### 8 APU HOURMETER

A The hourmeter is energized when the 95% switch transfers power from the ignition unit to the APU loading circuits. Therefore, it records throughout the APU operating periods to give a visual indication of the number of hours that the APU has been operated since the meter was reset to zero. The meter is basically an electric clock with a digital indicating dial that shows the total operating time in hours and tenths of hours. The meter is mounted on a shock absorbing bracket in the accessory section of the APU engine.

**EXHAUST GAS TEMPERATURE THERMOCOUPLE - MAINTENANCE PRACTICES**

EFFECTIVITY RTCA LX-N19997 LX-N20000

**1 REMOVAL/INSTALLATION**

Table 201 Materials and compounds

Material or Compound

Manufacturer

**NOTE** Equivalent substitutes may be used for listed item

High temperature compound  
(Fel-Pro C-5A) -

Fel-Pro Inc, Division of Felt Products Mfg Co  
7450 North McCormick Blvd  
Skokie, Illinois 60076

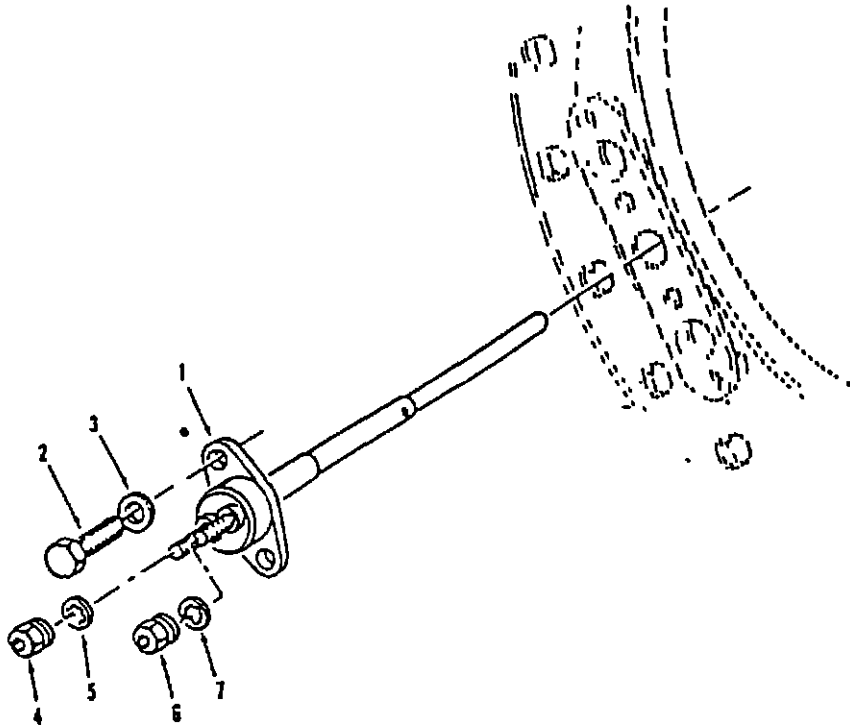
**A Remove exhaust Gas Temperature Thermocouple**

**CAUTION EXERCISE CARE WHEN REMOVING  
LOCKNUTS TO PREVENT DAMAGE TO  
THERMOCOUPLE**

- (1) Remove locknuts and harness assembly leads from terminals of exhaust gas temperature thermocouple
- (2) Remove attaching bolts and washers (See Figure 201 )
- (3) Carefully withdraw exhaust gas temperature thermocouple from exhaust duct flange assembly

**B Install exhaust Gas Temperature Thermocouple**

- (1) Install exhaust gas temperature thermocouple in exhaust duct flange assembly (See Figure 201 )
- (2) Coat threads of attaching bolts with high temperature compound (Table 201)
- (3) Secure exhaust gas temperature thermocouple with washers and bolts
- (4) Tighten bolts to torque value of 50 to 70 inch-pounds



- |                       |            |
|-----------------------|------------|
| 1. THERMOCOUPLE (ECT) | 5. WASHER  |
| 2. BOLT               | 6. LOCKNUT |
| 3. WASHER             | 7. WASHER  |
| 4. LOCKNUT            |            |

### EXHAUST GAS TEMPERATURE THERMOCOUPLE REMOVAL/INSTALLATION

FIGURE 201

Ref MM STEWARD-DAVIS



## MAINTENANCE MANUAL

- (5) Reconnect harness assembly leads to exhaust gas temperature thermocouple terminals, matching Chromel lead to CR and Alumel lead to AL marked terminals.

**CAUTION** DO NOT EXCEED 25 INCH-POUNDS TIGHTENING TORQUE AT AL TERMINAL AND 15 INCH-POUNDS TIGHTENING TORQUE AT CR TERMINAL WHEN TIGHTENING LOCKNUTS

- (6) Install locknuts to secure harness assembly leads

### 2 Inspection/Check

#### A Check Exhaust Gas Temperature Thermocouple

- (1) Check exhaust gas temperature thermocouple if special facilities are available
- (2) Provide a surrounding temperature of 677 (1250F), exhaust gas temperature thermocouple shall register 28 00 to 28 30 millivolts
- (3) If special facilities are not available, place thermocouple in a holder
- (4) Connect a millivoltmeter (register to 1 6 volts dc full scale deflection) to terminal connections on thermocouple
- (5) Apply heat to thermocouple in area of sensing holes As heat is applied millivoltmeter shall register increase If increase is noted, thermocouple is acceptable If no increase is noted, thermocouple is defective and shall be replaced
- (6) Using a multimeter, measure resistance from each stud to body Resistance shall be 20,000 ohms minimum at 20C (68F) or 10,000 ohms minimum at 649C (1200F)

APU EXHAUST SYSTEM

DESCRIPTION AND OPERATION

1. GENERAL

- A. The APU exhaust systems discharge the APU exhaust gases and cooling air overboard, provide a thermal barrier to shield the aft cargo compartment and the airplane structure from the high temperature of the exhaust gases, and they reduce the exhaust noise level. The APU exhaust system consists of an inboard and outboard exhaust assembly, an exhaust door, an exhaust door actuator, an exhaust door open and an exhaust door closed switch.
- B. The inboard and outboard exhaust assemblies consist of an outer exhaust duct and an inner exhaust duct that form an annular shaped cooling air chamber. The outer duct serves as the outer surface of the cooling air chamber and as the support structure for the assembly. The inner duct carries the hot exhaust gases and it is positioned concentric to the outer duct to form the inner surface of the cooling air chamber. The inner duct of the inboard exhaust assembly is smaller (8 inch I.D.) and extends, approximately one inch, into the larger (10 inch I.D.) inner duct of the outboard exhaust assembly to form an eductor section (a low pressure area created by the expansion of the exhaust gases as they pass into the outboard exhaust assembly) that draws air from the APU housing and from outside of the airplane body through the cooling air chambers of the exhaust assemblies. In addition to providing a thermal barrier to shield the aft cargo compartment and the airplane structure the cooling air mixes with the exhaust gases to reduce the temperature of the gases discharged overboard. All ducting, inner and outer, is made from corrosion resistant steel. The outer ducting is covered with a ceramic fiber insulation to provide a non-wetting thermal insulation of the exhaust system.
- C. The APU exhaust door provides an aerodynamically clean cover over the exhaust duct, when closed, and prevents the entry of foreign material into the APU engine and housing when the APU is not operating.
- D. The exhaust door actuator receives 28 VDC power from the APU aft DC bus through contacts of the APU master relay to open the exhaust door when the master relay closes (MASTER switch, ON) and to close the exhaust door when the master relay opens (MASTER switch, OFF).
- E. The exhaust door open switch provides a ground for the starter relay when the door reaches the fully open position. The exhaust door closed switch provides a ground for the door open light, on the first officer's door annunciator panel, when the door leaves the fully closed position. The switches are mounted to support structure and are actuated when the door reaches, or leaves, the open, or closed position.

## 2. APU INBOARD EXHAUST DUCT ASSEMBLY

- A. The APU inboard exhaust assembly provides the first level of noise reduction in the exhaust system by abruptly changing the direction of the exhaust gas flow. The abrupt change in direction, approximately  $158^{\circ}$ , practically eliminates the high frequency noise and, in addition, the change in direction creates turbulent flow that reduces the low frequency noise. The inner surface of the inner duct is protected by a ceramic coating to absorb the scrubbing action of the high temperature exhaust gases. The inner duct of the assembly is clamped directly to the exhaust flange of the turbine engine and is provided additional support through a foot located at approximately the mid-point of the bend. Spring clips maintain the relative position of the inner duct within the outer duct, but they do not provide any real support for the duct. Since the inner duct of the inboard exhaust assembly does not attach to the inner duct of the outboard exhaust assembly, provision for thermal expansion between the ducts is not required. The outer duct section of the assembly clamps directly to the cooling air outlet flange of the APU upper housing and to the outer duct of the outboard exhaust assembly. Two bellow sections in the outer duct of the inboard exhaust assembly absorb the thermal expansion and contraction of both outer duct sections.

3. APU EXHAUST DOOR

A The APU exhaust door provides the means of closing the gas outlet opening in the wing-to-body fairing. The exhaust door is located at body station 960M + 12.75 just aft of the wing flap fence. The door is hinged along its lower edge and actuates outward to the open position. The door is fabricated from corrosion resistant steel plate.

4. APU EXHAUST DOOR SWITCH #1

A. The APU exhaust door switch #1 prevents the APU from being started until the exhaust door is fully open and provides an indication on the APU control panel to that effect when the door reaches the fully open position. When actuated, the switch provides a ground for the starter relay.

5. APU EXHAUST DOOR SWITCH #2

A The APU exhaust door switch #2 provides an indication on the APU control panel when the exhaust door is in the fully closed position and in the control cabin when the door is not in the fully closed position. The switch is a plunger operated switch that applies a ground to the exhaust door open light on the first officer's door annunciator panel when the door leaves the fully closed position and to the door closed light on the APU control panel when the door reaches the fully closed position.

6. APU EXHAUST DOOR ACTUATION

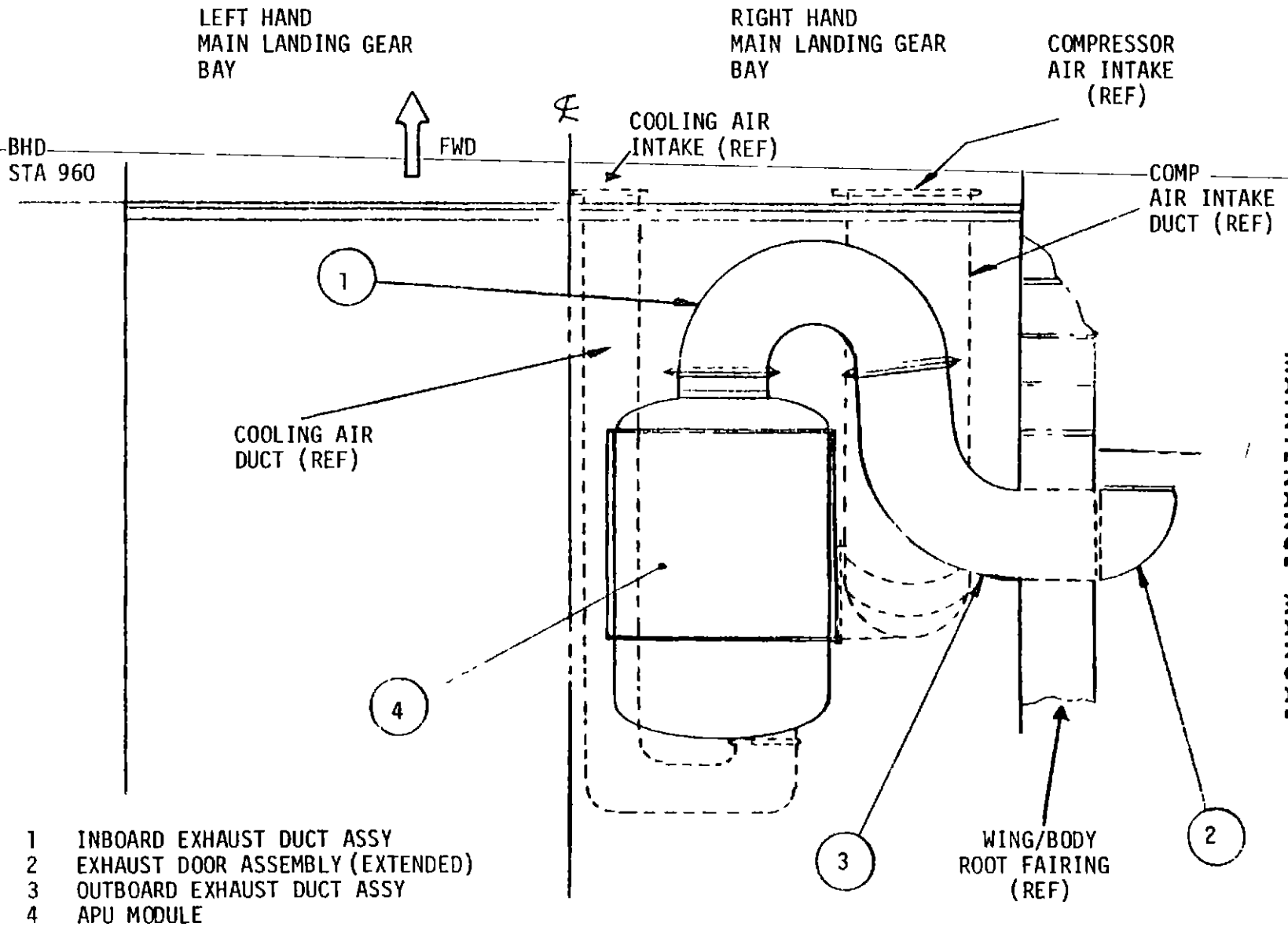
A The APU exhaust door actuator controls the opening and closing of the exhaust door. The actuator includes an electric motor, reduction gear train and internal limit switches. The internal limit switches interrupt control power to the actuator motor when full travel of the door is reached, open/closed.

B The actuator receives 28 VDC APU battery power from the APU DC bus through contacts of the master relay. When the master relay closes (MASTER switch ON) power is applied to the open windings of the actuator motor and when the master relay is open (MASTER switch OFF) power is applied to the close windings of the actuator motor.

## 7. OPERATION

- A. With the APU battery switch in the ON position, placing the APU master switch in the ON position will apply control power to the coil of the master relay. When the master relay closes, power from the APU aft bus is applied to the open windings of the exhaust door actuator to open the exhaust door. As the door leaves the closed position, the exhaust door open light on the first officer's door annunciator panel will come on and the door closed light on the APU control panel will go off, and when the door reaches the fully open position, a ground is applied to the coil of the starter relay and the door open light on the APU control panel. The starter relay can now be actuated to energize the starter motor when an APU start is desired.
- B. When the unit is operating, the exhaust gases leaving the unit pass through the eductor section at the junction of the inner ducts of the inboard and outboard exhaust assemblies. The exhaust gases leaving the eductor section draw air from the APU housing and from outside the airplane body through the cooling air chambers of the exhaust assemblies. In addition to providing a thermal barrier, between the hot exhaust gases and the aft cargo compartment and the airplane body structure, the cooling air mixes with the exhaust gases to reduce the temperature of the gas discharged overboard.
- C. When the MASTER switch is placed in the OFF position, the master relay will open and apply power to the close windings of the exhaust door actuator. When the door reaches the fully closed position, the exhaust door open light on the first officer's door annunciator panel will go off and the door closed light on the APU control panel will come on.

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APU EXHAUST SYSTEM  
(AFT BAGGAGE COMPARTMENT)  
FIGURE 1

BOEING  
707  
Maintenance Manual  
MAINTENANCE MANUAL

**APU EXHAUST SYSTEM**  
**DESCRIPTION AND OPERATION**

EFFECTIVITY RTCA LX-N19997 LX-N20000

**1 GENERAL**

- A The APU exhaust systems discharge the APU exhaust gases and cooling air overboard, provide a thermal barrier to shield the aft cargo compartment and the airplane structure from the high temperature of the exhaust gases, and they reduce the exhaust noise level. The APU exhaust system consists of an inboard and outboard exhaust assembly, an exhaust door, an exhaust door actuator, an exhaust door open and an exhaust door closed switch.
- B The inboard and outboard exhaust assemblies consist of an outer exhaust duct and an inner exhaust duct that form an annular shaped cooling air chamber. The outer duct serves as the outer surface of the cooling air chamber and as the support structure for the assembly. The inner duct carries the hot exhaust gases and it is positioned concentric to the outer duct to form the inner surface of the cooling air chamber. The inner duct of the inboard exhaust assembly is smaller (8 inch I D ) and extends, approximately one inch, into the larger (10 inch I D ) inner duct of the outboard exhaust assembly to form an eductor section (a low pressure area created by the expansion of the exhaust gases as they pass into the outboard exhaust assembly) that draws air from the APU housing and from outside of the airplane body through the cooling air chambers of the exhaust assemblies. In addition to providing a thermal barrier to shield the aft cargo compartment and the airplane structure the cooling air mixes with the exhaust gases to reduce the temperature of the gases discharged overboard. All ducting, inner and outer, is made from corrosion resistant steel. The outer ducting is covered with a ceramic fiber insulation to provide a non-wetting thermal insulation of the exhaust system.
- C The APU exhaust door provides an aerodynamically clean cover over the exhaust duct, when closed, and prevents the entry of foreign material into the APU engine and housing when the APU is not operating.
- D. The exhaust door actuator receives 28 VDC power from the APU aft DC bus through contacts of the APU master relay to open the exhaust door when the master relay closes (MASTER switch, ON) and to close the exhaust door when the master relay opens (MASTER switch, OFF).
- E The exhaust door open switch provides a ground for the starter relay when the door reaches the fully open position. The exhaust door closed switch provides a ground for the door open light, on the first officer's door annunciator panel, when the door leaves the fully closed position. The switches are mounted to support structure and are actuated when the door reaches, or leaves, the open, or closed position.

## 2 APU INBOARD EXHAUST DUCT ASSEMBLY

- A The APU inboard exhaust assembly provides the first level of noise reduction in the exhaust system by abruptly changing the direction of the exhaust gas flow. The abrupt change in direction, approximately 158°, practically eliminates the high frequency noise and, in addition, the change in direction creates turbulent flow that reduces the low frequency noise. The inner surface of the inner duct is protected by a ceramic coating to absorb the scrubbing action of the high temperature exhaust gases. The inner duct of the assembly is clamped directly to the exhaust flange of the turbine engine and is provided additional support through a foot located at approximately the mid-point of the bend. Spring clips maintain the relative position of the inner duct within the outer duct, but they do not provide any real support for the duct. Since the inner duct of the inboard exhaust assembly does not attach to the inner duct of the outboard exhaust assembly, provision for thermal expansion between the ducts is not required. The outer duct section of the assembly clamps directly to the cooling air outlet flange of the APU upper housing and to the outer duct of the outboard exhaust assembly. Two bellow sections in the outer duct of the inboard exhaust assembly absorb the thermal expansion and contraction of both outer duct sections.

### 3 APU EXHAUST DOOR

- A The APU exhaust door provides the means of closing the gas outlet opening in the wing-to-body fairing. The exhaust door is located at body station 960M + 12 75 just aft of the wing flap fence. The door is hinged along its lower edge and actuates outward to the open position. The door is fabricated from corrosion resistant steel plate

### 4 APU EXHAUST DOOR SWITCH #1

- A. The APU exhaust door switch #1 prevents the APU from being started until the exhaust door is fully open and provides an indication on the APU control panel to that effect when the door reaches the fully open position. When actuated, the switch provides a ground for the starter relay

### 5 APU EXHAUST DOOR SWITCH #2

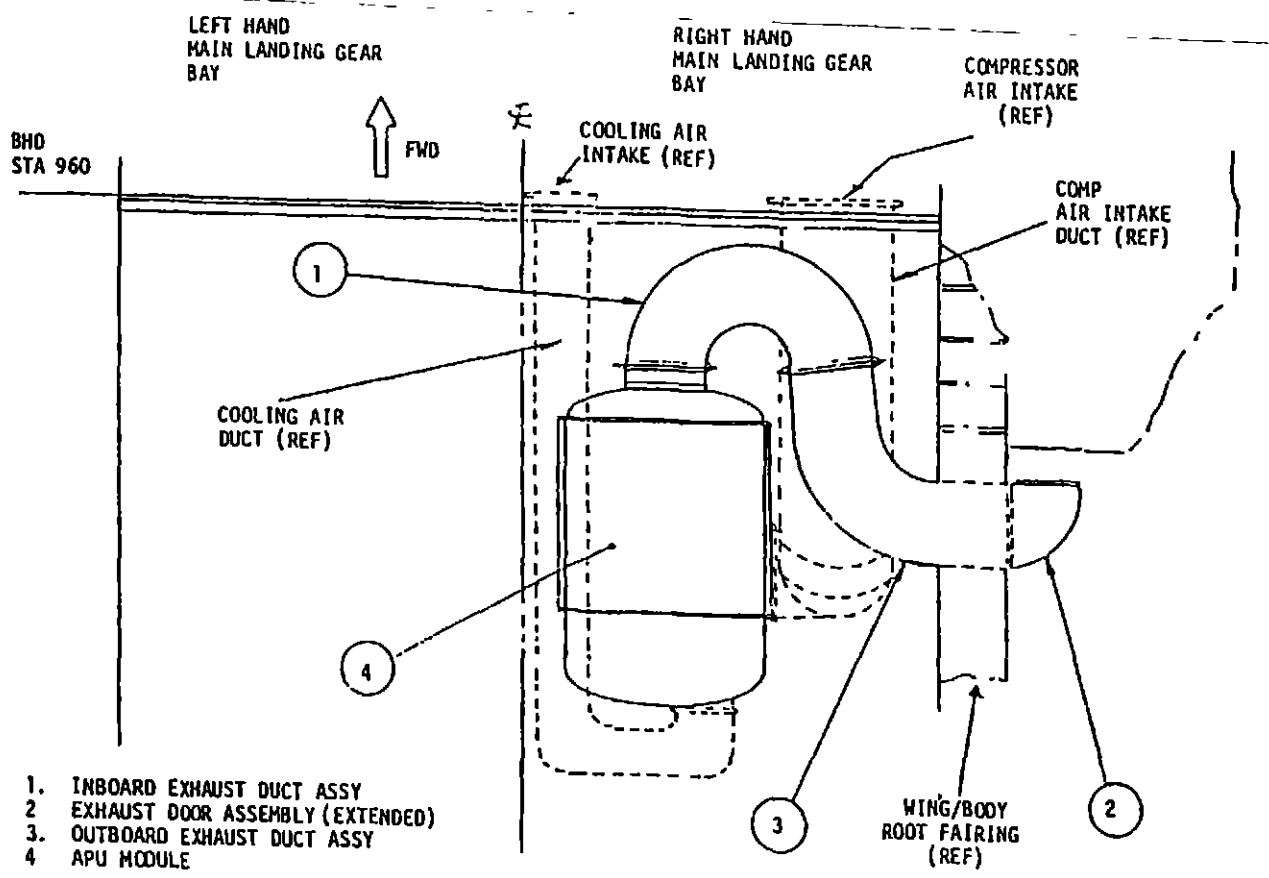
- A The APU exhaust door switch #2 provides an indication on the APU control panel when the exhaust door is in the fully closed position and in the control cabin when the door is not in the fully closed position. The switch is a plunger operated switch that applies a ground to the exhaust door open light on the first officer's door annunciator panel when the door leaves the fully closed position and to the door closed light on the APU control panel when the door reaches the fully closed position.

### 6 APU EXHAUST DOOR ACTUATION

- A The APU exhaust door actuator controls the opening and closing of the exhaust door. The actuator includes an electric motor, reduction gear train and internal limit switches. The internal limit switches interrupt control power to the actuator motor when full travel of the door is reached, open/closed.
- B The actuator receives 28 VDC APU battery power from the APU DC bus through contacts of the master relay. When the master relay closes (MASTER switch ON) power is applied to the open windings of the actuator motor and when the master relay is open (MASTER switch OFF) power is applied to the close windings of the actuator motor.

## 7 OPERATION

- A With the APU battery switch in the ON position, placing the APU master switch in the ON position will apply control power to the coil of the master relay. When the master relay closes, power from the APU aft bus is applied to the open windings of the exhaust door actuator to open the exhaust door. As the door leaves the closed position, the exhaust door open light on the first officer's door annunciator panel will come on and the door closed light on the APU control panel will go off, and when the door reaches the fully open position, a ground is applied to the coil of the starter relay and the door open light on the APU control panel. The starter relay can now be actuated to energize the starter motor when the APU start is desired.
- B When the unit is operating, the exhaust gases leaving the unit pass through the eductor section at the junction of the inner ducts of the inboard and outboard exhaust assemblies. The exhaust gases leaving the eductor section draw air from the APU housing and from outside the airplane body through the cooling air chambers of the exhaust assemblies. In addition to providing a thermal barrier, between the hot exhaust gases and the aft cargo compartment and the airplane body structure, the cooling air mixes with the exhaust gases to reduce the temperature of the gas discharged overboard.
- C When the MASTER switch is placed in the OFF position, the master relay will open and apply power to the close windings of the exhaust door actuator. When the door reaches the fully closed position, the exhaust door open light on the first officer's door annunciator panel will go off and the door closed light on the APU control panel will come on.



- 1. INBOARD EXHAUST DUCT ASSY
- 2. EXHAUST DOOR ASSEMBLY (EXTENDED)
- 3. OUTBOARD EXHAUST DUCT ASSY
- 4. APU MODULE

APU EXHAUST SYSTEM  
 (AFT BAGGAGE COMPARTMENT)

FIGURE 1

APU LUBRICATION SYSTEM

DESCRIPTION AND OPERATION

1. GENERAL

- A. Lubrication for the APU turbine engine is by a self-contained, positive pressure, dry-sump system, which cools and lubricates all gears and bearings in the engine by providing a pressurized and splash supply of oil. The components of the system are the oil pump, oil cooler, and oil tank.
- B. When the unit is started, the pressure pump draws oil from the oil tank and delivers it under pressure to the accessory drive section and to the bearing between the second stage compressor and the turbine. The oil drains into the accessory drive housing sump and into the second stage compressor and turbine bearing cavity. The scavenge pump draws the oil from the sump and bearing cavity and pumps it through the oil cooler back into the tank.

2. OIL PUMP

- A. The oil pump consists of separate pressure and scavenge pumps, a pressure regulating valve, an oil filter and a filter bypass valve. The oil pump is installed on the accessory drive gearbox.
- B. The pressure and scavenge pumps are driven by a common shaft. The pressure pump is a two gear, positive displacement pump which supplies oil under pressure to the bearings, gears and shafts of the turbine engine. The scavenge pump is a three gear positive displacement pump which scavenges oil from the accessory drive gearbox oil sump and from the bearing cavity between the second stage compressor impeller and the turbine wheel. It returns the oil through the oil cooler into the oil tank. External outlet and inlet lines are connected to threaded ports in the body, but scavenging from the accessory drive gearbox is through an internal opening between the oil pump and the gearbox.
- C. The maximum delivery pressure is regulated by a spring-loaded relief valve contained within the pump body. The function of this valve is to open when the pressure pump pressure exceeds 90 PSIG system pressure, thus allowing oil to bypass back to the inlet side of the pressure pump to maintain nearly constant system pressure.
- D. The oil filter is included within the oil pump assembly, and filters all the oil flowing from the pressure pump. The filter base is integral with the pump body and a removable case screwed into the base encloses a replaceable filter element.

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- E. The filter bypass valve is a spring-loaded relief valve contained within the pump body. The function of this valve is to yield to pressure slightly in excess of normal filter resistance, so that if the filter should become blocked, oil is permitted to bypass the filter and maintain a flow through the system.

### 3. OIL COOLER

- A. The oil cooler, installed on the upper aft side of the power unit, is a cylindrical unit constructed of mechanically bonded aluminum tubes housed in a shell. Oil delivered by the scavenge pump passes around the tubes in the cooler before returning to the tank, while air supplied by the cooling fan flows through the tubes and cools the oil.

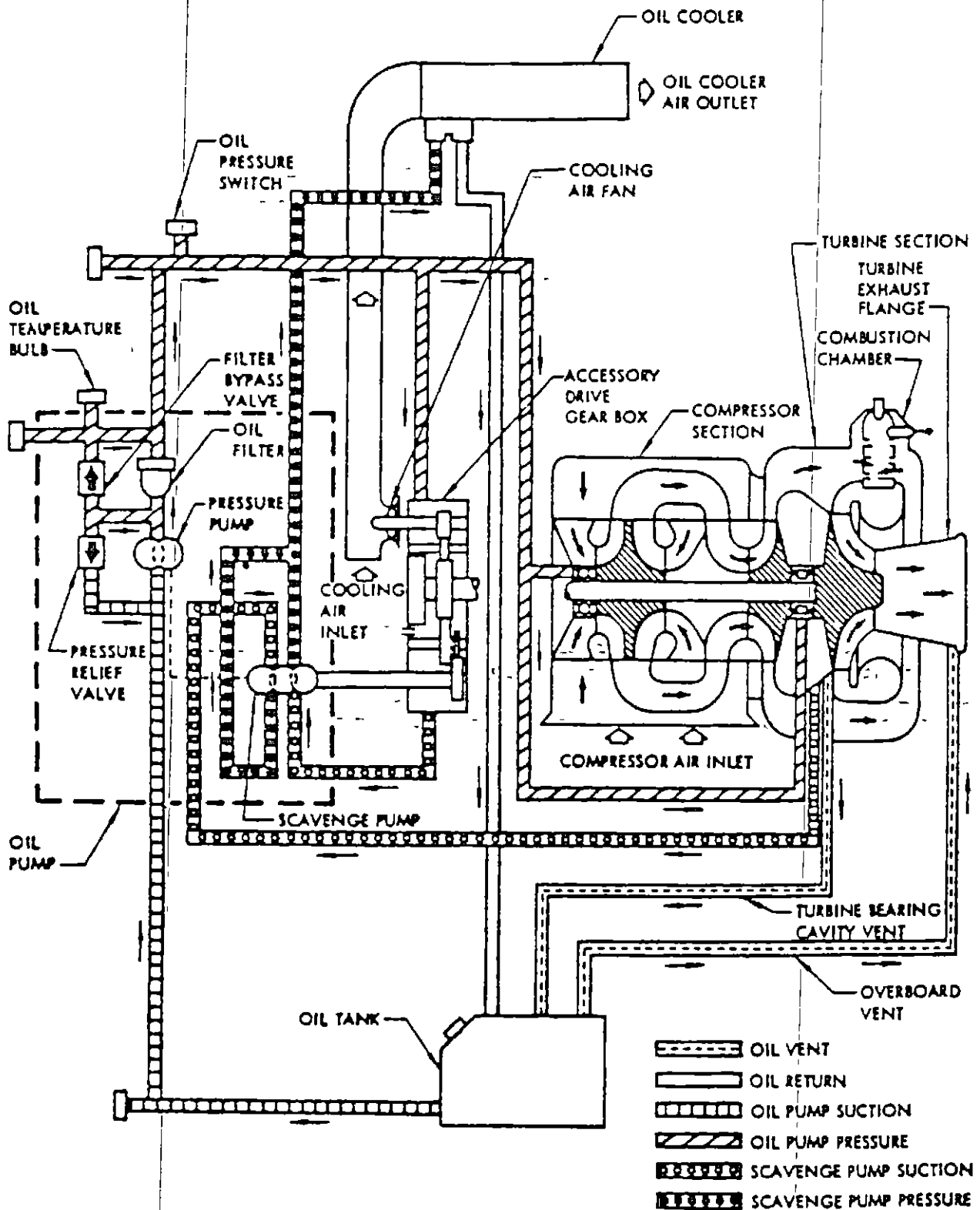
### 4. OIL TANK

- A. The oil tank contains the supply of oil for the system. It is mounted externally on the APU base below the aft end of the module lower housing. Oil is drawn from the tank by the pressure pump and returned, through the oil cooler, by the scavenge pump. An air-oil separator in the tank separates the oil from the air going through the tank to the vent.

#### OPERATION

- A. When the unit is started, the oil pressure is supplied by the oil pressure pump gears through the oil pump filter. If the filter is clogged, the bypass valve opens to permit continuing oil flow. From the oil pump, the oil is routed to the accessory drive gearbox and to the bearing between the second stage compressor impeller and the turbine wheel to provide pressure and splash lubrication for the engine gears and bearings. An oil pressure regulator valve in the oil pump operates to maintain the output oil pressure at  $95 \pm 5$  PSIG at 100% governed speed.
- B. Lubricating oil in the unit drains into the accessory drive gearbox oil sump and into the second stage compressor and turbine bearing cavity. It is pumped from the sump and cavity by the oil scavenge pump gears. Scavenge oil flows through the oil cooler back to the oil tank. Any air trapped in the second stage compressor and turbine bearing cavity is released through the oil tank vent line into the turbine exhaust.

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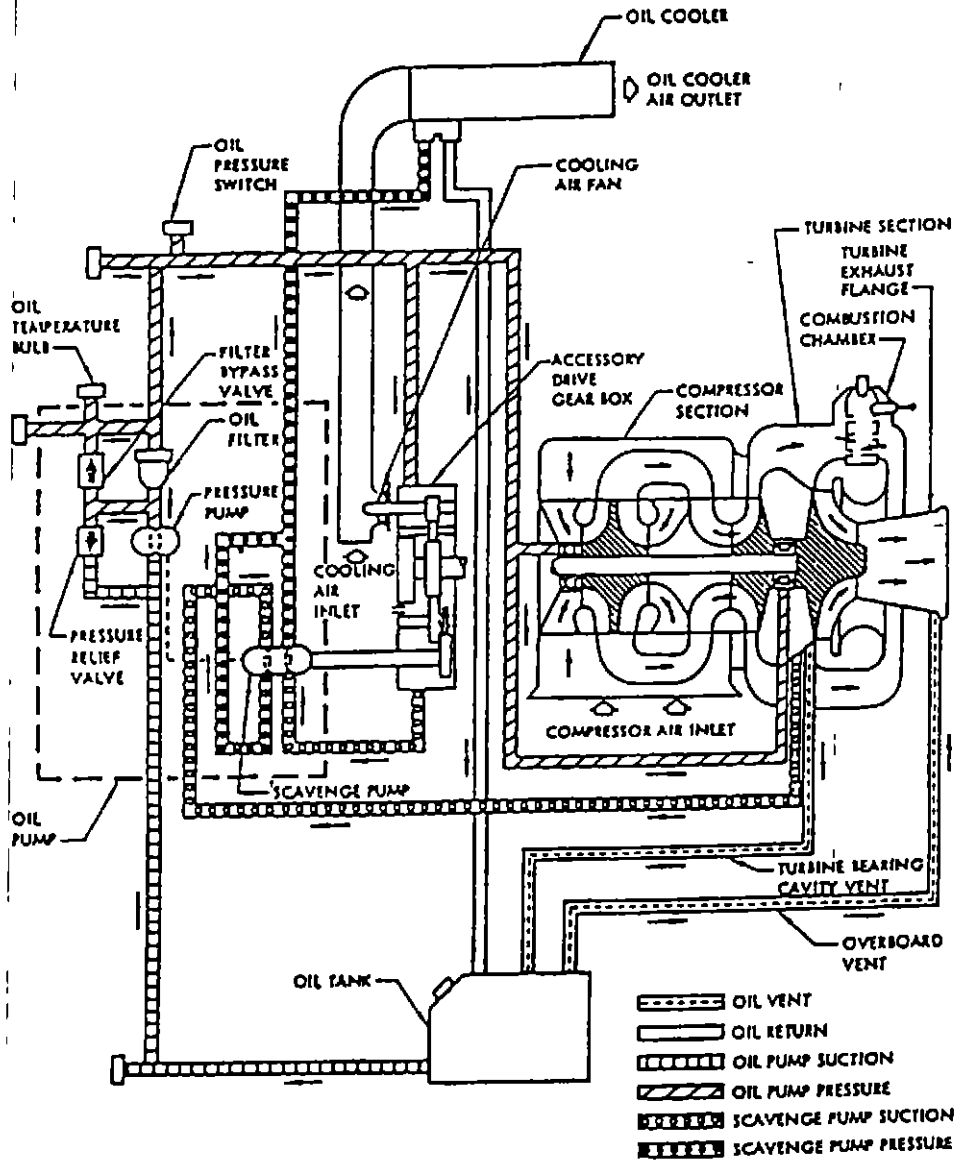
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APU LUBRICATING SYSTEM FLOW DIAGRAM,

FIGURE 1

