
TECHNICAL MANUAL

ENGINE STARTING SYSTEM

FMS SERIES F-15C AND F-15D AIRCRAFT

WR-ALC/LFIT

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15 APRIL 2001

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INTRODUCTION

PURPOSE AND SCOPE.

This technical manual is one of a series providing maintenance instructions for the F-15C and F-15D aircraft. Maintenance instructions are compatible with the provisioning of spare parts, test equipment and special tools.

Section I of this manual contains general description, principles of operation, sequence of operation and support equipment of the complete engine starting system. Section II contains pertinent information relating to the JFS hydraulic start system. Section III has specific information relating to the JFS and the JFS fuel system. Section IV contains detailed information relating to the CGB and the JFS/CGB oil system. Section V has pertinent information relating to the AMAD system and the LDM system. Sections II thru V also contain primary subsystem information such as; description and principles of operation, line replaceable units, special maintenance requirements, consumable materials and support equipment.

Five digit codes used throughout this publication to identify equipment manufacturer may be designated as Mfg. Code, FSCM or CAGE.

APPLICABILITY NOTATIONS.

Information and instructions contained in this manual unique to one model are identified as F-15C and F-15D. Data applicable to specific aircraft within a series are identified by aircraft serial numbers.

IMPROVEMENT REPORTS.

Recommendations for improvements to prescribed requirements and procedures will be submitted on AFTO Form 22, Technical Order System Publication Improvement Report per 00-5-19 and RSAF TO 00-35D-54 to WR-ALC/LFI, 296 COCHRAN STREET, ROBINS AFB, GA 31098-1622.

GLOSSARY.

Nonstandard abbreviations and symbols are described below. All abbreviations and symbols used in the maintenance manual set are described in TO SR1F-15C-2-00GV-00-1.

AMAD Airframe mounted accessory drive

CFT	Conformal fuel tank
CGB	Central gearbox
ESS	Essential
GCU	Generator control unit
IDG	Integrated drive generator
JFS	Jet fuel starter
LDM	Limited duty mode
LRU	Line replaceable unit
PC	Power control system
PMG	Permanent magnet generator
PPH	Pounds per hour
PSID	Pounds per square inch differential
ΔP	Differential pressure

RECORD OF APPLICABLE TIME COMPLIANCE TECHNICAL ORDERS.

The record of applicable time compliance technical orders is a list of all TCTO which affect the technical content (text or illustration) of this manual. Only current TCTO are listed. A TCTO is deleted from the list when any of the below occurs:

- a. The equipment configuration to which the TCTO is applicable is no longer covered in the manual.
- b. The TCTO is rescinded.
- c. The TCTO is superseded or replaced.

Record of Applicable Time Compliance Technical Orders

TCTO No.	Title	TCTO Date
SR1F-15-922	Increased JFS Hydraulic Start Energy and Additional JFS Accumulator Power Source for Emergency Gear Extension (ECP MDA-F15-1563, 1839)	4 May 90
SR1F-15-977	F-15 Fire Detection for the After Burner Section (ECP MDA-F15-1851)	8 Mar 91
2JA3-50-505	Jet Fuel Starter Fuel Control Unit Upgrade	15 Apr 01
2JA16-3-506	Improved AMAD Starter Cut-Out Switch Governor Redesign	3 Jul 86
2JA16-3-512	The Removal of Left Hand AMAD Limited Duty Mode (LDM) on F-15 Series Aircraft	1 May 92
SR1F-15-1210	Limited Duty Mode Deactivation F-15A/B/C/D Aircraft	30 May 93
SR1F-15-1253	JFS Exhaust Duct Replacement (ECP 2437-M)	3 Jan 94
2JA16-3-518	Left Hand Airframe Mounted Accessory Drive Pride Upgrade	15 Apr 01
2JA16-3-517	Right Hand Airframe Mounted Accessory Drive Pride Upgrade	15 Apr 01
2JA3-50-506	Jet Fuel Starter Pride Upgrade	15 Apr 01
2JA16-2-509	Central Gearbox Pride Upgrade	15 Apr 01

SECTION I

ENGINE STARTING SYSTEM

1-1. SYSTEM FUNCTIONAL DESCRIPTION.

1-2. **DESCRIPTION.** This section contains description and principles of operation for the engine starting system shown in figures 1-1, 1-2 and 1-3 for the F-15C and F-15D aircraft.

1-3. The engine starting system combines hydraulic, electrical and manual controls for JFS starting and engine starting.

1-4. **Engine Starting Hydraulic Control System.** When the JET FUEL STARTER control handle is pulled, the hydraulic start system receives hydraulic pressure from either of two accumulators. The pressure drives a hydraulic start motor, providing initial rotation of the jet fuel starter (JFS). The control handle is in the cockpit and the accumulators are in door 88L. To open door 88L with a conformal fuel tank installed, door 567L must be opened first. The start motor is on the central gearbox (CGB) in door 83.

1-5. Engine starting is regulated by the throttle fingerlifts which control the central gearbox (CGB) hydraulic clutch control valve. This valve, on the CGB, provides 350 psi control oil to the CGB isolation decouplers and the CGB clutch for engine starting. The valve contains an electrically energized torque motor, a flapper valve and control nozzles, a three spool director valve, a primary shuttle valve, a limited duty solenoid (CGB 386720-4-1), a limited duty shuttle valve (CGB 386720-4-1), a clutch programmer orifice and bellows, and a drain check valve.

1-6. The torque motor controls the decoupler selection by actuating the flapper valve and moving the normally centered director spool valve to open the decoupler port to the 350 psi supply pressure depending on which fingerlift was raised. The primary shuttle valve provides a hydraulic interlock to prevent both isolation decouplers from being pressurized simultaneously. The clutch programmer orifice and bellows restricts the pressure to the clutch and JFS fuel control port to make sure the isolation decouplers are extended before the CGB clutch is engaged or the fuel control pressure switch is actuated.

1-7. For right engine starting, control oil pressure is applied through the limited duty shuttle valve (CGB 386720-4-1) with the limited duty solenoid (CGB 386720-4-1) deenergized, while the primary shuttle valve locks out the left decoupler by closing the pressure port.

1-8. **Engine Starting Electrical Control System.** The permanent magnet generator (PMG) supplies the electrical requirements for the engine starting system. The PMG, power turbine overspeed switch and oil pump, right decoupler position switch (CGB 386720-4-1), CGB hydraulic clutch control valve and hydraulic start motor are mounted on the central gearbox in door 83. The JFS fuel control, JFS two-speed switch, generator control unit (GCU), JFS ignition unit and igniter plug are mounted on the JFS in door 94. An integrated drive generator (IDG), a utility hydraulic pump, power control (PC) hydraulic pump and an oil pump and start cutout switch are mounted on each AMAD in doors 85 L and R.

1-9. The PMG is a single phase, ac generator with a 10 pole permanent magnet rotor. The dual stator has a high voltage start winding and a low voltage load winding. Before TO 1F-15-922, aircraft wiring connects the PMG to the GCU. After TO SR1F-15-922, aircraft wiring connects the PMG to the GCU and to the ignition unit through the JFS run relay. The GCU rectifies and filters the PMG load voltage and before TO SR1F-15-922, it applies PMG start ac voltage to the JFS ignition unit. The GCU has a voltage regulator, rectifiers/filters, overvoltage protector and a start sequence relay.

1-10. The JFS ignition unit is a 1.5 joule, high voltage, capacitor discharge unit with an intermittent duty cycle rating of 10 seconds on and 10 minutes off. The ignition unit provides a minimum spark rate of 2.6 sparks per second at 10vac, 360 Hz. The ignition unit is connected through a shielded, high voltage ignition cable to a single igniter plug in the JFS combustor. The gas generator two-speed switch is connected to the gas generator power output shaft on the JFS. The 50 percent contacts of the switch close and complete a circuit to the STARTER-READY light in the cockpit when the JFS is at 50 percent speed. If the gas generator exceeds 110 percent, the contacts open,

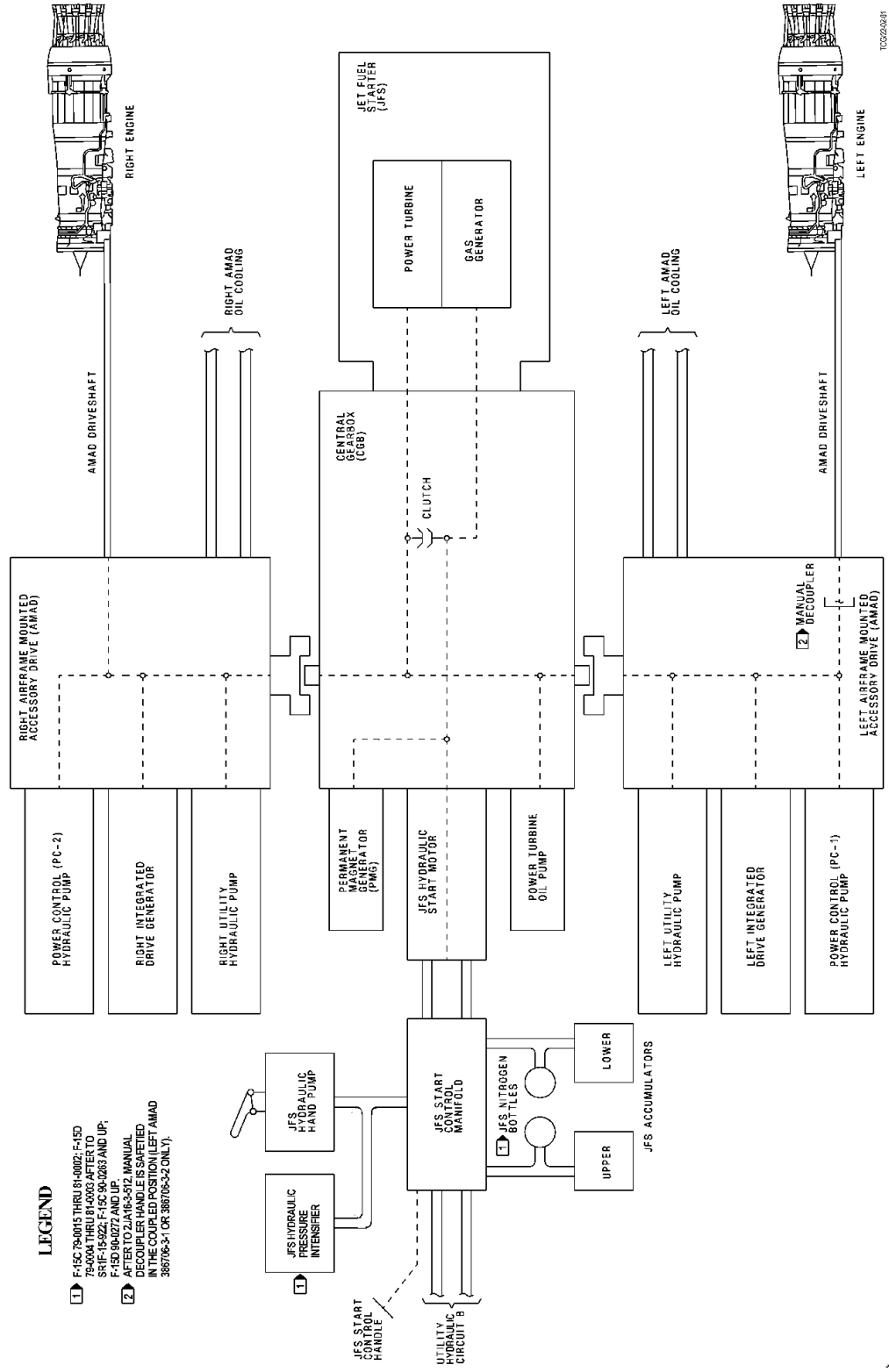
providing a safety cutoff, should the JFS overspeed. The 110 percent power turbine overspeed switch and pump is on the CGB. The centrifugal switch senses JFS power turbine speed. If the power turbine develops an overspeed condition the switch contacts open and shuts down the JFS.

1-11. The JFS control relay, JFS ready relay and the fire extinguisher bus control relay are in door 6L. The JFS control relay prevents cycling of the JFS control system if a malfunction should develop. The JFS ready relay when energized, applies 28vdc to the JFS/ESS 28VDC circuit breakers. See figure 1-3. The fire extinguisher bus control relay keeps the fire extinguisher bus powered to 14vdc on JFS shutdown. The JFS voltage output relay is on the no. 3 miscellaneous relay panel. This relay is voltage sensitive and will energize after 16 vdc is applied to the JFS voltage output relay with a time delay of 100 to 200 milliseconds BEFORE TO SR1F-15-922 and 800 to 1200 milliseconds AFTER TO SR1F-15-922. The

relay provides a circuit through the overspeed and cutout switches to the control winding of the JFS control relay.

1-12. AFTER TO SR1F-15-922 the JFS control timer and JFS run relay was added. The JFS run relay will keep power supplied to the JFS ignition unit until the JFS control timer (a 1.5 second delay to operate relay) energizes.

1-13. The STARTER switch, STARTER-READY light and ENG MASTER switches are on the ENGINE control panel in the cockpit. The STARTER switch controls the voltage to the JFS fuel shutoff valves. The STARTER-READY light comes on when the JFS is at 50 percent and indicates the JFS is ready for an engine start. The ENG MASTER switches activate the engine starting circuits.

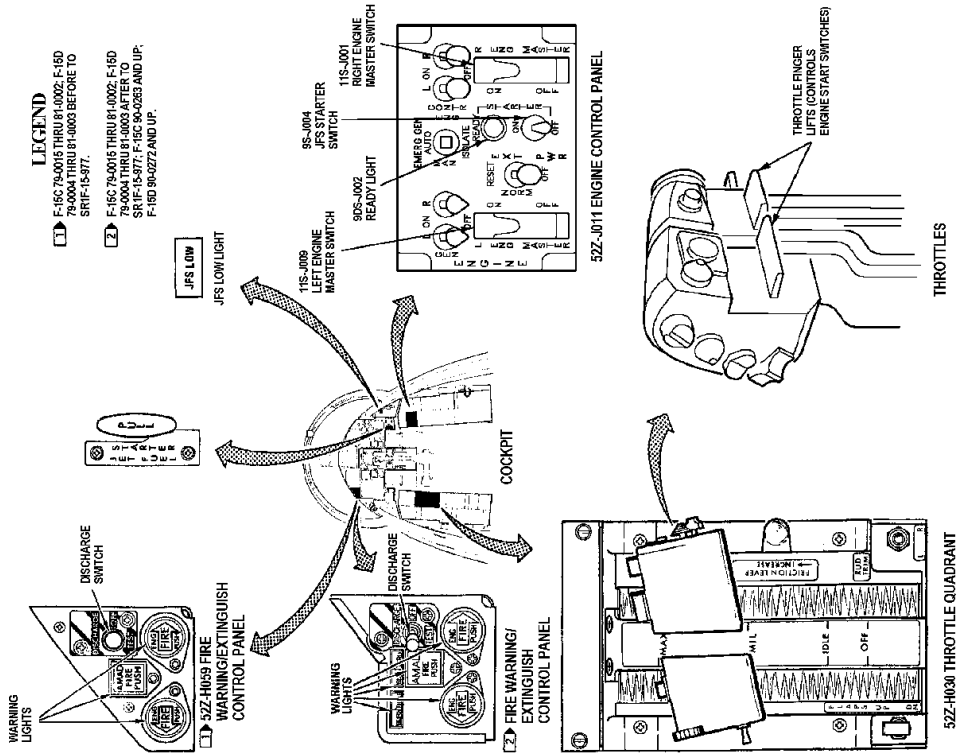


LEGEND

- 1 F-15C 79-0015 THRU 81-0002; F-15D 79-0004 THRU 81-0003 AFTER TD F-15D 80-02; F-15C 30-003 AND UP; F-15D 80-02
- 2 AFTER TO 2A/68-3/12 MANUAL DECOUPLER HANDLE IS SAFFETIED IN THE COUPLED POSITION (LEFT AMAD 386706-3-1 OR 386706-3-2 ONLY).

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Figure 1-1. Engine Start Simplified Block Diagram

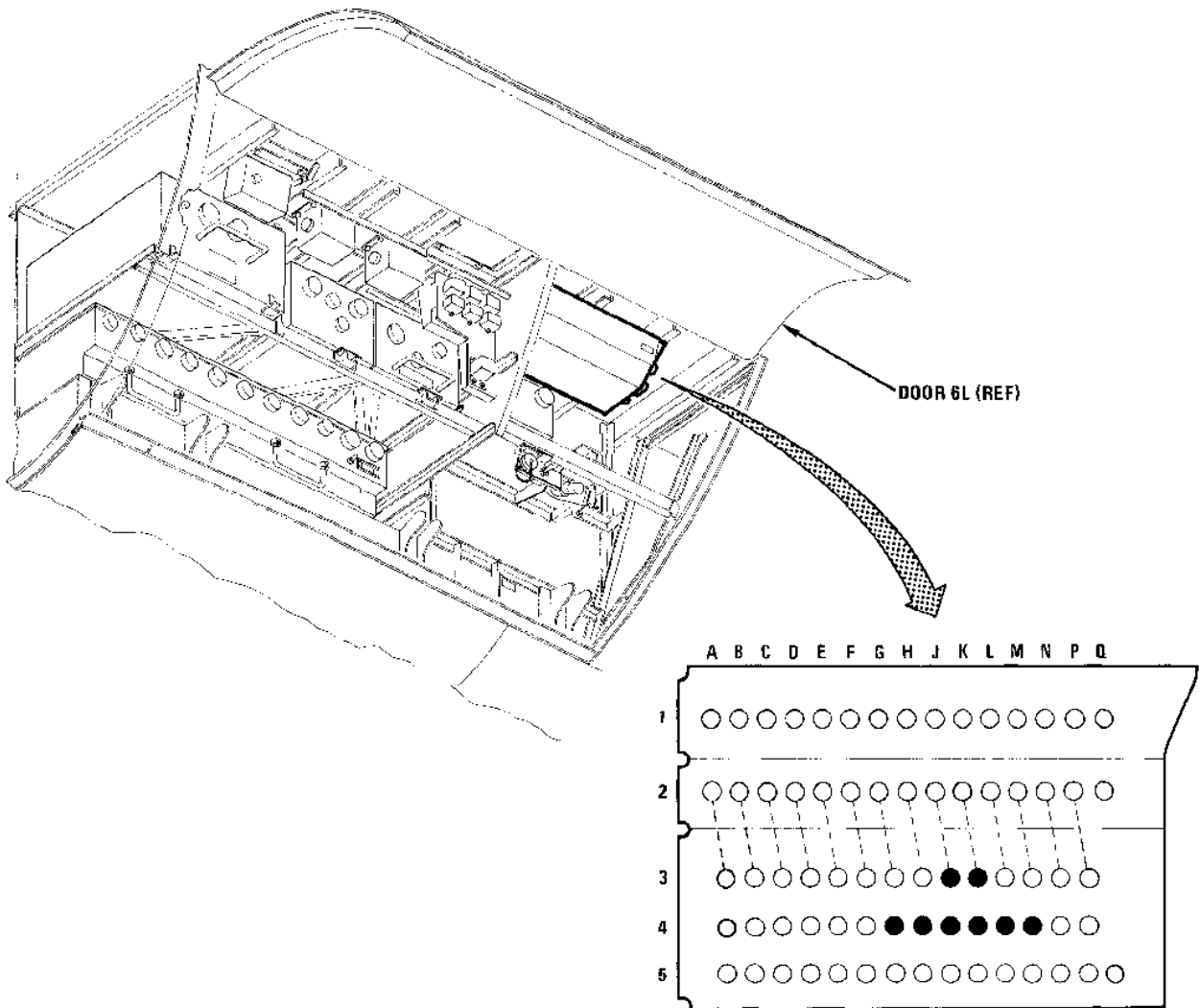


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Figure 1-2. Engine Start System Component Locator

80-00-00

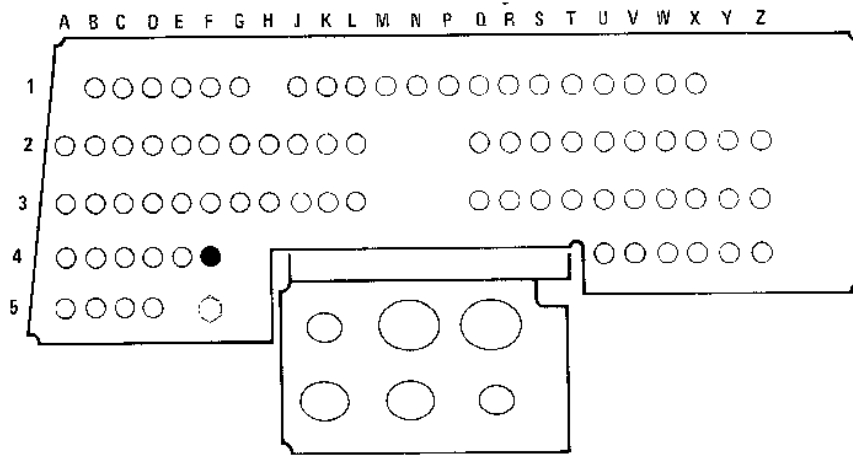
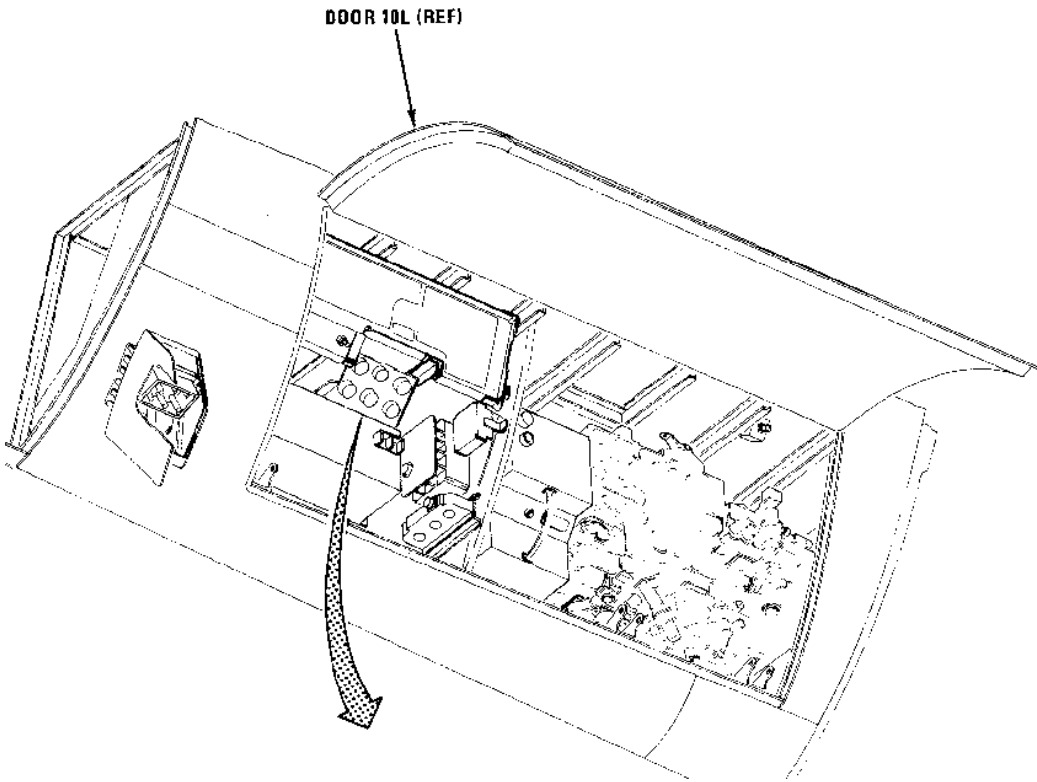
1-4



52Z-C007 ESSENTIAL BUS CIRCUIT BREAKER PANEL (24-50-12)				
REF DES	ZONE	NOMENCLATURE		BUS
11CBC004	K4	R AMAD SEL	28VDC	JFS/ESS 28VDC
11CBC008	J4	L AMAD SEL	28VDC	JFS/ESS 28VDC
12CBC010	J3	L ENG FUEL SOV	28VDC	ENG CONT/ESS 28VDC
12CBC011	K3	R ENG FUEL SOV	28VDC	ENG CONT/ESS 28VDC
21CBC004	M4	AMAD F DET SYS	28VDC	JFS/ESS 28VDC
24CBC011	L4	AMAD F EXT SYS	28VDC	FIRE EXT 28VDC
36CBC003	H4	UTILITY FLOOD LT/ FIT WARM	28VDC	JFS/ESS 28VDC
78CBC012	G4	INTERCOM	28VDC	JFS/ESS 28VDC

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Figure 1-3. Engine Start System Circuit Breakers (Sheet 1 of 2)



52Z-E006 LEFT BUS CIRCUIT BREAKER PANEL (24-50-13)				
REF DES	ZONE	NOMENCLATURE		BUS
6C8E012	F4	EMER GEN/EBP	28VDC	L 28VDC

TDC26-02-01

Figure 1-3. Engine Start System Circuit Breakers (Sheet 2)

1-14. **PRINCIPLES OF OPERATION.** With the STARTER switch to ON, pulling the JET FUEL STARTER control handle in the cockpit applies accumulator pressure to the hydraulic start motor and the JFS/PMG is rotated. This rotation produces a voltage for ignition and fuel valves. The JFS accelerates when lightoff occurs and the STARTER-READY light comes on. After the JFS stabilizes at idle, the JFS is ready for engine starting. When the ENG MASTER switch is set to ON and the throttle fingerlift is raised, the left or right isolation decoupler extends, depending on the side selected. The JFS accelerates to 100 percent speed and the AMAD/engine cranks. After engine lightoff and acceleration of 50 to 54 percent (BEFORE TO 6JA16-3-506) or 41 to 43 percent (AFTER TO 6JA16-3-506) N₂ rpm, the AMAD start cutout switch opens and the JFS returns to idle speed. After the second engine arrives at starter cutout speed the JFS shuts down automatically.

1-15. **JFS Starting Sequence.** See figure 1-4. The JFS is started by setting the STARTER switch on the ENGINE control panel to ON and pulling the JET FUEL STARTER control handle. The control sequence is started when JFS accumulator discharge pressure is applied to the hydraulic start motor and the JFS/PMG rotates. As PMG rotation increases, ac voltage is applied to the GCU from the generator start and load windings. BEFORE TO SR1F-15-922, the start voltage is connected through the GCU start sequence relay to the ignition exciter unit. AFTER TO SR1F-15-922, the start voltage is connected through the JFS run relay to the ignition unit. The load voltage is connected through the GCU rectifier and filter to the JFS control circuits. When this rectified voltage is at 16vdc, the voltage sensitive JFS voltage output relay energizes. A circuit is completed through the series connected gas generator and power turbine overspeed switches, and the parallel connected left and right AMAD start cutout switches to the JFS control relay.

1-16. BEFORE TO SR1F-15-922, the control relay applies 28vdc from the GCU, through the STARTER switch, to the JFS fuel shutoff valves. With fuel and ignition at the JFS combustor, lightoff occurs. The JFS accelerates, releasing the start motor and providing increased PMG rotation. When 25 vac output is arrived at, the GCU start sensor energizes the start sequence relay, removing start voltage from the ignition unit. When the gas generator 50 percent switch actuates, 28vdc is applied to the STARTER-READY light and the JFS ready relay. The ready relay energizes and

isolates the ENG CON/TESS 28VDC bus from the JFS/ESS 28VDC bus to prevent the PMG from paralleling with the integrated drive generators. The ready relay also applies 28vdc to the JFS/ESS 28VDC bus. The JFS/CGB accelerates to idle speed and is ready for engine starting.

1-17. AFTER TO SR1F-15-922 the control relay applies 28vdc from the GCU, through the STARTER switch, to the JFS fuel shutoff valves. With fuel and ignition at the JFS combustor, lightoff occurs. The JFS accelerates, releasing the start motor and providing increased PMG rotation. Approximately 1000 milliseconds after 16 vdc is applied to the JFS voltage output relay it will energize. The JFS control timer will energize 1.5 seconds after the voltage output relay energizes. This will energize the JFS run relay and it will remove power from the ignition unit, stopping ignition. When the gas generator 50 percent switch actuates, 28vdc is applied to the STARTER-READY light and the JFS ready relay. The ready relay energizes and isolates the ENG CONT/ESS 28VDC bus from the JFS/ESS 28VDC bus to prevent the PMG from paralleling with the integrated drive generators. The ready relay also applies 28vdc to the JFS/ESS 28VDC bus to prevent the PMG from paralleling with the integrated drive generators. The ready relay also applies 28vdc to the JFS/ESS 28VDC bus. The JFS/CGB accelerates to idle speed and is ready for engine starting.

1-18. **Right Engine Starting Sequence.** See figures 1-5 and 1-6. With the JFS running at idle speed, 28vdc is available from the JFS/ESS 28VDC bus through the R AMAD SEL circuit breaker. When the R ENG MASTER switch is set to ON, the right engine master relays no. 1 and no. 2 energize. This applies 28vdc through the right AMAD oil pump and start cutout switch to the right engine start switch. When the right throttle fingerlift is raised (start switch actuated) 28vdc is directed through the deenergized left AMAD select control relay to the right AMAD select control relay which energizes. With the right AMAD select control relay energized, 28vdc energizes the right coil of the CGB hydraulic clutch control valve. Simultaneously, 28vdc is now applied through the right AMAD oil pump and start cutout switch, keeping 28vdc on the right AMAD select control relay when the fingerlift is released.

1-19. With the CGB hydraulic clutch control valve energized, CGB control oil pressure extends the right isolation decoupler into the AMAD pawl carrier. With increased oil pressure, the CGB clutch engages and the JFS fuel control clutch pressure switch actuates, causing 28vdc to be applied to the JFS acceleration control valve. The right AMAD/engine is coupled to the CGB and the JFS accelerates to maximum speed. After engine lightoff and acceleration to starter cutout speed (BEFORE TO 2JA16-3-506 50 to 54 percent N₂ rpm AFTER TO 2JA16-3-506 41 to 43 percent N₂ rpm), the right AMAD oil pump and start cutout switch actuates. This removes 28vdc from the right AMAD select control relay and the CGB hydraulic clutch control valve. Now 28vdc is applied to energize the right engine run relay. With 28vdc removed from the control valve, CGB control oil pressure is removed from the right isolation decoupler, CGB clutch and the fuel control pressure switch. This action decelerates the JFS back to idle and decouples the CGB from the right AMAD/engine.

1-20. **Left Engine Starting Sequence.** See figures 1-5 and 1-6. With the JFS running at idle speed, 28vdc is available from the JFS/ESS 28VDC bus through the L AMAD SEL circuit breaker. When the L ENG MASTER switch is set to ON, the left engine master relay no. 1 and no. 2 energize. This applies 28vdc through the left AMAD oil pump and start cutout switch to the left engine start switch. When the left throttle fingerlift is raised (start switch actuated), 28vdc is directed through the deenergized right AMAD select control relay, to the left AMAD select control relay which energizes. BEFORE TO 1F-15-1210, 28vdc is applied through the manual decoupler switch to energize the left coil of the CGB hydraulic clutch control valve. AFTER TO 1F-15-1210, 28vdc is applied to energize the left coil of the CGB hydraulic clutch control valve. Now 28vdc is applied to the left AMAD select control relay from the left AMAD oil pump and start cutout switch, to keep the relay energized when the fingerlift is released.

1-21. With the CGB hydraulic clutch control valve energized, CGB control oil pressure extends the left

isolation decoupler into the AMAD pawl carrier. With increased oil pressure, the CGB clutch engages and the JFS fuel control clutch pressure switch actuates, causing 28vdc to be applied to the JFS acceleration control valve. The left AMAD/engine is coupled to the CGB and the JFS accelerates to maximum speed. After engine lightoff and acceleration to starter cutout speed (BEFORE TO 2JA16-3-506 50 to 54 percent N₂ rpm AFTER TO 2JA16-3-506 41 to 43 percent N₂ rpm) the left AMAD oil pump and start cutout switch actuates. This removes 28vdc from the left AMAD select control relay and the CGB hydraulic clutch control valve. Now 28vdc is applied to energize the left engine run relay. With 28vdc removed from the control valve, CGB control oil pressure is removed from the left isolation decoupler, CGB clutch and the fuel control pressure switch. This action decelerates the JFS back to idle and decouples the CGB from the left AMAD/engine.

1-22. **JFS Shutdown Sequence.** See figures 1-5 and 1-6. When the second engine arrives at starter cutout speed the start cutout switch actuates. When the second engine is the left engine, the left start cutout switch actuates, removing the holding voltage from the left AMAD select control relay and the CGB hydraulic clutch control valve. When 28vdc is removed from the CGB hydraulic clutch control valve, CGB control oil pressure is removed from the hydraulic clutch and left isolation decoupler and the left AMAD is disengaged from the CGB. The JFS control relay is deenergized when the remaining start cutout switch actuates and 28vdc is removed from the JFS fuel shutoff valves, and the JFS shuts down. When the second engine to arrive at start cutout speed is the right, the sequence is started when the right start cutout switch is actuated (the left start cutout switch would have been opened). When 28vdc is removed from the CGB hydraulic clutch control valve, CGB control oil pressure is removed from the hydraulic clutch, isolation decoupler and the right AMAD is disengaged from the CGB. When the remaining start cutout switch opens, 28vdc is removed from the JFS control relay. The control relay drops out and 28vdc is removed from the fuel shutoff valves causing the valve to close.

1-23. With fuel cutoff, the JFS shuts down, the STARTER-READY light goes out, the JFS ready relay drops out, and 28vdc is removed from the JFS/ESS 28VDC bus. Twenty-eight vdc is now applied to the JFS/ESS 28VDC bus from the ENG CON/TESS 28VDC bus through the deenergized contacts of the ready relay. When GCU output voltage decreases to 14vdc, the JFS voltage output relay deenergizes. Also, when GCU voltage is at 4vdc, the start sequence relay deenergizes, resetting the ignition circuit in readiness for the next JFS start. If the STARTER switch on the ENGINE control panel is set to OFF, a series circuit from the switch to the fuel shutoff valves is opened. This removes 28vdc from the fuel shutoff valves, causing the valves to close and the JFS to shut down.

1-24. **Sequence of Operation of Engine Starting.** This sequence of operation is not meant to replace the engine starting procedure nor should it be used for engine starting. This sequence of operation is meant to familiarize the operator with obvious indications that occur within the engine starting system when an engine start is done. Refer to 05-20-05 for engine starting procedure and limits.

1-25. During normal starting sequence, the JFS is started by setting the STARTER switch to ON and pulling the JET FUEL STARTER control handle to the first detent. Normally, the JFS accelerates to 50 percent within approximately 7 seconds, then the STARTER-READY light comes on, indicating the JFS is ready to engage. The JFS continues to accelerate to 60 percent (idle rpm). At this time, the AMAD bay fire warning and extinguishing systems with intercom and utility flood light are operational. Setting the L or R ENG MASTER switch to ON, then raising the fingerlift with the respective throttle at OFF, causes the JFS to audibly decelerate (decrease in JFS whine) then audibly accelerate (increase in JFS whine) to 100 percent gas generator speed. Engine rotation is obvious in about 3 seconds. If external electrical power is not available, rotation can be felt and heard. If external electrical power is

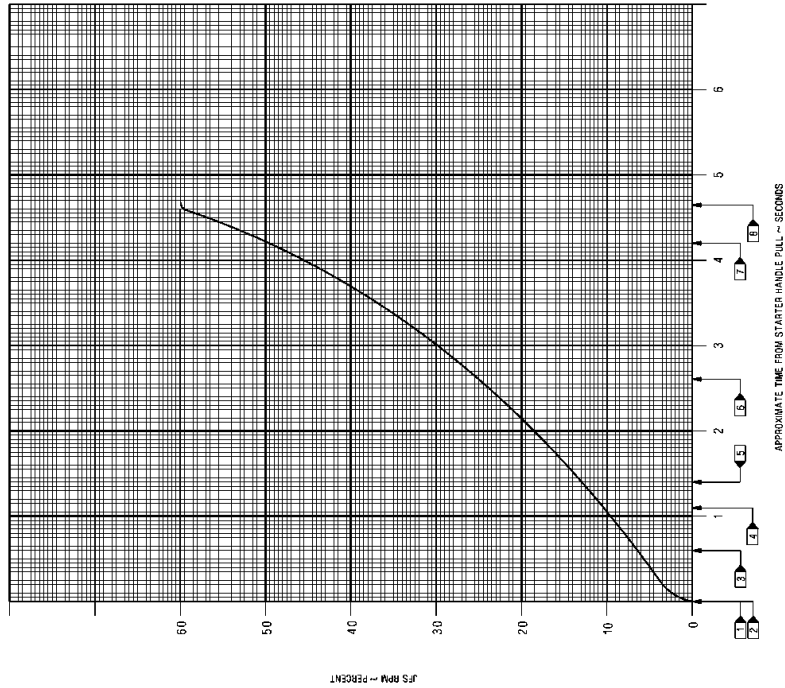
available or second engine is being started, N₂ rpm is indicated on percent rpm indicator. The throttle can then be advanced and engine lighthoff is indicated by a rise in FTIT. After engine lighthoff, JFS whine arrives at a higher pitch as engine rpm increases. When the engine arrives at BEFORE TO 2JA16-3-506, 50 to 54 percent N₂ RPM or AFTER TO 2JA16-3-506, 41 to 43 percent N₂ rpm, the JFS decelerates to idle where 20 seconds must pass before second start is tried. JFS shutdown is automatic when second engine arrives at BEFORE TO 2JA16-3-506, 50 to 54 percent N₂ RPM AFTER TO 2JA16-3-506, 41 to 43 percent N₂ rpm.

1-26. **Sequence of Operation of JFS Inflight.** This sequence of operation is not meant to replace the emergency inflight engine starting procedure nor should it be used for an emergency. This sequence of JFS inflight operation is meant to familiarize the operator with obvious indications that occur within the engine starting system when an emergency inflight restart is required. Refer to TO SRIF-15C-1 for emergency inflight procedure.

1-27. During an emergency inflight engine restart, the JFS is started by setting the STARTER switch to ON and pulling the JET FUEL STARTER control handle to the first detent when engine N₂ rpm is below 40 percent. This accelerates the JFS to 50 percent within approximately 7 seconds, causing the STARTER-READY light to come on, indicating the JFS is ready for engine restart. With JFS at idle, ENG MASTER switch ON and applicable throttle OFF, restart is done by raising the applicable fingerlift. Engine lighthoff is indicated by rise in FTIT. When the engine arrives at BEFORE TO 2JA16-3-506 50 to 54 percent N₂ RPM or AFTER TO 2JA16-3-506 41 to 43 percent N₂ rpm, the JFS decelerates to idle. This procedure is repeated for starting the second engine. When both engines have been started, the JFS automatically shuts down.

LEGEND

- 1 JFS STARTER SWITCH ON.
- 2 JFS START CONTROL HANDLE PULLED TO FIRST POSITION.
(A) ACCUMULATOR CONTROL VALVE OPENS, RELEASING HYDRAULIC PRESSURE FROM UPPER ACCUMULATOR.
(B) JFS HYDRAULIC START MOTOR STARTS DRAWING FUEL FROM LOWER ACCUMULATOR.
(C) JFS FUEL SHUTOFF VALVE (ACTIVATED ONLY WHEN DEFERENTIAL OF GAS GENERATOR AND POWER TURBINE RPM IS PRESENT), FUEL CONTROL, TWO SPEED SWITCH, AND FINE TUNE BEGINS PROVIDING POWER TO JFS STARTER PLUS.
- 3 JFS FUEL SHUTOFF VALVE AND JFS FUEL CONTROL SHUTOFF VALVE OPEN, SUPPLYING FUEL TO JFS FUEL MANIFOLD NOZZLES.
- 4 JFS VOLTAGE OUTPUT RELAY AND JFS CONTROL RELAY ENERGIZE BEING IN TO VIOC OUTPUT FROM PMA.
(A) JFS CONTROL HOLDING CIRCUIT ESTABLISHED.
(B) JFS FAN AND THE EXHAUSTER BLS ENERGIZED.
- 5 JFS LIGHTS OFF.
(A) JFS POWER TURBINE ASSIST IN ACCELERATING JFS GAS GENERATOR FOR ACCELERATES OVERSPEEDING.
(B) JFS GAS GENERATOR STARTS DRAWING FUEL FROM JFS HYDRAULIC START MOTOR.
(C) JFS GAS GENERATOR NOW DRIVES FUEL CONTROL, TWO SPEED SWITCH, AND FINE TUNE.
- 6 JFS POWER TURBINE DRIVES POWER TURBINE OVERSPEED CONTROL PUMP, AND COB FAN AND CLUTCH CLUTCH IS DISENGAGED.
- 7 JFS START SEQUENCE RELAY ENERGIZES.
(A) PMS NOT RUNNING DEENERGIZED.
(B) JFS COB FAN TEMPORAL.
- 8 JFS GAS GENERATOR 80 PERCENT SWITCH ACTUATES.
(A) JFS READY RELAY ENERGIZES.
(B) COB FAN SPEED RELAY STARTS COMES ON.
(C) COB FAN BLS ENERGIZED.
(D) INTERCOM. UTILITY FLOOD LIGHT (FIT MARK, AND JFS FAN AND FUEL DELECTOR BLS) ENERGIZED.
(E) JFS FAN AND FUEL DELECTOR BLS DEPLETED.
- 9 JFS GAS GENERATOR AND POWER TURBINE ATTAIN 80 PERCENT SPEED (RUE).



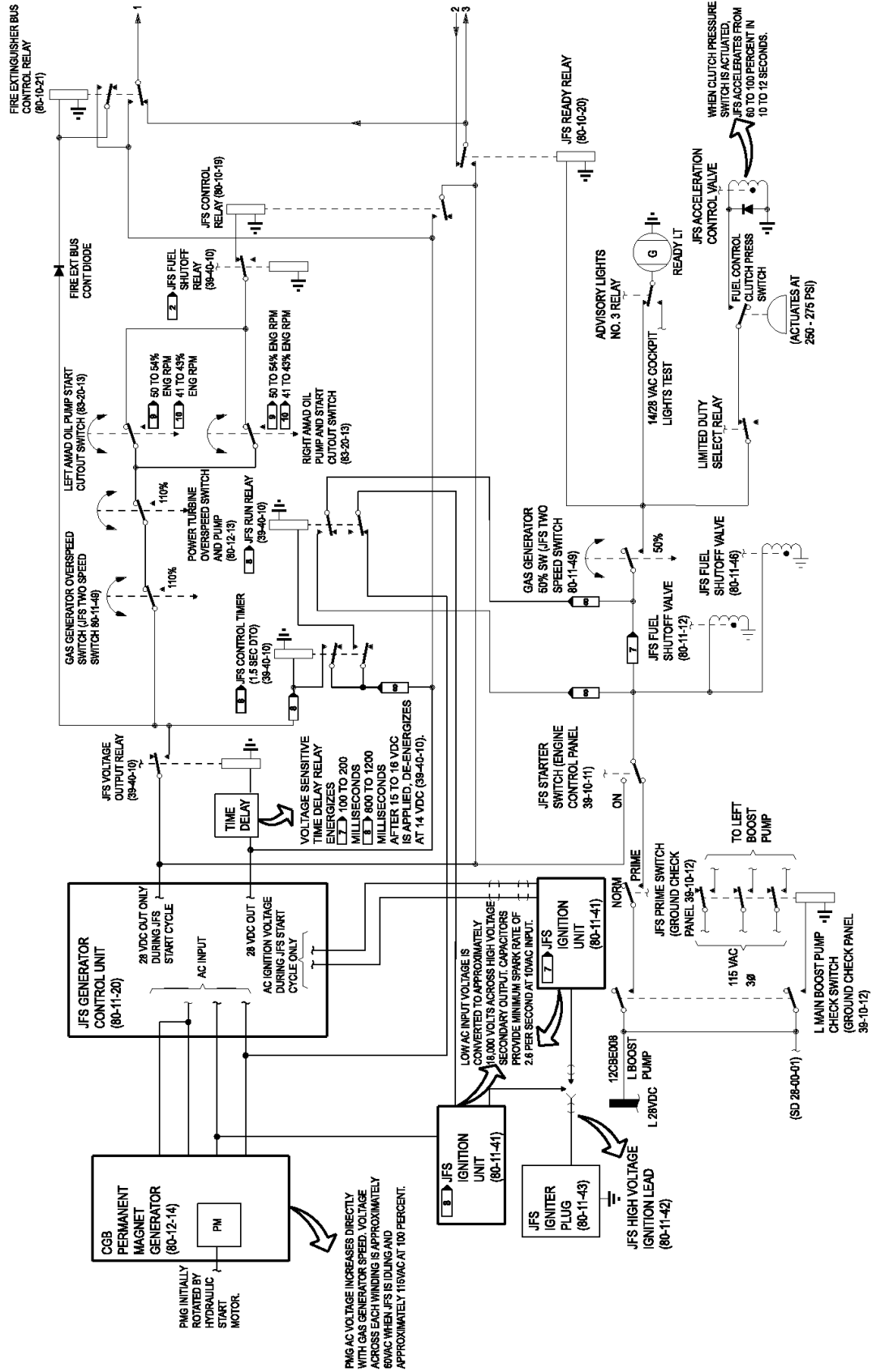
11/22/2011

Figure 1-4. JFS Start Sequence

LEGEND

1. THIS SCHEMATIC PROVIDES A SIMPLIFIED VERSION OF THE ENGINE STARTING SYSTEM.
 2. FUEL SHUTOFF RELAY IS ENERGIZED WHEN FIRE EXTINGUISHER DISCHARGE SWITCH IS SET TO DISCHARGE.
 3. FIRE EXT BUS CONTROL RELAY KEEPS FIRE EXT CONT BUS POWERED DOWN TO 15VDC ON JFS SHUTDOWN.
 4. ENGINE CONT/ESS 28VDC BUS IS POWERED BY EMERGENCY GENERATOR UNTIL LEFT OR RIGHT GENERATOR COMES ON LINE (APPROXIMATELY 50% ENGINE RPM). EMERGENCY GENERATOR IS DRIVEN BY UTILITY HYDRAULIC SYSTEM AND STARTS PROVIDING ELECTRIC POWER AT APPROXIMATELY 12% ENGINE RPM.
 5. JFS/ESS 28VDC BUS IS POWERED BY PMG UNTIL EMERGENCY GENERATOR COMES ON LINE.
 6. LEFT OR RIGHT FIRE EXTINGUISHER RELAY IS ENERGIZED WHEN RESPECTIVE FIRE WARNING/EXTINGUISHER CONTROL PANEL ENGINE FIRE PUSH LIGHT IS PUSHED.
 7. F-15C 79-0015 THRU 81-0002; F-15D 79-0004 THRU 81-0003 BEFORE TO SRIF-15-922.
 8. F-15C 79-0015 THRU 81-0002; F-15D 79-0004 THRU 81-0003 AFTER TO SRIF-15-922; F 15C 90-0263 AND UP, F-15D 90-0272 AND UP.
 9. BEFORE TO 21A16-3-506.
 10. AFTER TO 21A16-3-506.
 11. BEFORE TO SRIF-15-1210.
 12. AFTER TO SRIF-15-1210.
 13. AFTER TO 21A16-3-512, MANUAL DECOUPLER HANDLE IS SAFETIED IN THE COUPLED POSITION. THIS CAUSES LEFT AMAD MANUAL DECOUPLER SWITCH TO REMAIN IN THE START POSITION (COUPLED).
 14. LEFT AMAD 386706-3-1 OR 386706-3-2.

Figure 1-5. Engine Starting System Simplified Schematic (Sheet 1 of 4)



TR023-02-01

Figure 1-5. Engine Start System Simplified Schematic (Sheet 2)

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 1-12

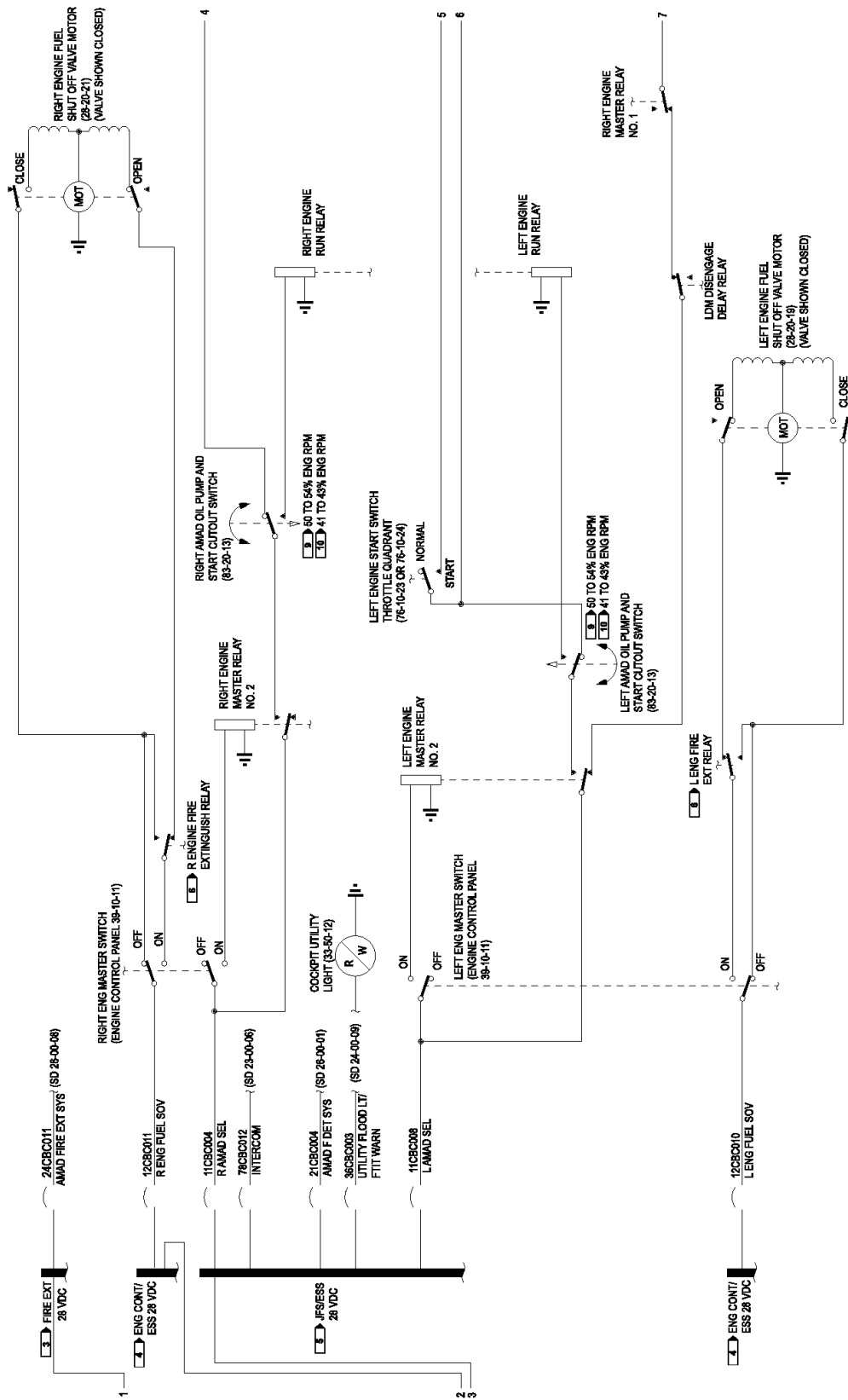
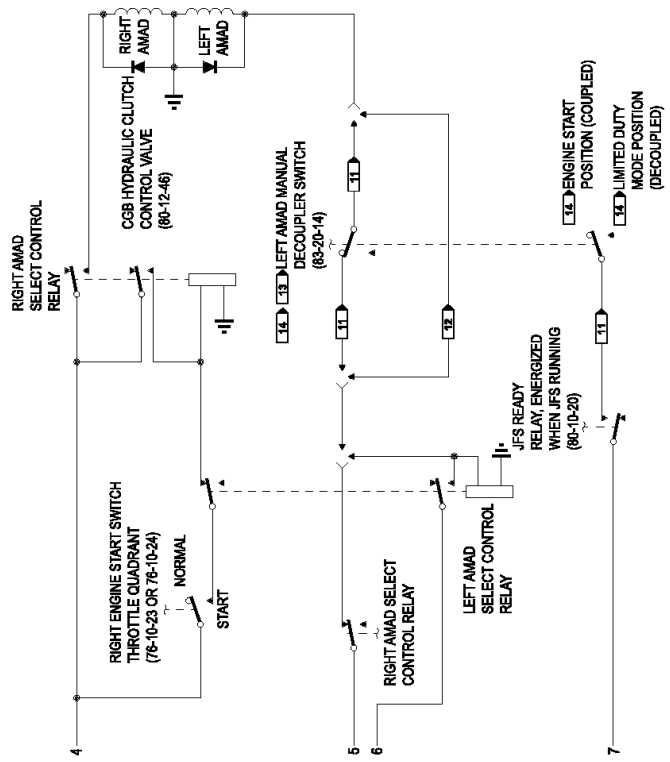


Figure 1-5. Engine Start System Simplified Schematic (Sheet 3)



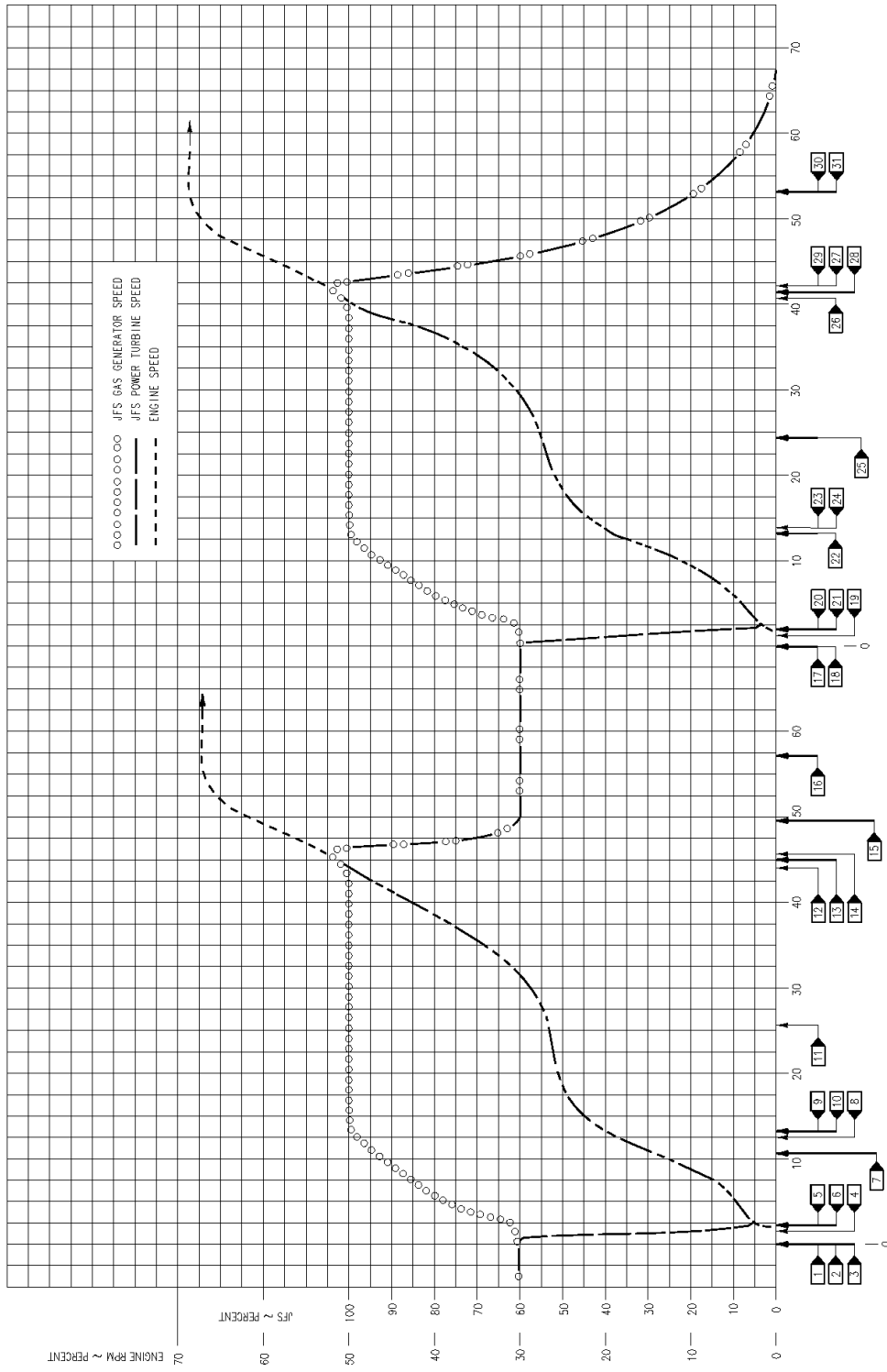
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Figure 1-5. Engine Start System Simplified Schematic (Sheet 4)

LEGEND

- 1** JFS AT IDLE (READY LIGHT ON).
- 2** R ENGINE MASTER SWITCH ON.
(A) R ENGINE MASTER RELAYS NO. 1 AND NO. 2 ENERGIZED.
(B) R ENGINE START SWITCH ARMED.
(C) FUEL TRANSFER PUMPS CIRCUIT ARMED.
(D) R ENGINE FUEL SHUTOFF VALVE ARMED.
(E) R START CUTOFF SWITCH ARMED.
- 3** R THROTTLE FINGERLIFT RAISED AND RELEASED.
(A) R AMAD SELECT CONTROL RELAY ENERGIZED.
(B) R ENGINE HOLDING CIRCUIT ESTABLISHED.
(C) CGB HYDRAULIC CLUTCH CONTROL VALVE R COIL ENERGIZED.
(D) R ISOLATION DECOUPLER STARTS TO EXTEND AS OIL PRESSURE INCREASES.
(E) DIFFERENTIAL SPEED LUBE PUMP ACTIVATED.
- 4** R ISOLATION DECOUPLER IS FULLY EXTENDED.
- 5** CGB CLUTCH ENGAGES AS OIL PRESSURE INCREASES.
(A) R AMAD ACCELERATES.
(1) PC-2 AND UTILITY PUMPS ACCELERATE.
(2) IDG ACCELERATES.
(3) R ENGINE STARTS TO CRANK.
(B) JFS FUEL CONTROL CLUTCH PRESSURE SWITCH ACTUATES AS OIL PRESSURE INCREASES.
(1) JFS ACCELERATION CONTROL VALVE ENERGIZED.
- 6** JFS STARTS TO ACCELERATE.
- 7** EMERGENCY GENERATOR ON LINE.
(A) ENGINE INSTRUMENT BUS ENERGIZED.
(1) N₂ RPM INDICATORS ENERGIZED.
(2) FTIT INDICATORS ENERGIZED.
(B) ENGINE CONTROL/ESSENTIAL DC BUS ENERGIZED.
(1) ENGINE FIRE DETECTOR/ EXTINGUISHER CIRCUIT ARMED.
(2) R AIRFRAME MOUNTED ENGINE FUEL SHUTOFF VALVE ENERGIZED, AND IF CLOSED, STARTS TO OPEN, SUPPLYING FUEL TO MAIN FUEL PUMP.
(3) R ENGINE FUEL DERICHMENT VALVE OPENS.
- 8** R THROTTLE ADVANCED TO IDLE AT APPROXIMATELY 18 PERCENT N₂ RPM.
(A) R ENGINE IGNITION INITIATED.
- 9** JFS ATTAINS 100 PERCENT SPEED.
- 10** R ENGINE FUEL PRESSURIZING AND DUMP (P AND D) VALVE OPENS, SUPPLYING FUEL TO CORE ENGINE MANIFOLD AND NOZZLES.
- 11** R ENGINE LIGHTS OFF.
- 12** R AMAD STARTER CUTOFF SWITCH ACTIVATES.
(A) ENGINE RUN RELAY ENERGIZED.
(B) R AMAD CONTROL RELAY ENERGIZED.
(C) CGB HYDRAULIC CLUTCH CONTROL VALVE R COIL DEENERGIZED.
(1) OIL PRESSURE REMOVED FROM CGB CLUTCH, AND JFS FUEL CONTROL CLUTCH PRESSURE SWITCH ISOLATION DECOUPLERS STOP ROTATING).
- 13** R ISOLATION DECOUPLER RETRACTS.
- 14** R IDG ON LINE (APPROXIMATELY 55 PERCENT N₂ RPM).
(A) AIRCRAFT BUSES ENERGIZED.
(1) OIL PRESSURE INDICATORS ENERGIZED.
(2) FUEL FLOW INDICATORS ENERGIZED.
(3) L AND R BOOST PUMPS ENERGIZED.
(4) FUEL TRANSFER PUMPS ENERGIZED.
(B) DIFFERENTIAL SPEED LUBE PUMP DEACTIVATED.
- 15** JFS REACHES IDLE.
- 16** R ENGINE STABILIZES AT IDLE.
(A) JFS ACCUMULATOR HYDRAULICALLY RECHARGED.
- 17** L ENGINE MASTER SWITCH ON.
(A) L ENGINE MASTER RELAYS NO.1 AND NO.2 ENERGIZED.
(B) L ENGINE START SWITCH ARMED.
(C) L AIRFRAME MOUNTED ENGINE FUEL SHUTOFF VALVE ENERGIZED AND CLOSED STARTS TO OPEN, SUPPLYING FUEL TO MAIN FUEL PUMP.
(D) L ENGINE FUEL DERICHMENT VALVE OPENS.
(E) L START CUTOFF SWITCH ARMED.
- 18** L THROTTLE FINGERLIFT RAISED AND RELEASED.
(A) L AMAD CONTROL RELAY ENERGIZED.
(B) L ENGINE HOLDING CIRCUIT ESTABLISHED.
(C) CGB HYDRAULIC CLUTCH CONTROL VALVE L COIL ENERGIZED.
(D) L ISOLATION DECOUPLER STARTS TO EXTEND AND OIL PRESSURE INCREASES.
(E) DIFFERENTIAL SPEED LUBE PUMP ACTIVATED.
- 19** L ISOLATION DECOUPLER FULLY EXTENDED.
- 20** CGB CLUTCH ENGAGES AS OIL PRESSURE INCREASES.
(BOTH ISOLATION DECOUPLERS ROTATE).
(A) L AMAD ACCELERATES.
(1) PC1 AND UTILITY PUMPS ACCELERATE.
(2) IDG ACCELERATES.
(3) L ENGINE STARTS TO CRANK.
(B) JFS FUEL CONTROL CLUTCH PRESSURE SWITCH ACTUATES AS OIL PRESSURE INCREASES.
- 21** JFS STARTS TO ACCELERATE.
- 22** L THROTTLE ADVANCED TO IDLE AT APPROXIMATELY 18 PERCENT N₂ RPM.
(A) L ENGINE IGNITION INITIATED.
- 23** JFS ATTAINS 100 PERCENT SPEED.
- 24** L ENGINE FUEL PRESSURIZING AND PUMP (P AND D) VALVE OPENS, SUPPLYING FUEL TO CORE ENGINE MANIFOLD AND NOZZLES.
- 25** L ENGINE LIGHTS OFF.
- 26** L IDG ON LINE.
(A) DIFFERENTIAL SPEED LUBE PUMP DEACTIVATED.
(B) EMERGENCY GENERATOR DEENERGIZED.
(C) CGB HYDRAULIC CLUTCH CONTROL VALVE L COIL DEENERGIZED.
(1) OIL PRESSURE REMOVED FROM CGB CLUTCH, AND JFS FUEL CONTROL CLUTCH PRESSURE SWITCH AND CGB CLUTCH BRAKE ACTUATES. (BOTH ISOLATION DECOUPLERS STOP ROTATING).
(2) JFS CONTROL CIRCUITS DEENERGIZED.
(3) JFS FUEL VALVES DEENERGIZED.
- 27** L AMAD STARTER CUTOFF SWITCH ACTIVATES.
(A) L ENGINE RUN RELAY ENERGIZED.
(B) L AMAD SELECT CONTROL RELAY DEENERGIZED.
(C) CGB HYDRAULIC CLUTCH CONTROL VALVE L COIL DEENERGIZED.
(1) OIL PRESSURE REMOVED FROM CGB CLUTCH, AND JFS FUEL CONTROL CLUTCH PRESSURE SWITCH AND CGB CLUTCH BRAKE ACTUATES. (BOTH ISOLATION DECOUPLERS STOP ROTATING).
(2) JFS CONTROL CIRCUITS DEENERGIZED.
(3) JFS FUEL VALVES DEENERGIZED.
- 28** JFS SHUTS DOWN.
- 29** L ISOLATION DECOUPLER RETRACTS.
- 30** L ENGINE STABILIZES AT IDLE.
- 31** JFS STARTER SWITCH OFF.

Figure 1-6. Two Engine Start Sequence (Sheet 1 of 2)



APPROXIMATE TIME FROM FINGERLIFT ACTUATION ~ SECONDS

TCC22-02-01

Figure 1-6. Two Engine Start Sequence (Sheet 2)

80-00-00
1-16

1-28. **SPECIAL MAINTENANCE REQUIREMENTS.**

1-29. Not applicable.

1-30. **CONSUMABLE MATERIALS LIST.**

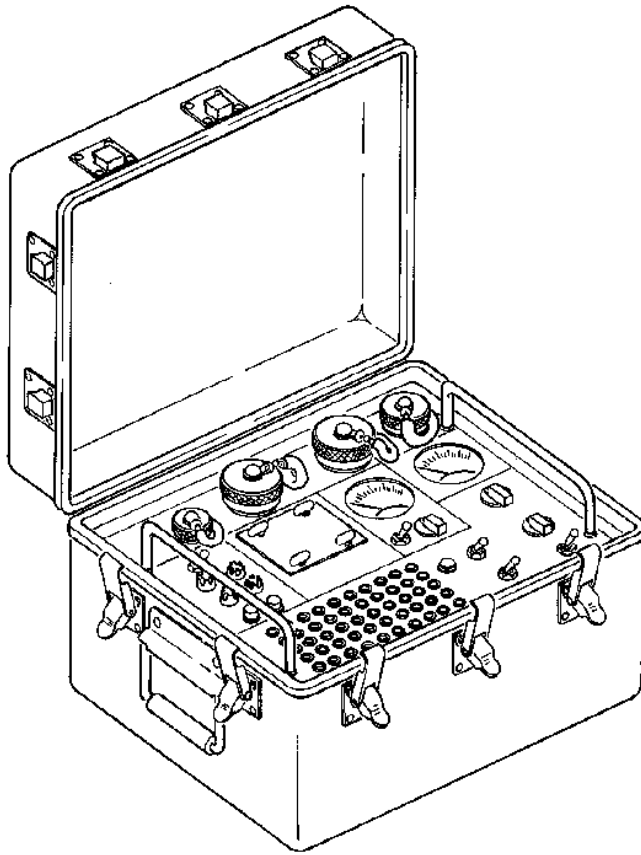
1-31. Not applicable.

1-32. **SUPPORT EQUIPMENT LIST.**

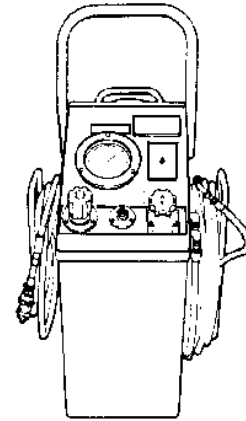
1-33. **TEST EQUIPMENT.** Test equipment required for maintenance of the engine starting system is listed in table 1-1 and shown in figure 1-7. References in the Use and Application column indicate only one of the possible uses of this equipment.

Table 1-1. Test Equipment List

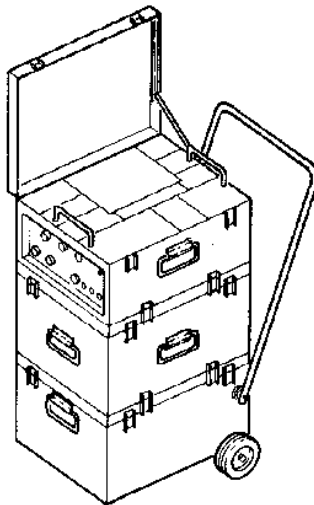
Equipment Number	Nomenclature	Use and Application
PWA50081	Engine Trim Box (ETB)	Used for troubleshooting
PWA50096	Pressurizing unit, variable vane	Used for troubleshooting
68D170009-1001	Test set, secondary power system	Used for troubleshooting
68D170013-1003	Gage assembly, control oil pressure	Used for troubleshooting
(alternate) 1 68D170013-1001	Gage assembly, control oil pressure	Used for troubleshooting
1 CGB 386720-4-1.		



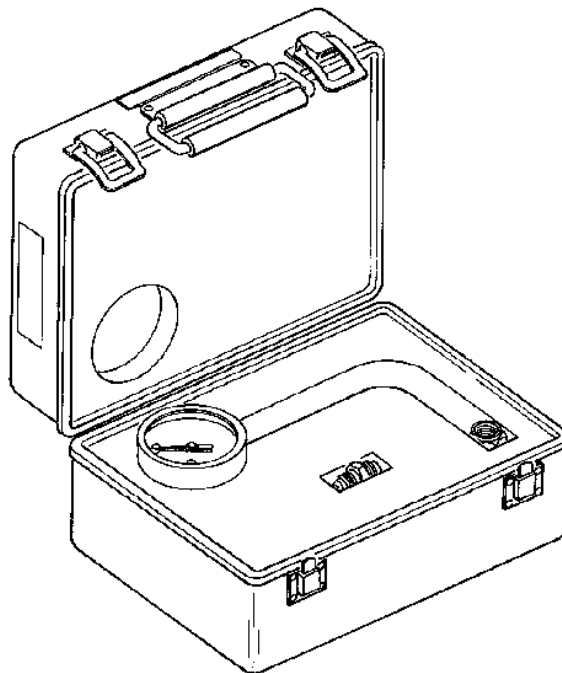
**SECONDARY POWER SYSTEM
TEST SET 68D170009-1001**



**VARIABLE VANE
PRESSURIZING UNIT
PWA50096**



**ENGINE TRIM BOX
(ETB) PWA50081**



**CONTROL OIL PRESSURE GAGE
ASSEMBLY 68D170013-1003**

TC923-02-01

Figure 1-7. Test Equipment

SECTION II

JFS START SYSTEM

2-1. SYSTEM FUNCTIONAL DESCRIPTION.

2-2. **DESCRIPTION.** This section contains description and principles of operation for the JFS start system shown in figures 2-1 and 2-2, and is made up of equipment listed in table 2-1 for the F-15C and F-15D aircraft.

2-3. The Jet Fuel Starter (JFS) start system shown in figure 2-3 is the only method by which the JFS can be started. The start system stores hydraulic fluid under pressure and on demand releases the pressure to start the JFS. The start system contains two JFS accumulators, JFS hydraulic hand pump, JFS hydraulic start motor, JFS start control manifold, a JFS accumulator gas servicing manifold, and F-15C 79-0015 THRU 81-0002; F-15D 79-0004 THRU 81-0003, AFTER TO SR1F-15-922; F-15C 90-0263 AND UP, F-15D 90-0272 AND UP, a hydraulic pressure intensifier.

2-4. **System Control.** The cockpit mounted control handle transmits movement through a cable. The cable routes through the aircraft fuselage and into door 88L area. In this area, the cable is connected by an adjustable turnbuckle to the start control manifold. The handle has two predetermined internal stops that limit travel of the start control manifold control arm. The handle is attached to the cable with a channel and swaged cable fitting connection. The cable assembly contains a prelubricated cable that moves within a teflon lined conduit.

2-5. **JFS Accumulators (80-10-10).** The two self displacing JFS accumulators store hydraulic fluid under pressure and each has a capacity of 215 cubic inches. Each accumulator provides one start at normal temperature. The accumulators have visual indicators that indicate internal piston position. The piston position must be known to correctly service the JFS accumulators. The accumulators provide a secondary source of emergency hydraulic pressure to operate nose

gear steering, wheel brakes and extend the landing gear if utility hydraulic system fails.

2-6. **JFS Hydraulic Hand Pump (80-10-11).** The JFS start system has a manually operated hand pump which hydraulically charges the JFS accumulators. The hydraulic hand pump is a double action, two stage type that requires approximately 25 pounds of force at the handle to cycle. The hydraulic side of the JFS accumulators are automatically charged when external utility power is applied, or if either engine is operated.

2-7. **JFS Hydraulic Start Motor (80-12-12).** The hydraulic start motor on the Central Gearbox (CGB) uses the stored hydraulic pressure to drive a constant displacement piston type motor. The start motor rotates the JFS gas generator, fuel control and two speed switch. Also rotated on the CGB is the differential speed tube pump and the Permanent Magnet Generator (PMG). The CGB has an overrun clutch which automatically disengages when the JFS becomes self maintaining.

2-8. **JFS Start Control Manifold (80-10-14).** The JFS start control manifold functions primarily to allow hydraulic fluid to enter into or discharge from the JFS accumulators. The internal, two way, two position control valves are normally closed and are manually opened to allow fluid to get to the hydraulic start motor. The manifold also has two thermal relief valves, a surge damper, check valves and restrictors. The start control manifold provides mounting pads for the JFS accumulators.

2-9. **JFS Accumulator Gas Servicing Manifold (80-10-15).** The gas servicing manifold provides a common mounting pad for the JFS accumulator gas servicing valves, JFS accumulator pressure gages and the JFS accumulator low gas pressure switches. This manifold is in door 88L area and functions primarily as a servicing point for accumulator precharge gas.

2-10. **PRINCIPLES OF OPERATION.** The JFS start system stores high pressure hydraulic fluid and on demand, discharges this fluid energy to the hydraulic start motor. The start motor converts the fluid energy into mechanical energy and drives a gear train which rotates the JFS and related components until the JFS becomes self maintaining. To get a JFS start, the STARTER switch must be set to ON and the JET FUEL STARTER control handle pulled and released. When a start cycle has been started, the accumulator discharge cannot be interrupted; however, the JFS start can be prevented or stopped by setting the STARTER switch to OFF.

2-11. **Compressed Gas System.** The accumulator gas precharge is serviced with nitrogen through two gas servicing valves on the gas servicing manifold. The gas servicing manifold has two gas pressure gages which indicate precharge gas pressure within the gas chambers of the JFS accumulators. Two pressure switches, which monitor pressure within the JFS accumulators, are on the gas servicing manifold. If the pressure within either of the accumulators drops to 2400 psi or lower, the electrical contacts within the respective pressure switch opens, causing the JFS LOW light on the caution lights display panel to come on.

2-12. **Hydraulic System.** The JFS accumulators, which have a self displacing fluid action, are controlled by the start control manifold. When fluid is discharged from the pressure side of the accumulators, an equal amount of fluid is entering the return side and results in the fluid level of the system remaining unchanged. The start control manifold controls the discharge of the accumulators by opening an internal mechanically actuated pilot valve. The pilot valve allows a small volume of accumulator high pressure fluid to open the poppet type main control valve which remains open until accumulator pressure is approximately 450 psi. The start control manifold provides two thermal relief valves that allow flow of hydraulic fluid from the pressure side to the return side of the accumulators when over-pressurization occurs because of temperature increase. A surge damper which controls the rate of pressure applied to the JFS hydraulic start motor is also in the start control manifold.

2-13. The hydraulic start motor changes the hydraulic pressure input to rotational power required to drive the JFS gas generator, differential speed lube pump, permanent magnet generator, fuel control and two

speed switch. The fluid pressure cycles the internal pistons turning a rotor coupled to a concentric output shaft. The start motor shaft torque is transmitted to the CGB gear train through a ratchet type overrun clutch. The recharging of the accumulators is normally done when the utility hydraulic system is pressurized by either external hydraulic power or engine operation. The check valves in the start control manifold are forced open allowing fluid to transfer from the return side to the pressure side of the accumulators. A hand pump is used to recharge or top off the JFS accumulators. The hand pump operation is done by inserting the pump handle and cycling through full travel being sure to make contact with both stops. To get a pressure buildup from precharge, the hand pump is cycled approximately 325 times. The pressure may be increased to 3800 psi by cycling the hand pump approximately an additional 104 times.

2-14. **JFS Accumulator Hydraulic Pressure Intensifier, F-15C 79-0015 THRU 81-0002; F-15D 79-0004 THRU 81-0003, AFTER TO SR1F-15-922; F-15C 90-0263 AND UP, F-15D 90-0272 AND UP.** The JFS accumulator hydraulic pressure intensifier recharges the JFS accumulators to 3500 psi when the utility hydraulic system is pressurized by external hydraulic power or during engine operation.






2-15. **JFS Starting Sequence.** The start cycle is started from the cockpit by pulling the JET FUEL STARTER control handle aft to the first stop which results in the discharge of the upper JFS accumulator. A second starting sequence may be started, without recharging the upper JFS accumulator, by turning the handle 45° counterclockwise and pulling aft to the second stop. This results in the release of hydraulic fluid from the lower accumulator. Both accumulators can be discharged simultaneously, but only one accumulator at a time is used for starts. The JFS control handle movement is transmitted by a flexible push-pull cable routed through the fuselage and connected to the start control manifold by an adjustable turnbuckle. The start control manifold controls the discharge of the accumulators to the hydraulic start motor. The fluid pressure drives the start motor which rotates the gas generator drive train until the supplying accumulator has discharged to 450 psi or the gas generator has accelerated to a higher speed than of the start motor.



















2-16. **Starting Termination.** When the JFS rotation exceeds that of the hydraulic start motor, the overrun clutch disengages the CGB gear train. However, since

the start control manifold controls the output of the accumulator, the hydraulic start motor remains in operation until the pressure at the accumulator control valve discharges to 450 psi. The control valve then

shuts off the flow from the accumulator and the start motor stops. Though the start system cannot be interrupted after a start is started, a JFS start can be prevented by setting the STARTER switch to OFF.

Table 2-1. Line Replaceable Units

Common Name	S/S/SN	Ref Des	Nomenclature
Fire Extinguisher Bus Control Relay	80-10-21	9K-C030	Relay
JFS Accumulator Gas Servicing Manifold	80-10-15	9CAP505	Manifold, Charging Accumulator, JFS Pneumatic
JFS Bottom Accumulator Low Gas Pressure Switch	80-10-17	18S-P020	Switch, Pressure
JFS Control Relay	80-10-19	9K-C001	Relay
JFS Hydraulic Hand Pump	80-10-11	9BAP510	Pump Hydraulic Ram, Hand Driven
JFS Ready Relay	80-10-20	9K-C010	Relay
JFS Start Control Cable	80-10-13	9W-J511	Control Assy, JFS
JFS Start Control Handle	80-10-12	9MPJ513	Control Handle, Push - Pull, JFS
JFS Start Control Manifold	80-10-14	9VAP512	Manifold, Hyd, JFS
JFS Top Accumulator Low Gas Pressure Switch	80-10-17	18S-P019	Switch, Pressure
Lower JFS Accumulator	80-10-10	9CAP504	Accumulator, Hyd-Jet Fuel Starter
Lower JFS Accumulator Gas Servicing Valve	80-10-18	9VAP507	Valve, Air
Lower JFS Accumulator Pressure Gage	80-10-16	9M-P509	Gage, Pressure, Dial Indicating, Pneumatic Accumulator
Upper JFS Accumulator	80-10-10	9CAP503	Accumulator, Hydraulic-Jet Fuel Starter
Upper JFS Accumulator Gas Servicing Valve	80-10-18	9VAP506	Valve, Air
Upper JFS Accumulator Pressure Gage	80-10-16	9M-P508	Gage, Pressure, Dial Indicating, Pneumatic Accumulator
 JFS Nitrogen Bottle (2)	80-10-23	9CAP501	Bottle, Nitrogen
 JFS Accumulator Hydraulic Pressure Intensifier	80-10-22	9CAR560	Intensifier, Hydraulic Pressure
 JFS Control Timer	39-40-10	9K-P036	Relay
 JFS Run Relay	39-40-10	9K-P037	Relay
 F-15C 79-0015 THRU 81-0002; F-15D 79-0004 THRU 81-0003, AFTER TO SR1F-15-922; F-15C 90-0263 AND UP, F-15D 90-0272 AND UP.			

INDEX NO.	COMMON NAME	S/S/SN	REF DES	ACCESS
1	JFS CONTROL RELAY	80-10-19	9K-C001	DOOR 6L
2	JFS READY RELAY	80-10-20	9K-C010	DOOR 6L
3	FIRE EXTINGUISHER BUS CONTROL RELAY	80-10-21	9K-C030	DOOR 6L
4	JFS START CONTROL CABLE	80-10-13	9W-J511	COCKPIT
5	JFS START CONTROL HANDLE	80-10-12	9MPJ513	COCKPIT
6	JFS HYDRAULIC HAND PUMP	80-10-11	9BAP510	DOOR 88L 
7	JFS TOP ACCUMULATOR LOW GAS PRESSURE SWITCH	80-10-17	18S-P019	DOOR 88L 
8	JFS BOTTOM ACCUMULATOR LOW GAS PRESSURE SWITCH	80-10-17	18S-P020	DOOR 88L 
9	LOWER JFS ACCUMULATOR	80-10-10	9CAP504	DOOR 88L 
10	JFS ACCUMULATOR GAS SERVICING MANIFOLD	80-10-15	9CAP505	DOOR 88L 
11	LOWER JFS ACCUMULATOR GAS SERVICING VALVE	80-10-18	9VAP507	DOOR 88L 
12	LOWER JFS ACCUMULATOR PRESSURE GAGE	80-10-16	9M-P509	DOOR 88L 
13	UPPER JFS ACCUMULATOR PRESSURE GAGE	80-10-16	9M-P508	DOOR 88L 
14	UPPER JFS ACCUMULATOR GAS SERVICING VALVE	80-10-18	9VAP506	DOOR 88L 
15	UPPER JFS ACCUMULATOR	80-10-10	9CAP503	DOOR 88L 
16	JFS START CONTROL MANIFOLD	80-10-14	9VAP512	DOOR 88L 
 17	JFS NITROGEN BOTTLE (2)	80-10-23	9CAP501	DOOR 88L 
 18	JFS ACCUMULATOR HYDRAULIC PRESSURE INTENSIFIER	80-10-22	9CAR560	DOOR 144R
 19	JFS CONTROL TIMER	39-40-10	9K-P036	LMG 
 20	JFS RUN RELAY	39-40-10	9K-P037	LMG 

LEGEND

 ACCESS TO DOOR 88L WITH CONFORMAL FUEL TANK (CFT) INSTALLED, IS THRU DOOR 567.


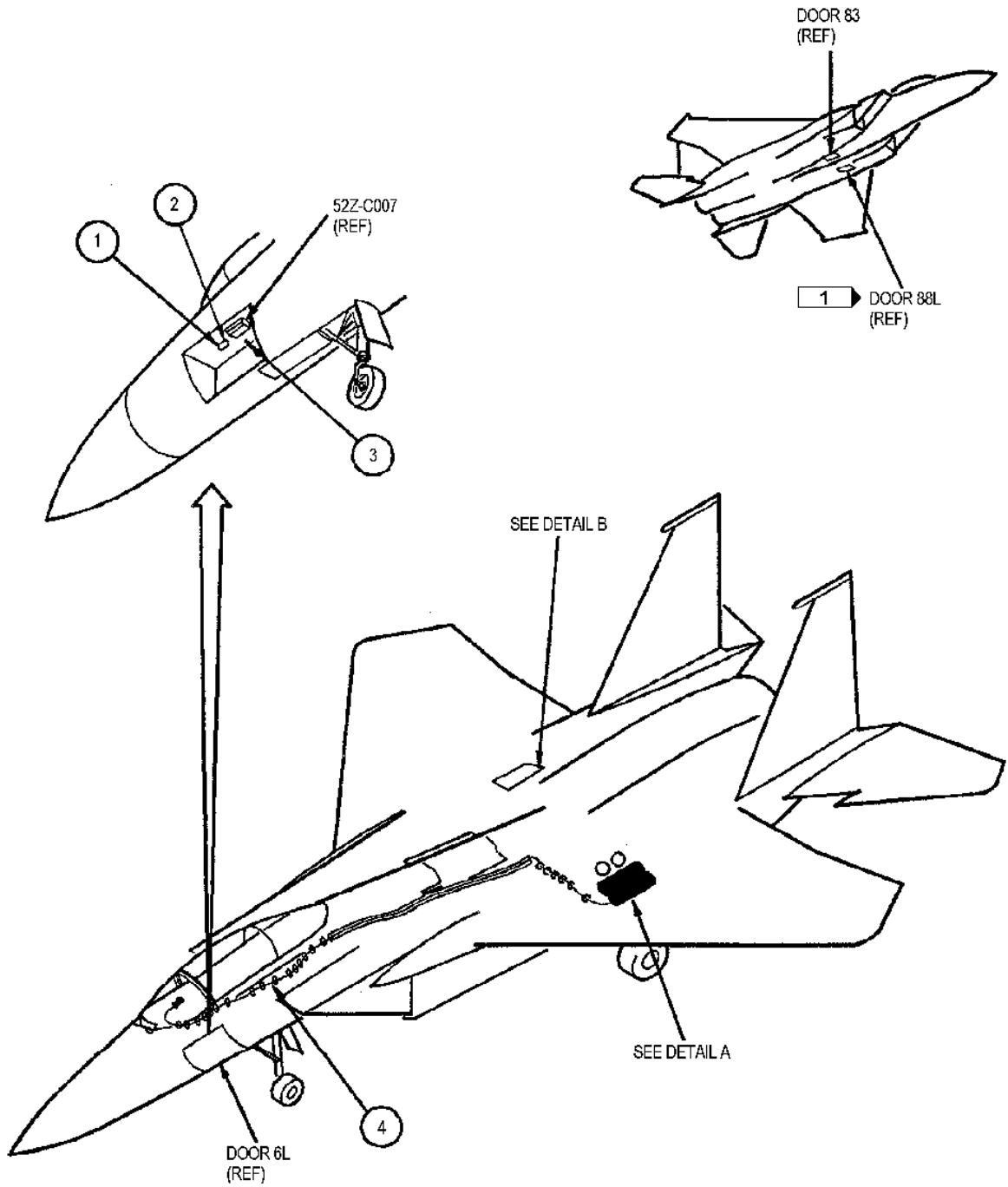
 F-15C 79-0015 THRU 81-0002; F-15D 79-0004 THRU 81-0003 AFTER TO SR1F-15-922; F-15C 90-0263 AND UP; F-15D 90-0272 AND UP.

Figure 2-1. JFS Start System Component Locator (Sheet 1 of 4)



TCG26-02-01

Figure 2-1. JFS Start System Component Locator (Sheet 2)

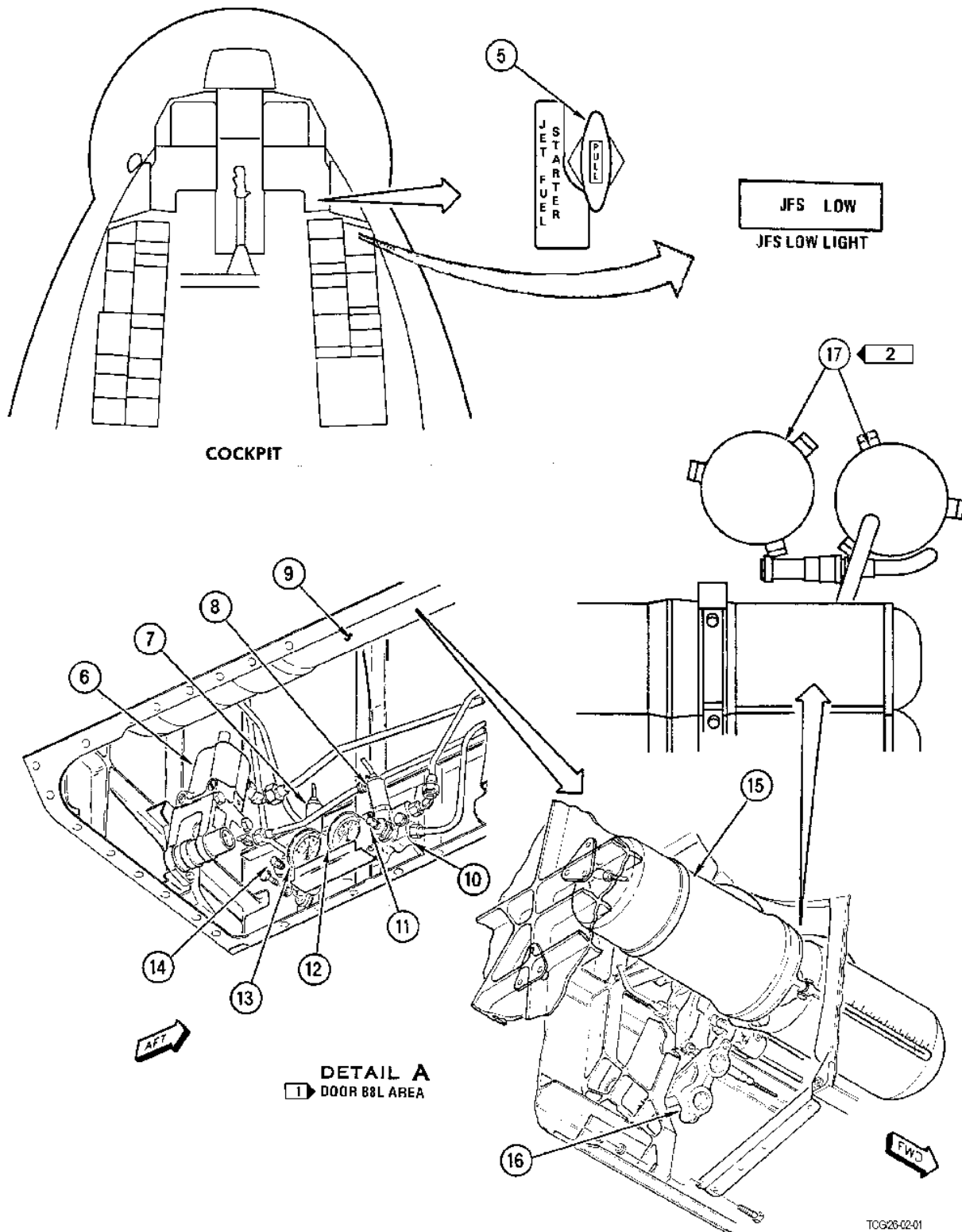
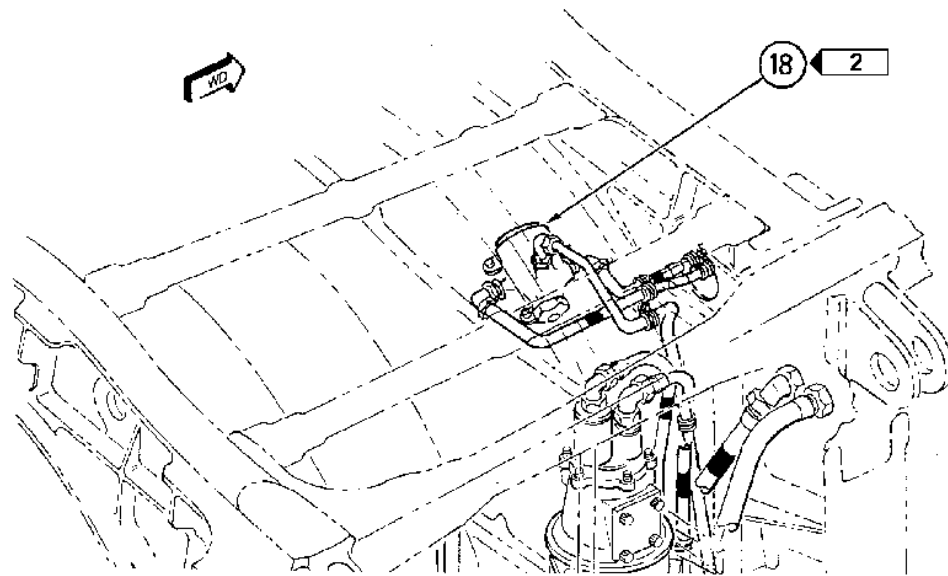
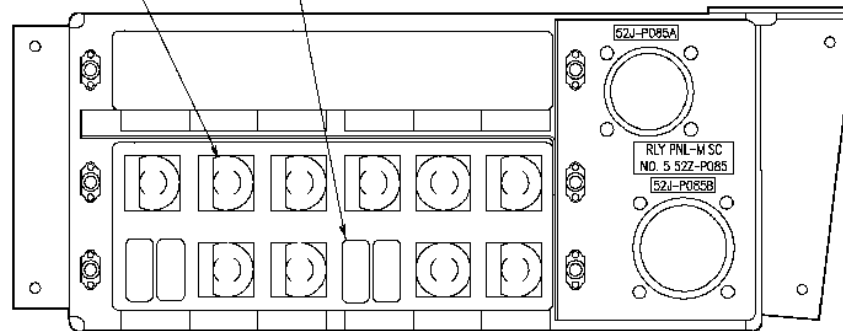
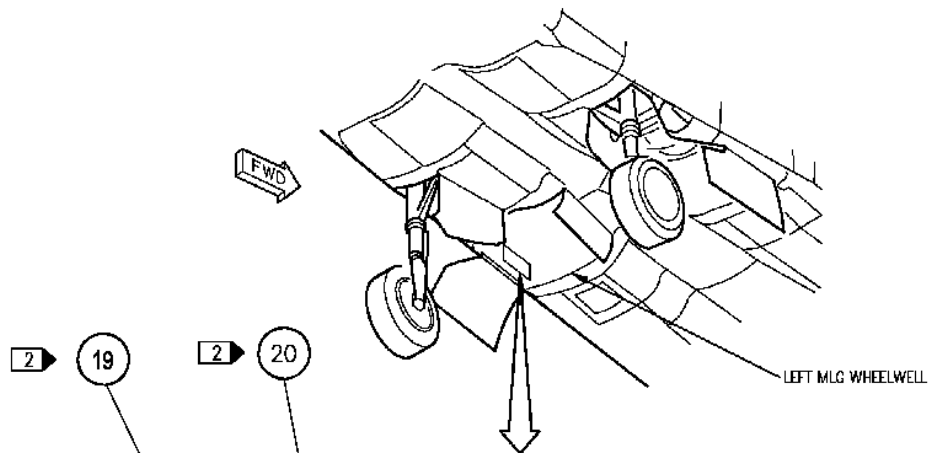


Figure 2-1. JFS Start System Component Locator (Sheet 3)



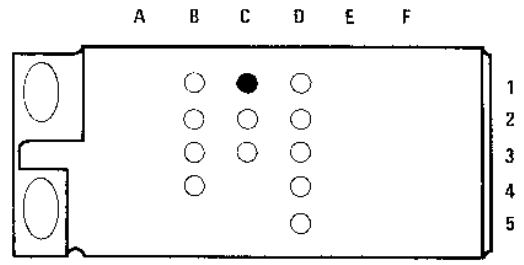
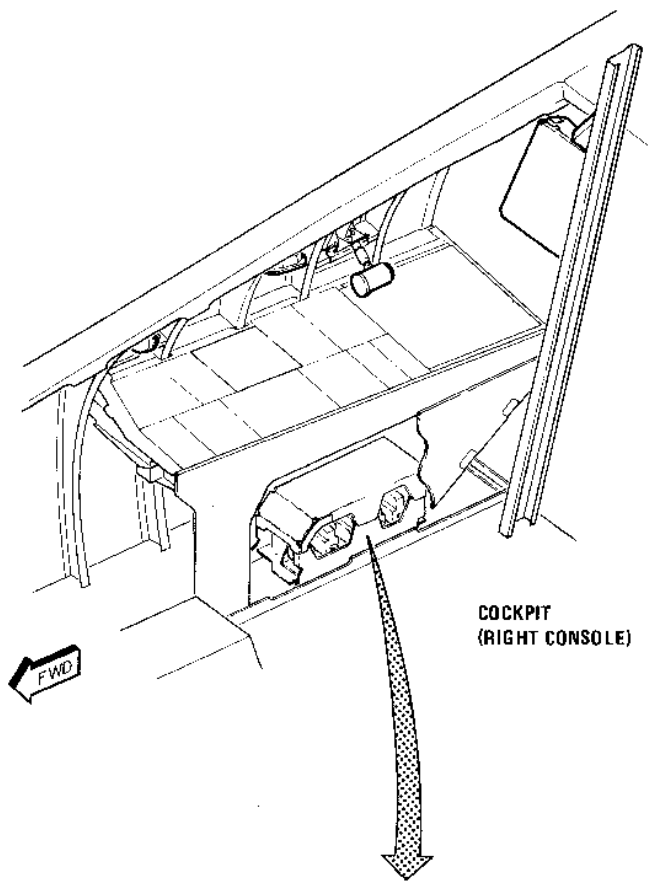
DETAIL B
DOOR 1443 AREA



52Z-P085 NO. 5 MISCELLANEOUS RELAY PANEL
(39-40-30)

TCG26-02-01

Figure 2-1. JFS Start System Component Locator (Sheet 4)



52Z-J009		INTERIOR LIGHTS POWER SUPPLY		(33-10-22)
REF DES	ZONE	NOMENCLATURE	VOLTAGE	
35CBJ011	C1	CAUTION LT	28VAC/6-14VAC	

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Figure 2-2. JFS Start System Circuit Breaker Locator

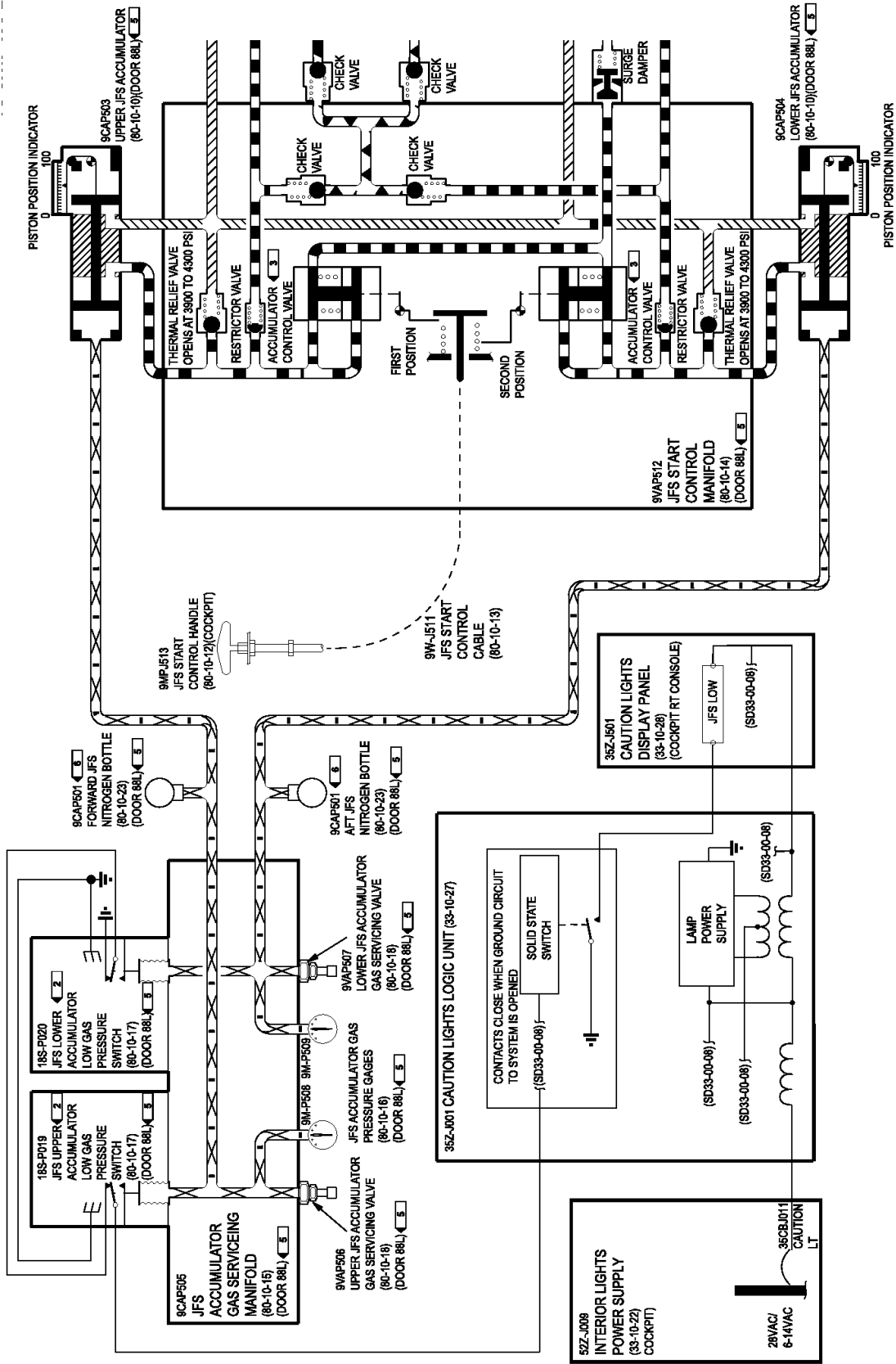


Figure 2-3. JFS Start System Schematic (Sheet 1 of 2)

2-17. **SPECIAL MAINTENANCE REQUIREMENTS.**

2-18. **JFS START SYSTEM PERTINENT DATA.**
Data pertinent to the operation and properties of the JFS, start system are found in table 2-2.

Table 2-2. Pertinent Data

JFS START SYSTEM	
JFS ACCUMULATOR	
Characteristics (Approximate)	
Dry Weight	27 pounds
Length	27 inches
Width	6 inches
Volumes	
Gas (Piston bottomed at oil end)	215 to 225 cubic inches
Discharge Oil	140 to 145 cubic inches
Residual	3.6 cubic inches (including port) maximum
Capacity	215 cubic inches
Temperature Ranges	
Ambient-Gas	-65° to 250°F 345°F for 10 minutes 450°F for 1 minute
Ambient Fluid	-65° to 275°F
Pressures	Accumulator Reservoir
Operating	1 100 to 3960 psig 55 psig (Transients to 1000 psig)
Proof	5250 psig 1500 psig 7000 psig (Midposition)
Burst	14000 psig 2500 psig
Servicing	
Hydraulic Fluid	MIL-H-83282
Nitrogen Gas	BBN-411 Type 1, Class 1, Grade A or B
Leak Limits (Stabilized and at ambient temperature)	
Piston position indicator	3 units per 4 hours
Gas Pressure (accumulator temperature stabilized and no piston position indicator movement)	No loss allowed
Hydraulic	No leakage allowed
JFS HYDRAULIC HAND PUMP	
Characteristics	
One Cycle of pump handle	25 lbs of force required
Pressures	
3000 psi	Approximately 325 cycles
3800 psi	Approximately 429 cycles

2-19. EXTREME CLIMATIC AND ENVIRONMENTAL INFORMATION.

2-20. JFS Accumulator Servicing. Refer to 12-10-09 for JFS accumulator inspecting or servicing instructions. JFS accumulators are normally serviced to a minimum of 2500 psi for starts between 10° and 80°F. Above 80°F accumulators are required to be serviced to an increased pressure of 2840 psi. The minimum pressure also increases from 2500 psi at 10°F to 2880 psi at 0°F or lower.

2-21. JFS Starting. JFS accumulators must be serviced to the applicable minimum value for the ambient temperature shown in 12-10-09 during the -

65° to 120°F range. Simultaneous discharge of accumulators is prohibited at temperatures between -30° and 120°F. However, between -30° and -40°F simultaneous discharge is required. When operating below -40°F, heat is required before a JFS start is tried. Refer to 12-11-02 for heating procedure and heating time.

2-22. CONSUMABLE MATERIALS LIST.

2-23. SUPPLIES (CONSUMABLES). A list of supplies required to support the organizational maintenance of the JFS start system is provided in table 2-3.

Table 2-3. Supplies (Consumables)

Nomenclature	Material	Part Number MFG Code
Clip		MS2156-1
Grease, Aircraft		MIL-G-81322
Grease, Pneumatic		MIL-G-4343
Hydraulic Fluid		MIL-H-83282
Keywasher		MS25081-6
Lockwire		MS20995NC32
Lockwire		MS20995NC40
Nitrogen, Tech		BBN411, TYPE 1, CLASS 1, GRADE A or B
Packing		MS28775-211
Packing		MS28775-008
Packing		MS28775-010
Packing		MS28775-015
Packing		MS28778-4
Pin		MS24665-132
Retainer		MS28774-008
Retainer		MS28774-010
Ring		MS27595-211
Spiral wrap		500024-1
Washer		MS27111-3

2-24. **SUPPORT EQUIPMENT LIST.**

2-4. References in the Use and Application column indicate only one of the possible uses of this equipment..

2-25. **TEST EQUIPMENT.** Test equipment required for maintenance of the JFS start system is listed in table

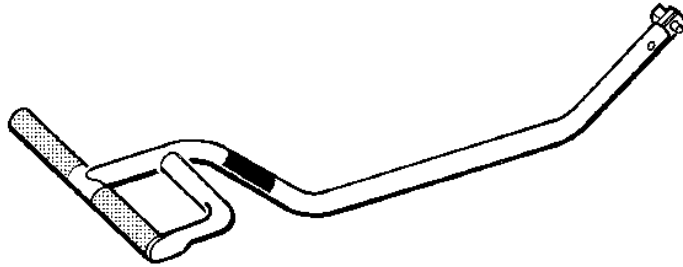
Table 2-4. Test Equipment List

Equipment Number	Nomenclature	Use and Application
AN/PSM-37	Multimeter	Used to checkout JFS accumulator low gas pressure switch.
MD-3	Trailer, compressed gas air/nitrogen	Used for system bleeding.
PPH-200	Tester, spring resiliency	Used for testing cable resistance.

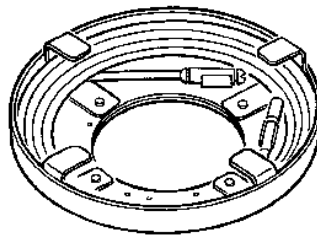
2-26. **SPECIAL TOOLS.** Special tools required for maintenance of the JFS start system are listed in table 2-5. Special tools are shown in figure 2-4.

Table 2-5. Special Tools List

Tool Number	Nomenclature	Use and Application
68D170016-1001	Handle, pump, JFS accumulator	Used to pump up JFS accumulators.
68D390010-1003	Installing tool, control cable	Used for JFS control cable removal and installation.



JFS ACCUMULATOR PUMP HANDLE
68D170016-1001



CONTROL CABLE INSTALLING TOOL
68D390010-1003

TC927-02-01

Figure 2-4. Special Tools

SECTION III

JET FUEL STARTER SYSTEM

3-1. SYSTEM FUNCTIONAL DESCRIPTION.

3-2. **DESCRIPTION.** This section contains description and principles of operation for the jet fuel starter system shown in figures 3-1 and 3-2, and made up of equipment listed in table 3-1 for the F-15C and F-15D aircraft.

3-3. **Jet Fuel Starter (JFS 80-11-10).** The JFS is a concentric shaft-type free turbine engine in door 94. The JFS contains a gas generator that produces a high velocity hot gas flow to drive the power turbine. The power turbine connects directly to the central gearbox (CGB) and supplies power to start the main engines. The JFS receives fuel from the aircraft fuel tanks. The electrical power for start and continued operation is provided by the permanent magnet generator (PMG). The PMG is driven through the CGB by the hydraulic start motor when starting and by the gas generator during continued operation. Lubrication for the JFS is supplied from the CGB through transfer tubes at the JFS/CGB interface. Pressurized oil (60 psi) flows through the inside of the power turbine shaft and through oil lines to the front and rear JFS bearings. On JFS 384238-5-1 there is a JFS/CGB clutch pressure switch. This is the only oil system component mounted on the JFS. The switch is on the forward side of the JFS intake duct. The switch is actuated when control pressure is approximately 73 psi.

3-4. **Gas Generator.** The gas generator is a compact gas turbine engine operating on an internal concentric shaft with the power turbine. The gas generator and power turbine concentric shafts are separated within JFS gas generator accessory gearbox and exit the JFS individually. The gas generator requires no external power for start or continued operation. The gas generator shaft transmits rotational power from the hydraulic start motor into the gas generator during the starting sequence. After the gas generator has continuing self-speed and the hydraulic start motor has decoupled, the gas generator shaft becomes a power output shaft and drives the two speed switch, the fuel control components, and the PMG during the operating cycle of the JFS. The acceleration, deceleration, and continued speeds of the gas generator are controlled by the pressure and volume output of the fuel control.

3-5. **JFS Power Turbine.** The single stage power turbine is aft of the gas generator turbine and provides power to the CGB. The power turbine contains a stator and a rotor section. The stator section has vanes that direct the gases onto the blades of the power turbine wheel. The stator section also houses the bearings which provides a mounting point for the rotor section. The rotor section contains vanes which are attached to a disk that transmits power to the power turbine shaft. The power turbine shaft delivers rotational power to the CGB for main engine start. The power turbine also aids the gas generator during acceleration.

3-6. **JFS Mounting.** The forward support is a V-band clamp at the JFS/CGB interface. The aft two supports are dual-coil, shock-dampening mounts from the airframe to the JFS exhaust flange at approximately the 10 o'clock and 2 o'clock positions. The aft supports provide G loading support for inflight maneuvers.

3-7. The JFS/CGB coupling interface contains four oil transfer tubes, two inlet and two return, that integrate the CGB oil system with the JFS. The JFS gas generator and power turbine shafts are connected to the CGB in the same area.

3-8. **JFS Fuel System.** See figure 3-3. The JFS operates on MIL-T-5624 grade JP4 or grade JP5 or alternate MIL-T-83133 grade JP8 fuel received from tank no. 3A. Fuel to the JFS shutoff valve is controlled by a JFS suction feed check valve and JFS pressure feed check/relief valve that are inside and near the bottom of tank no. 3A. The check valves prevent loss of prime on the JFS even if aircraft is defueled or refueled.

3-9. **JFS Fuel Valves and Accumulator.** The electrically operated JFS fuel shutoff valve controls fuel flow to the JFS and recirculation system. The valve is above the CGB in the internal access door along with the JFS bypass relief valve and JFS fuel return check valve. The bypass relief valve and return check valve help provide fuel recirculation back to tank no. 3A. The JFS fuel accumulator is downstream of the JFS fuel shutoff valve in door 95L. Approximately 400cc of fuel, at a pressure of 25 psig, is directed from the accumulator to the primary fuel filter to increase the starting ability of the JFS.

3-10. **JFS Fuel Filter Assembly (80-11-13).** The fuel filter assembly is on the lower right side of the JFS and is aft of the air inlet duct. The fuel filter unit contains a replaceable filter element, a DP indicator, a bypass valve and jet boost pump. If fuel flow within the filter element becomes restricted, the bypass valve automatically opens allowing fuel flow around the filter element. The DP indicator extends, visually indicating filter element replacement is required. The jet boost pump provides pressurized fuel to the fuel control.

3-11. **JFS Fuel Control (80-11-46).** The fuel control is on the forward right side of the JFS. The fuel control is an electro-hydraulically controlled unit used to regulate the fuel supply to the JFS. The fuel control is a high pressure, positive displacement, gear type fuel pump that is mechanically driven by the gas generator and supplies approximately 250 psi fuel pressure. The acceleration schedule valve, two speed governor, differential pressure valve, acceleration control valve, priority valve, check valve, inline filters and orifices which meter fuel into the fuel manifold are also in the fuel control.

3-12. **JFS Combustion Chamber.** The fuel manifold passes fuel from the fuel control to 10 evenly spaced fuel nozzles that circle the combustion chamber. The pressure sensitive fuel spray nozzles emit fuel into the combustor at a rate controlled by pressure and volume output of the fuel control. To keep the fuel from vaporizing when operating in high heat areas and improve JFS starts after shutdown, the priority valve directs fuel recirculation at a rate of 50 to 130 pph back to tank no. 3A from the fuel control. On completion of JFS operation, any residual fuel in the combustor is drained overboard by the JFS combustion drain valve.

3-13. **JFS Electrical System.** The JFS provides rotational power, through the gas generator shaft, to turn the PMG. The PMG supplies electrical power for JFS ignition and for control of the JFS/AMAD and related aircraft circuits during JFS start and engine start.

3-14. **Generator Control Unit (GCU 80-11-20), F-15C 79-0015 THRU 81-0002; F-15D 79-0004 THRU 81-0003, BEFORE TO SR1F-15-922.** The GCU, a rectangular unit in the JFS inlet, is cooled by inlet air. It contains an automatic resetting overvoltage protection circuit and a start sequencing relay. This relay controls the power produced from the start winding of the PMG and is used by the ignition unit to

supply high voltage to the igniter plug. The ac power produced by the PMG load winding is directed to the GCU where it passes through a current limiting inductor and is then filtered, rectified, and regulated before being transmitted to the de control circuit and fuel solenoid valves.

3-15. **Generator Control Unit (GCU 80-11-20), F-15C 79-0015 THRU 81-0002; F-15D 79-0004 THRU 81-0003, AFTER TO SR1F-15-922; F-15C 90-0263 AND UP, F-15D 90-0272 AND UP.** The GCU, a rectangular unit in the JFS inlet, is cooled by inlet air. It contains an automatic resetting overvoltage protection circuit and a start sequencing relay. Part of the ac power produced by the PMG is directed to the GCU where it passes through a current limiting inductor and is then filtered, rectified, and regulated before being transmitted to the de control circuit and fuel solenoid valves.

3-16. **JFS Ignition Unit (80-11-41), F-15C 79-0015 THRU 81-0002; F-15D 79-0004 THRU 81-0003, AFTER TO SR1F-15-922; F-15C 90-0263 AND UP, F-15D 90-0272 AND UP.** The JFS ignition unit is a 1.5 joule, high voltage, capacitor discharge unit with an intermittent duty cycle rating of 10 seconds on and 10 minutes off. The ignition unit provides a minimum spark rate of 2.6 sparks per second at 10vac, 360 Hz. The ignition unit is connected through a shielded, high voltage ignition cable to a single igniter plug in the JFS combustor. The ignition unit is powered from the PMG through the JFS run relay. The ignition unit will continue to supply 2.6 sparks per second until the JFS run relay energizes.

3-17. **JFS Two Speed Switch (80-11-49).** The JFS two speed switch is a dual function centrifugal switch mounted upon the JFS. One set of contacts within the switch completes an electrical circuit at 50 percent gas generator speed. When this circuit is complete, the STARTER-READY light on the ENGINE control panel comes on. The other set of contacts provides an electrical safety cutoff of the JFS, if the gas generator should accelerate to a 110 percent overspeed condition.

3-18. **JFS Exhaust Duct and Collar System.** The JFS exhaust duct in door 94 carries exhaust gases aft and then down to exit through a collared door in the lower moldline of the aircraft. A slip joint in the duct limits the axial load on the JFS because of thermal expansion. The duct is covered with an insulating blanket to limit skin temperature and to keep compartment heat at a minimum. In addition to the JFS support, the exhaust

duct is supported from the aircraft structure by an adjustable gimbal mount near the exit of the duct. The collared exhaust panel aft of door 94 provides the opening in the aircraft structure to direct the exhaust gases down and aft.

3-19. JFS Compartment Cooling. Compartment cooling and ventilation is done, during JFS run, by a mechanical fan driven by the CGB. The fan pulls ambient air into the CGB, where it is passed through an air/oil cooler and vented into the JFS bay. The air exits the JFS bay through an opening in door 94, through the upper moldline, and through the JFS exhaust duct opening aft of door 94. This circulating air maintains a JFS compartment temperature of less than 250°F. After a JFS run, excessive compartment temperatures are prevented by convection cooling. Air is pulled through a lower moldline screened opening, aft of the JFS inlet duct. Absorbed compartment heat exits through an upper screened opening and is vented through the aircraft upper moldline at an average temperature of 230°F.

3-20. PRINCIPLES OF OPERATION. The JFS start is started from the cockpit by pulling the JET FUEL STARTER control handle with the STARTER switch ON. This action, through a cable system, releases high pressure hydraulic fluid from one of the JFS accumulators to the hydraulic start motor. When the start sequence is started, the discharge of hydraulic fluid from the accumulator cannot be interrupted; however, a start can be prevented by setting the STARTER switch to OFF. The high pressure hydraulic fluid enters the inlet port of the hydraulic start motor causing rotation that is transmitted through an overrunning clutch to the gas generator gear train within the CGB. This gear train drives the differential speed lube pump, PMG, fuel control, two speed switch, and gas generator shaft. The differential speed lube pump aids the primary lube pump in supplying lubrication during start, acceleration, or when the load on the gas generator increases so that a differential speed condition exists between the gas generator drive train and the power turbine drive train.

3-21. The lube oil is supplied from the CGB reservoir and spread through internal vanes to the moving components within the JFS. Rotational power from the CGB is transmitted into the JFS during the start sequence by the gas generator shaft. When ignition and combustion occur within the combustor and the gas

generator has a self-continuing speed, the hydraulic start motor is disengaged from the CGB through the overrunning clutch. The gas generator shaft drives the gas generator gear train. During normal operation, the gas generator speed is higher than the power turbine speed, but the power turbine aids the gas generator in acceleration through a sprague clutch in the CGB.

3-22. Gas Generator. The gas generator has a single stage centrifugal compressor and a single stage axial turbine. The compressor pulls ambient air through the inlet duct. The air is compressed and directed to the combustor. The annular reverse flow combustor is where air and fuel mixing occurs and combustion occurs. The now expanded high velocity hot gases are used to rotate the axial turbine which drives the compressor. The hot gases are passed through the power turbine and into the JFS exhaust duct. When the gas generator arrives at 50 percent speed, the two speed switch completes an electrical circuit causing the STARTER READY light to come on, indicating that the JFS has completed a start and is ready for an engine start.

3-23. Another set of contacts in the two speed switch actuate and stop the JFS run when the gas generator overspeeds 110 percent. The gas generator can run at two different continued speeds; 60 percent idle and 100 percent rated maximum power output speed. The gas generator is accelerated to maximum speed automatically by fuel control operation only when main engine start is selected. The gas generator shaft rotates the differential speed lube pump, fuel control, two speed switch, PMG, and works with the power turbine shaft to drive the differential speed lube pump.

3-24. JFS Power Turbine. The single stage axial power turbine is rotated by the high velocity hot gases emitted from the gas generator. The power turbine shaft is directly engaged to the CGB to provide rotational power to the isolation decouplers for main engine starts. The power turbine is protected from overspeed by a 110 percent electrical switch on the primary lube pump. When actuated, the electrical contacts within the overspeed switch completes a circuit which stops the gas generator operation. The power turbine aids the gas generator in acceleration by driving it through a sprague clutch in the CGB. The sprague clutch also prevents power turbine rpm from exceeding gas generator rpm.

3-25. **Electrical System.** The PMG, when rotated, immediately starts supplying ac power from the start and load windings to the GCU. F-15C 79-0015 THRU 81-0002; F-15D 79-0004 THRU 81-0003, BEFORE TO SR1F-15-922, the ac power provided by the start winding passes through the normally closed contacts of the start sequencing relay within the GCU, and is applied to the JFS ignition unit. F-15C 79-0015 THRU 81-0002; F-15D 79-0004 THRU 81-0003, AFTER TO SR1F-15-922; F-15C 90-0263 AND UP, F-15D 90-0272 AND UP, the ac power provided by the start winding is applied to the JFS ignition unit through the JFS run relay located in the no. 5 miscellaneous relay panel. The ignition unit contains a high voltage ignition coil and storage capacitor which discharges automatically when a predetermined high voltage level is received. The ejected high voltage is directed to the igniter plug that extends into the combustor and emits an electrical arc between the air gap electrodes and produces combustion when fuel exists.

3-26. F-15C 79-0015 THRU 81-0002; F-15D 79-0004 THRU 81-0003, BEFORE TO SR1F-15-922, when the PMG output exceeds approximately 25vac, the start sequencing relay circuit stops ignition. This occurs at approximately 20 percent gas generator speed. When the JFS is started, the gas generator normally becomes self-continuing within 3 seconds and accelerates to idle or standby within 7 seconds. The ac electrical power produced by the PMG load winding is applied to the GCU where it is rectified, filtered and used to actuate both fuel solenoid valves. During JFS start and operating cycles, the PMG load winding provides electrical power for the JFS/CGB airframe mounted accessory drive (AMAD) control circuits. The GCU also has a dc voltage regulator and overvoltage protective unit. When an overvoltage condition occurs, the JFS run is stopped; however, the overvoltage unit automatically resets allowing another try.

3-27. F-15C 79-0015 THRU 81-0002; F-15D 79-0004 THRU 81-0003, AFTER TO SR1F-15-922; F-15C 90-0263 AND UP, F-15D 90-0272 AND UP, approximately 150 milliseconds after 16vdc is applied to the JFS voltage output relay it will energize. The JFS control timer will energize 1.5 seconds after the voltage output relay energizes. This will energize the JFS run relay and it will remove power from the ignition unit, stopping ignition. With all the above delays ignition stays on for a much longer period of time. When the JFS is started, the gas generator normally becomes self-continuing within 3 seconds and accelerates to idle or standby within 7 seconds. The ac electrical power

produced by the PMG load winding is applied to the GCU where it is rectified, filtered and used to actuate both fuel solenoid valves. During JFS start and operating cycles, the PMG load winding provides electrical power for the JFS/CGB airframe mounted accessory drive (AMAD) control circuits. The GCU also has a dc voltage regulator and overvoltage protective unit. When an overvoltage condition occurs, the JFS run is stopped; however, the overvoltage unit automatically resets allowing another try.

3-28. **JFS Fuel System.** When doing a normal JFS start, gravity fed fuel is supplied from tank no. 3A through the JFS suction feed check valve to the JFS fuel shutoff valve. The fuel flow is controlled by the shutoff valve which is energized by a low dc voltage supplied during the start cycle by the GCU. The fuel downstream of the JFS fuel shutoff valve is pressurized to 25 psig from the, JFS fuel accumulator and passed through the primary fuel filter element. The fuel pressure is increased in the fuel filter housing by the jet boost pump. The boost pump increases fuel flow through the filter and to the inlet of the high pressure pump to provide enough flow to allow the JFS to operate with a minimum input fuel pressure of 5 psi. A differential pressure indicator in the fuel filter housing compares fuel pressure on both sides of the filter and indicates when filter replacement is required. Fuel is routed from the filter unit directly to the inlet of the fuel control. In the fuel control, the fuel passes through the high pressure fuel pump. The positive displacement pump is gear driven by the gas generator accessory gearbox and supplies fuel to the fuel manifold and spray nozzles at pressures up to 250 psi. Excess fuel pressure is routed to the jet boost pump, bypassed to the inlet of the high pressure pump and recirculated back to tank 3A through action of the priority valve.

3-29. The JFS two speed switch is also directly driven by the fuel pump shaft and contains two sets of electrical contacts. The first set of contacts actuate and complete an electrical circuit at 50 percent gas generator speed. This actuation causes the STARTER-READY light to come on, indicating to the operator that the JFS is ready for an engine start. The other set of contacts will open the JFS control holding circuit, which operates the fuel valves, should the gas generator speed exceed 110 percent. If these contacts do open, the JFS shuts down immediately due to fuel starvation.

3-30. The differential pressure valve maintains a constant pressure drop across the acceleration schedule valve and the governor valve. In addition, it ports excess fuel to the jet boost pump in the fuel filter. During start, when the acceleration schedule valve is metering fuel flow and the governor valve is open, the differential pressure valve maintains a constant pressure drop across the acceleration schedule valve. When gas generator speed is 60 percent or higher, the governor valve assumes the fuel metering function causing the differential pressure valve to maintain a constant pressure drop across the governor valve.

3-31. The acceleration schedule valve controls fuel flow to the JFS during start and during acceleration to 60 percent gas generator speed. The scheduling valve receives fuel from the high pressure pump and meters the required fuel to the governor valve. A bellows inside the acceleration schedule valve receives compressor discharge pressure and compares compressor discharge pressure with an evacuated aneroid bellows to limit the amount of fuel passing from the pump to the governor.

3-32. The governor valve meters fuel during steady-state operation, either 60 percent or 100 percent gas generator speed. The governor valve contains a governor shaft and a metering sleeve. The position of the metering sleeve is the result of spring tension applied down on the sleeve, and the opposing centrifugal force produced by a fly-weight assembly. At controlled speed, the metering sleeve is repositioned by centrifugal force to maintain a constant speed as selected by the acceleration control valve. A minimum flow orifice prevents flameout from not enough fuel flow during JFS deceleration.

3-33. The acceleration control valve establishes two controlled speeds; 60 and 100 percent gas generator speed and two separate schedules for going from one speed to the other. It contains a solenoid, an acceleration limiter piston and an acceleration limiter shaft. The solenoid is controlled by the JFS/AMAD control systems. When energized, the solenoid opens a passage and high pressure fuel is directed to the top of the acceleration limiter piston. High pressure fuel is allowed to enter the governor and move a piston to increase the force on the speeder spring. Fuel from the low pressure side of the piston escapes to the governor cavity, at near nozzle pressure, through a controlled leakage path. The 100 percent gas generator speed set point is arrived at when the piston arrives at the end of its stroke. When deenergized, the solenoid ports fuel from the top of the piston to a low pressure fuel

passage, which relieves the piston to the 60 percent position. The deceleration from 100 to 60 percent is almost immediate when the top of the acceleration limiter piston is ported to the low pressure fuel passage.

3-34. The fuel nozzles contain five primary and five secondary nozzles. Three primary nozzles open at 10 psig and two nozzles open at 30 psig to provide start fuel. The secondary nozzles open at 70 psig for JFS run. The nozzles open at different pressure to aid starting in cold weather conditions.

3-35. The fuel control shutoff valve is an electrically actuated solenoid valve that opens or closes the fuel manifold. When energized, the solenoid allows metered fuel to exit the fuel control to the fuel nozzles. When deenergized, the solenoid closes the passage to the nozzles and routes the fuel to the inlet of the high pressure pump. This prevents a fuel pressure shock inside the fuel control on shutdown.

3-36. The priority valve functions as a result of differential pressure. When the JFS fuel control shutoff valve is energized, metered fuel flows to the nozzles. At approximately 50 percent gas generator speed, manifold back pressure increases causing the priority valve to shuttle down allowing high pressure fuel to unseat the check valve at 40 psi. Fifty to one hundred thirty pph of fuel at approximately 180°F maximum is routed through the JFS fuel return check valve to tank no. 3A for recirculation. When the fuel control shutoff valve is deenergized, manifold back pressure is reduced, causing the high pump discharge pressure to act upon the priority valve to shut off fuel recirculation. The priority valve and 40 psi check valve trap bypass fuel inside the fuel control to prevent pumping the fuel control dry of fuel during JFS shutdown. Upon completion of the JFS run, any residual fuel within the combustor is drained overboard by the JFS combustion drain valve.

3-37. **JFS Shutdown.** Normal JFS shutdown is done when the second engine is started. This shutdown is controlled by the start cutout switch on each AMAD. As each engine arrives at BEFORE TO 2JA16-3-506 50 to 54 percent N₂ RPM or AFTER TO 2JA16-3-506 41 to 43 percent N₂ RPM, electrical contacts within the related start cutout switch break the circuit to the fuel shutoff valves. Since the switches are wired in parallel in the circuit, either main engine can be started first. JFS shutdown is automatic through the overspeed switch on the primary lube pump when a 110 percent speed is arrived at by the power turbine, or by

the power turbine, or by the two-speed switch on the JFS when the gas generator arrives at 110 percent speed. An overvoltage protective unit in the GCU can also stop a JFS run when an overvoltage condition from the PMG occurs. Manual shutdown of the JFS is

done by setting the STARTER switch on the ENGINE control panel to OFF. This action breaks the electrical circuit to the fuel shutoff valves and stops the fuel flow to the JFS.

Table 3-1. Line Replaceable Units


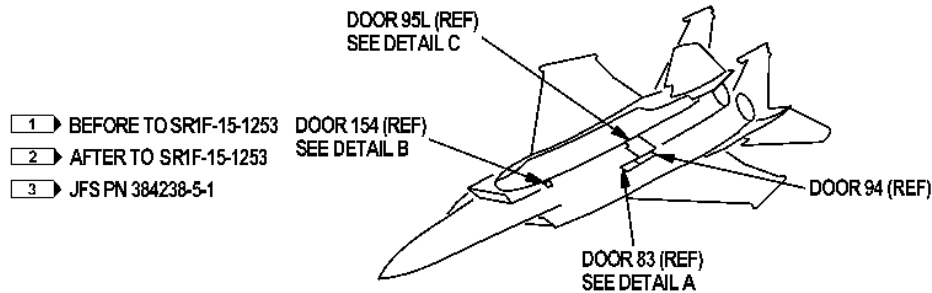
Common Name	S/S/SN	Ref Des	Nomenclature
Jet fuel Starter (JFS)	80-11-10	9Z-S003	Starter, Jet Fuel
JFS Boss Plug	80-11-36	9U-T549	Plug, Boss
JFS Bypass Relief Valve	80-11-17	9VAP528	Valve, Relief
 JFS/CGB Clutch Pressure Switch	80-11-21	9S-S514	Switch, Pressure Oil
JFS Combustor Drain Line	80-11-37	9U-T551	Support Assy, Fuel Drain
JFS Combustion Drain Valve	80-11-38	9VAS515	Valve, Check, Drain
JFS Compressor Discharge Air Plug	80-11-34	9U-S552	Plug
JFS Compressor Discharge Pressure Line	80-11-27	9U-T532	Tube Assy, Jet Fuel Starter
JFS Compressor Discharge Pressure Line	80-11-27	9U-T534	Tube Assy, Jet Fuel Starter
JFS Compressor Discharge Pressure Line Adapter	80-11-28	9U-T533	Union
JFS Compressor Inlet Screen	80-11-19	9MPS531	Screen, Compressor Inlet
JFS Exhaust Duct	80-11-50	9MPS516	Duct, Exhaust, Jet Fuel Starter
JFS Exhaust Louver	80-11-45	9MPS517	Collar, JFS Exhaust
JFS Fuel Accumulator	80-11-11	9CAP530	Accumulator - Fuel
JFS Fuel Bypass Line Adapter	80-11-26	9U-T539	Nipple, Tube
JFS Fuel Control	80-11-46	9BAS556	Control, Fuel
JFS Fuel Control Bypass Line	80-11-25	9U-T535	Tube Assy, Fuel Bypass
JFS Fuel Control Line Adapter	80-11-31	9U-S554	Union
JFS Fuel Control Pressure Bypass Line	80-11-24	9U-T542	Tube Assy, Jet Fuel Starter
JFS Fuel Control Pressure Line	80-11-23	9U-T543	Tube Assy, Jet Fuel Starter

Table 3-1. Line Replaceable Units (CONT)

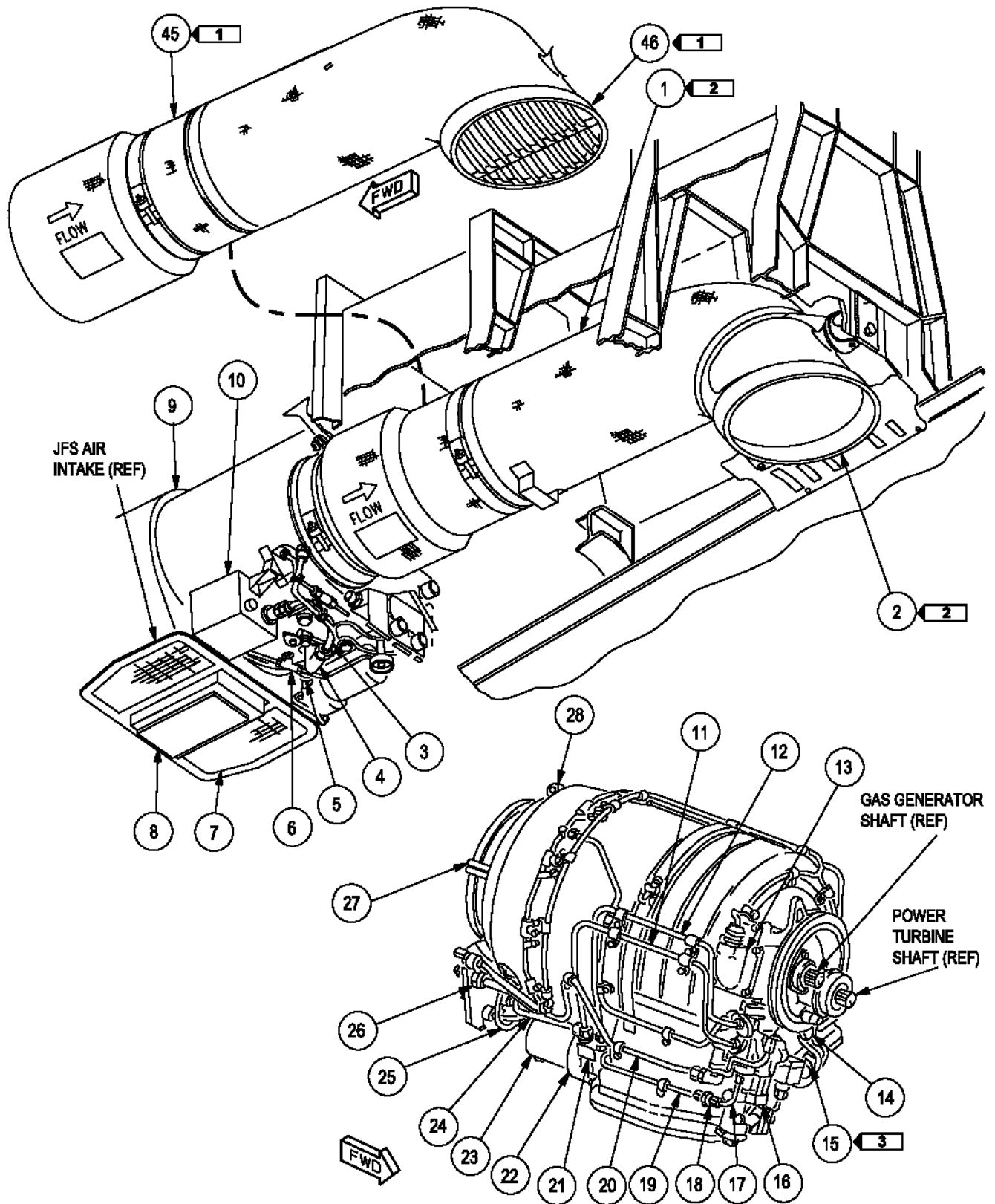
Common Name	S/S/SN	Ref Des	Nomenclature
JFS Fuel Filter Assembly	80-11-13	9FAT518	Filter Assembly
JFS Fuel Filter DP Indicator	80-11-14	9DST519	Differential Pressure Indicator
JFS Fuel Filter Element	80-11-15	9FAT520	Filter Element
JFS Fuel Filter Identification Plate	80-11-16	9MAT536	Plate, Identification
JFS Fuel Inlet Line	80-11-29	9U-T537	Tube Assy, Jet Fuel Bypass
JFS Fuel Inlet Line Adapter	80-11-33	9U-S548	Nipple, Tube
JFS Fuel Manifold Plug	80-11-35	9U-S550	Plug
JFS Fuel Return Check Valve	80-11-18	9VAR529	Valve, Check
JFS Fuel Shutoff Valve	80-11-12	9L-P005	Valve, Solenoid, Fuel Shutoff
JFS Generator Control Unit	80-11-20	9PST521	Control Unit, Generator
JFS High Voltage Ignition Lead	80-11-42	9W-S522	Electrical Lead
JFS Igniter Plug	80-11-43	9ATT524	Igniter, Plug, Gas Turbine Engine
JFS Ignition Unit	80-11-41	9R-S525	Ignition Unit, High Voltage Capacitor Discharge
JFS Left Rear Mount Bracket	80-11-39	9U-S540	Bracket Assy, Engine Mount Rear
JFS Plenum Gasket Seal	80-11-40	9MPS557	Seal, Plenum Gasket
JFS Power Turbine Scavenge Line	80-11-32	9U-S547	Tube Assy
JFS Power Turbine Scavenge Line	80-11-32	9U-T538	Tube Assy
JFS Power Turbine Scavenge Line	80-11-32	9U-S553	Tube Assy
JFS Pressure Switch Transfer Tube	80-11-48	9V-S558	Tube, Transfer Oil, Pressure Switch
JFS Rear Bearing Oil Scavenge Transfer Tube	80-11-47	9U-S557	Tube, Transfer Oil Scavenge, Rear Bearing
JFS Right Rear Mount Bracket	80-11-39	9U-T541	Bracket Assy, Engine Mount Rear
JFS Two Speed Switch	80-11-49	9U-T559	Switch Assy, Two Speed
Oil Pressure Inlet Transfer Tube	80-11-30	9U-S545	Tube, Transfer Oil Pressure Inlet
Transfer Tube Retainer	80-11-22	9MPT544	Retainer, Transfer Tubes
1 JFS 386238-5-1.			



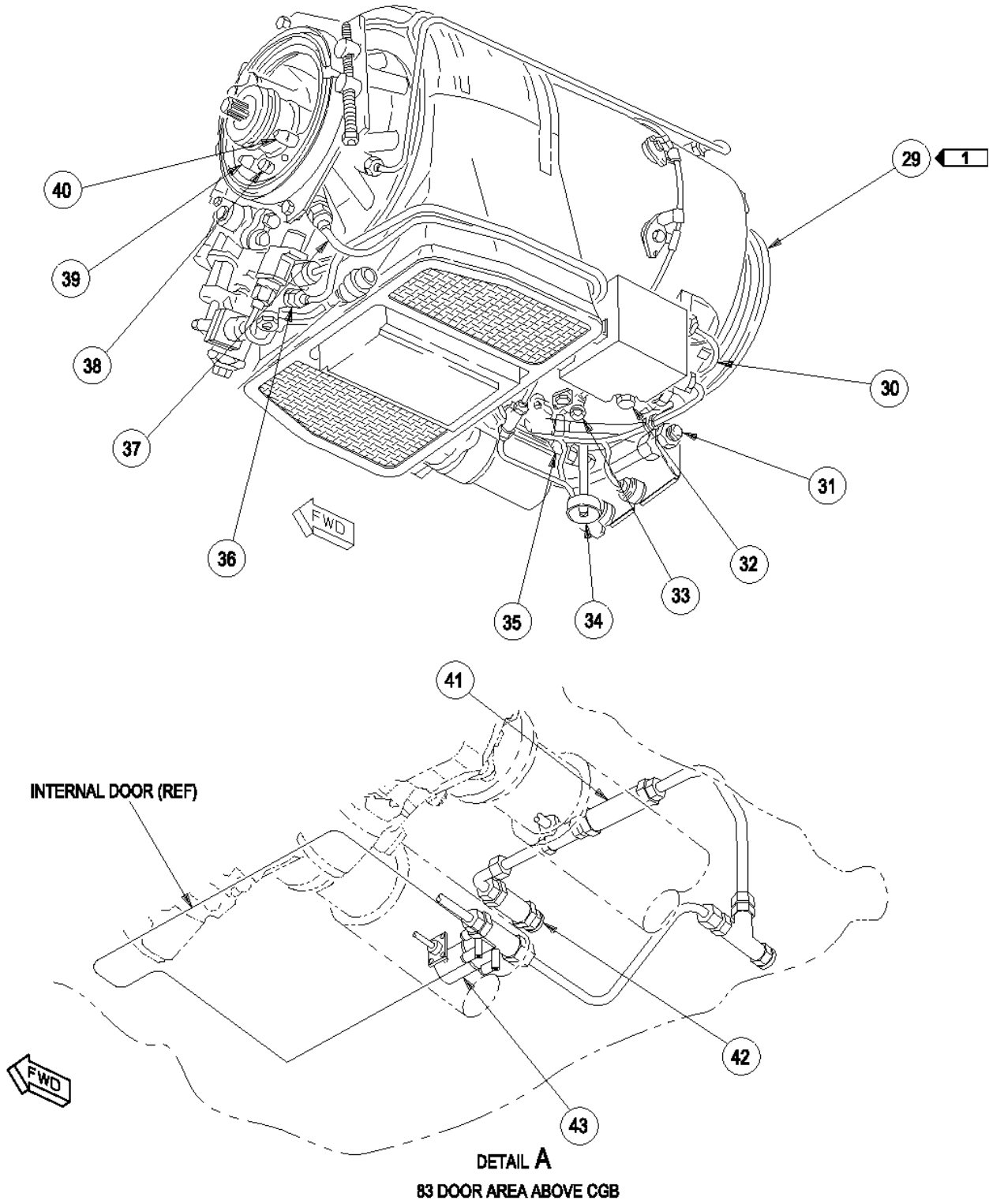
INDEX NO.	COMMON NAME	S/S/SN	REF DES	ACCESS
2	1 JFS EXHAUST DUCT ASSEMBLY	80-11-50	9MPS516	DOOR 94
2	2 JFS EXHAUST COLLAR	80-11-45	9MPS517	
	3 JFS HIGH VOLTAGE IGNITION LEAD	80-11-42	9W-S522	DOOR 94
	4 JFS IGNITER PLUG	80-11-43	9ATT524	DOOR 94
	5 JFS FUEL FILTER ΔP INDICATOR	80-11-14	9DST519	DOOR 94
	6 JFS COMBUSTION DRAIN VALVE	80-11-38	9VAS515	DOOR 94
	7 JFS COMPRESSOR INLET SCREEN	80-11-19	9MPS531	DOOR 94
	8 JFS GENERATOR CONTROL UNIT	80-11-20	9PST521	DOOR 94
	9 JET FUEL STARTER	80-11-10	9Z-S003	DOOR 94
	10 JFS IGNITION UNIT	80-11-41	9R-S525	DOOR 94
	11 JFS FUEL CONTROL PRESSURE BYPASS LINE	80-11-24	9U-T542	DOOR 94
	12 JFS FUEL CONTROL PRESSURE LINE	80-11-23	9U-T543	DOOR 94
	13 JFS TWO SPEED SWITCH	80-11-49	9U-T559	DOOR 94
	14 TRANSFER TUBE RETAINER	80-11-22	9MPT544	DOOR 94
3	15 JFS/OGB CLUTCH PRESSURE SWITCH	80-11-21	9S-S514	DOOR 94
	16 JFS FUEL CONTROL	80-11-46	9BAS556	DOOR 94
	17 JFS COMPRESSOR DISCHARGE PRESSURE LINE	80-11-27	9U-T532	DOOR 94
	18 JFS COMPRESSOR DISCHARGE PRESSURE LINE ADAPTER	80-11-28	9U-T533	DOOR 94
	19 JFS COMPRESSOR DISCHARGE PRESSURE LINE	80-11-27	9U-T534	DOOR 94
	20 JFS FUEL CONTROL BYPASS LINE	80-11-25	9U-T535	DOOR 94
	21 JFS FUEL FILTER IDENTIFICATION PLATE	80-11-16	9MAT536	DOOR 94
	22 JFS FUEL FILTER ELEMENT	80-11-15	9FAT520	DOOR 94
	23 JFS FUEL FILTER ASSEMBLY	80-11-13	9FAT518	DOOR 94
	24 JFS FUEL INLET LINE	80-11-29	9U-T537	DOOR 94
	25 JFS POWER TURBINE SCAVENGE LINE	80-11-32	9U-T538	DOOR 94
	26 JFS FUEL BYPASS LINE ADAPTER	80-11-26	9U-T539	DOOR 94
	27 JFS LEFT REAR MOUNT BRACKET	80-11-39	9U-S540	DOOR 94
	28 JFS RIGHT REAR MOUNT BRACKET	80-11-39	9U-T541	DOOR 94
1	29 JFS PLENUM GASKET SEAL	80-11-40	9MPS557	DOOR 94
	30 JFS POWER TURBINE SCAVENGE LINE	80-11-32	9U-S547	DOOR 94
	31 JFS FUEL INLET LINE ADAPTER	80-11-33	9U-S548	DOOR 94
	32 JFS COMPRESSOR DISCHARGE AIR PLUG	80-11-34	9U-S552	DOOR 94
	33 JFS FUEL MANIFOLD PLUG	80-11-35	9U-S550	DOOR 94
	34 JFS COMBUSTOR DRAIN LINE	80-11-37	9U-T551	DOOR 94
	35 JFS BOSS PLUG	80-11-36	9U-T549	DOOR 94
	36 JFS FUEL CONTROL LINE ADAPTER	80-11-31	9U-S554	DOOR 94
	37 JFS POWER TURBINE SCAVENGE LINE	80-11-32	9U-S553	DOOR 94
	38 JFS REAR BEARING OIL SCAVENGE TRANSFER TUBE	80-11-47	9U-S557	DOOR 94
	39 JFS PRESSURE SWITCH TRANSFER TUBE	80-11-48	9U-S558	DOOR 94
	40 OIL PRESSURE INLET TRANSFER TUBE	80-11-30	9U-S545	DOOR 83
	41 JFS BYPASS RELIEF VALVE	80-11-17	9VAP528	DOOR 83
	42 JFS FUEL RETURN CHECK VALVE	80-11-18	9VAR529	DOOR 83
	43 JFS FUEL STUTOFF VALVE	80-11-12	9L-P005	DOOR 95L
	44 JFS FUEL ACCUMULATOR	80-11-11	9CAP530	DOOR 95L
1	45 JFS EXHAUST DUCT	80-11-44	9MPS516	DOOR 94
1	46 JFS EXHAUST LOUVER	80-11-45	9MPS517	

TCG28-02-01

Figure 3-1. Jet Fuel Starter Component Locator (Sheet 1 of 4)

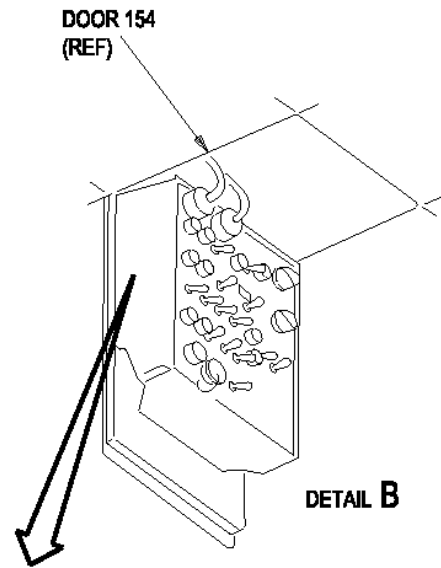
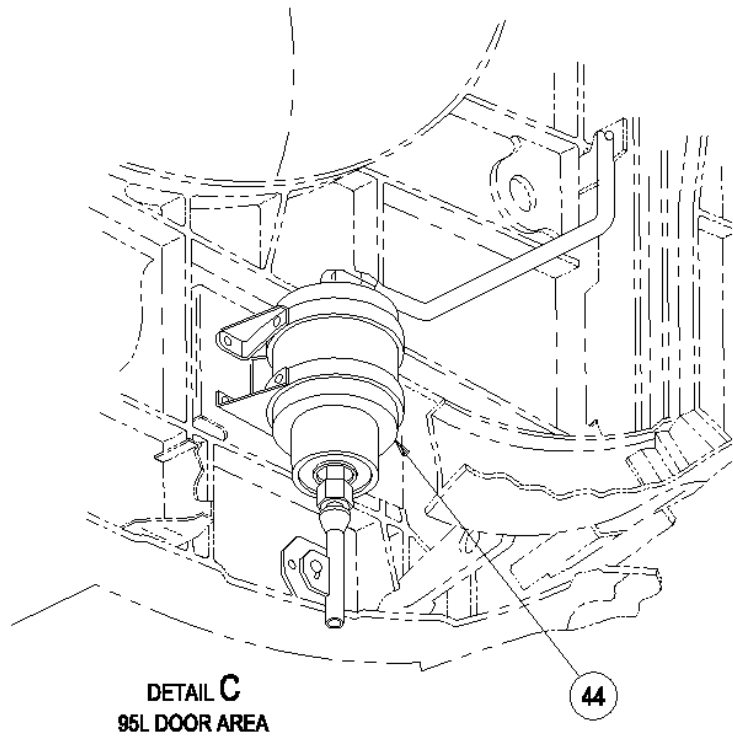


**Figure 3-1. Jet Fuel Starter System Component Locator
(Sheet 2)**



TCG/01-03-01

**Figure 3-1. Jet Fuel Starter System Component Locator
(Sheet 3)**



12S-P017
L MAIN BOOST
PUMP TEST
SWITCH (REF)

9S-P029
JFS PRIME
SWITCH (REF)

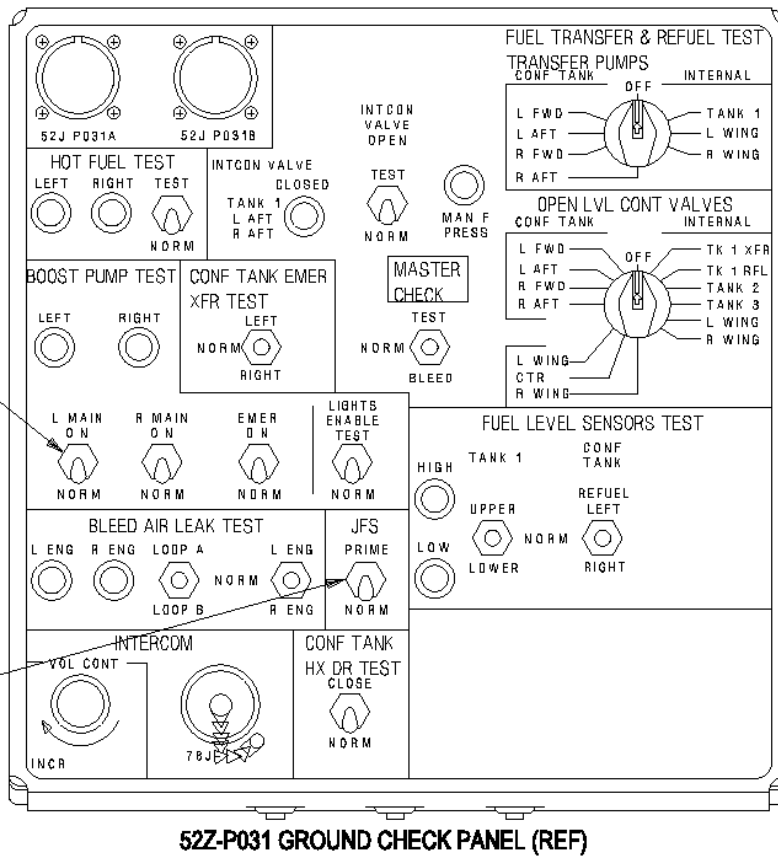
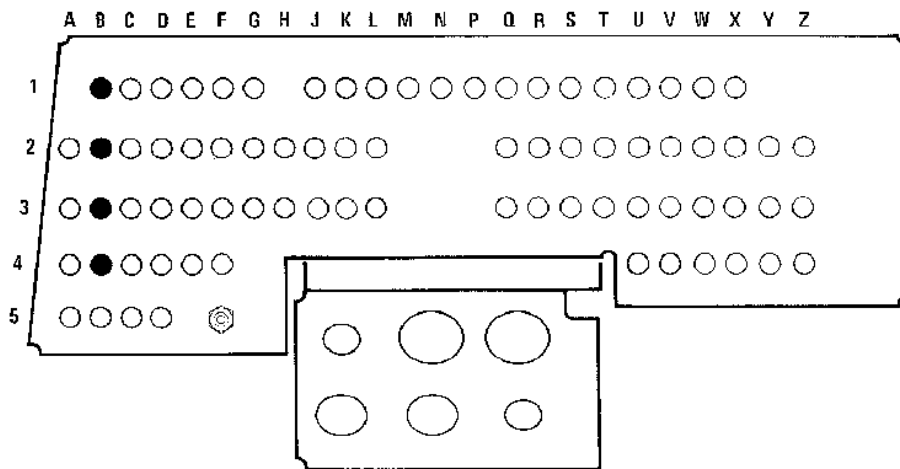
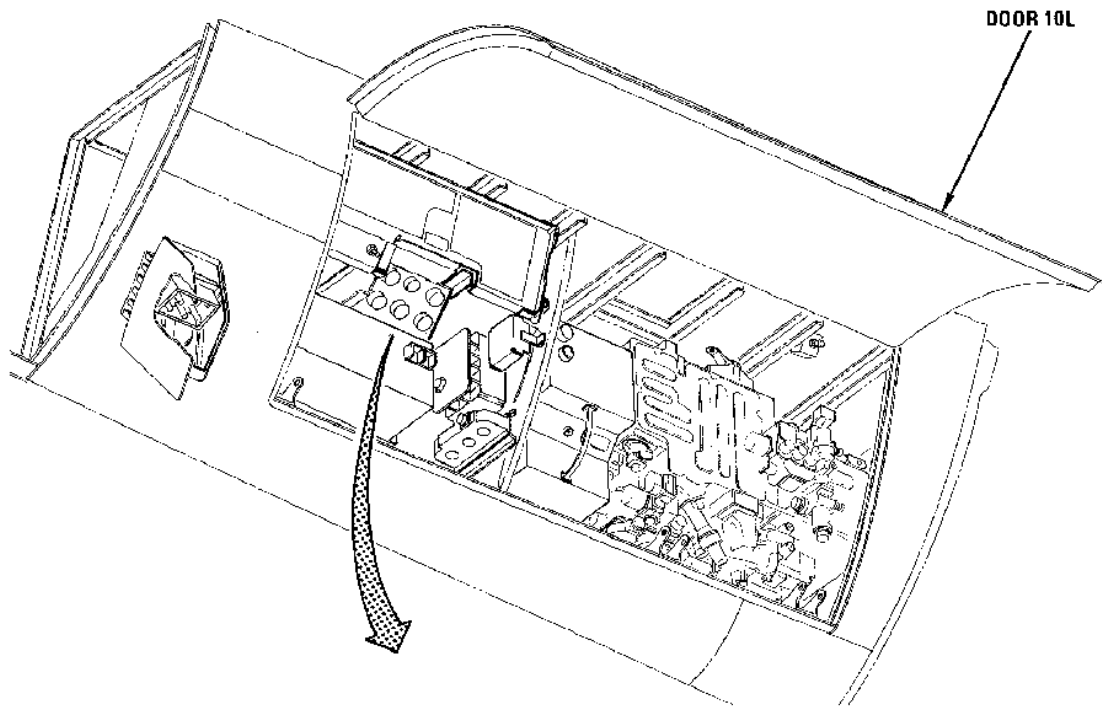


Figure 3-1. Jet Fuel Starter System Component Locator (Sheet 4)



52Z-E006 LEFT BUS CIRCUIT BREAKER PANEL (24-50-13)				
REF DES	ZONE	NOMENCLATURE		BUS
12CBE002	B1	L BOOST PUMP	115V ϕ A	L 115VAC ϕ A
12CBE003	B2	L BOOST PUMP	115V ϕ B	L 115VAC ϕ B
12CBE004	B3	L BOOST PUMP	115V ϕ C	L 115VAC ϕ C
12CBE008	B4	L BOOST PUMP	28 VDC	L 28VDC

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Figure 3-2. Jet Fuel Starter System Circuit Breakers

3-38. **SPECIAL MAINTENANCE REQUIREMENTS.**

3-39. **JET FUEL STARTER SYSTEM PERTINENT DATA.** Data pertinent to the operation and properties of the jet fuel starter system are found in table 3-2.

Table 3-2. Pertinent Data

JET FUEL STARTER	
Characteristics (Approximate)	
Dry Weight	99 pounds
Length	25 inches
Width	13 inches
Height	14 inches
Horsepower	166 HP (Minimum)
Exhaust Gas (at exhaust exit)	
Maximum Temperature	800°F
Maximum Velocity	340 mph
Gas Generator	
Idle Speed	37,441 rpm
100 Percent Speed	62,402 rpm
Power Turbine	
Idle Speed	35,659 rpm
100 Percent Speed	59,432 rpm
JFS Acceleration	
Start to Idle	3 to 7 seconds
Idle to 100 Percent	8 to 12 seconds
JFS Deceleration	Instantaneous
Compartment Temperature	
Operating	-65 to 680°F
Non-operating	-65 to 250°F continuous
Lubrication	Depends on CGB oil system
Lubricant	MIL-L-7808
Pressure	60 psi
Fuel System	
Fuel	MIL-T-5624, grade JP4 or grade JP5 or alternate MIL-T-83133, grade JP8
Source	Tank 3A
Low Pressure	5 to 50 psi
Pump (all operation)	Jet boost
Overboard Drain and Leakage Limits	
JFS Fuel Control	2 Drops in 5 Minutes

Table 3-2. Pertinent Data (CONT)

JFS START SYSTEM	
High Pressure Pump	250 psi
Fuel Spray Nozzles	Positive displacement, gear type
Primary	10 units
Opening Pressure	3 units
Intermediate	10 psi
Opening Pressure	2 units
High	30 psi
Opening Pressure	5 units
Electrical System	70 psi
Source	Permanent Magnet Generator (PMG)
Type	Dual winding, gear driven
Output	0 to 115vac
dc Source	Generator Control Unit (GCU)
dc Output	0 to 28vdc

3-40. **JFS EXHAUST DUCT REPAIR - BEFORE TO SRIF-15-1253.** See figure 3-4.



3-41. **INPUT CONDITIONS.**

To prevent an overheat condition, fire or damage to aircraft, repair of JFS exhaust duct is limited to the below:

3-42. **Required Conditions:**

- Aircraft safe for maintenance (05-00-01)

3-46. **Procedure.**

3-43. **Support Data:**

- 80-11-44
- 80-11-45
- TO 1-1A-9
- TO 33B-1-1

- Remove JFS exhaust duct (80-11-44).
- Cut a piece of stainless steel, 5.0 x 23.5 inches.
- Trim stainless steel to dimension of 0.59 ±0.030 inch and butt weld to JFS exhaust duct outlet lip as shown in figure 3-4. Refer to TO 1-1A-9.

3-44. **Supplies (Consumables):**

Stainless Steel, MIL-S-6721, COMP T1, TYPE 321, 0.032 inch

- Clean and grind weld on ID of JFS exhaust duct. Refer to TO 1-1A-9.

3-45. **Personal Safety Equipment:**

- Goggles, safety

- Using penetrant inspection, Type I, Method A, inspect weld for defects. Refer to TO 33B-1-1.

- Install JFS exhaust duct (80-11-44), but do not install JFS exhaust louver at this time.

- Adjust serrated plate on rear of JFS exhaust duct to the highest position.

NOTE

When installing JFS exhaust louver, welded extension of JFS exhaust duct outlet lip must be trimmed.

Final dimension of JFS exhaust duct outlet lip to top of JFS exhaust louver vanes is 0.10 inch minimum.

h. Temporarily install JFS exhaust louver and inspect for minimum of 0.10 inch gap between JFS exhaust duct outlet lip and top of exhaust louver vanes. Remove louver.

i. Trim JFS exhaust duct outlet lip until a dimension of 0.10 inch minimum exists between outlet lip and top of JFS exhaust louver vanes.

j. Install JFS exhaust louver (80-11-45).

3-47. JFS EXHAUST DUCT INSULATION BLANKET AND/OR FOIL REPAIR - BEFORE TO SRIF-15-1253. See figure 3-5.

3-48. INPUT CONDITIONS.

3-49. Required Conditions:

- Aircraft safe for maintenance (05-00-01)

3-50. Support Data:

- 80-11-44
- TO 1-1A-9

3-51. Supplies (Consumables):

KAOWOOL, 1/4 inch, 8 pounds per cubic foot density, 19740
Stainless steel, AMS5510 or 5512, AR

3-52. Procedure.

a. Remove JFS exhaust duct (80-11-44).

b. Trim damaged or deteriorated foil from exhaust duct.

c. Trim insulation blanket to get a clean cut edge. Cut need not coincide with the foil cut line.

NOTE

Repair material may be obtained from another JFS exhaust duct.

d. If new repair material is required, use KAOWOOL or equivalent.

e. Cut insulation blanket to fit area of removed blanket, allowing 1/4 inch minimum overlap.

f. Cut a section of foil to fit area of removed foil, allowing 1/4 inch overlap. Use 0.002 inch double corrugated stainless steel, AMS5510 or AMS5512.

NOTE

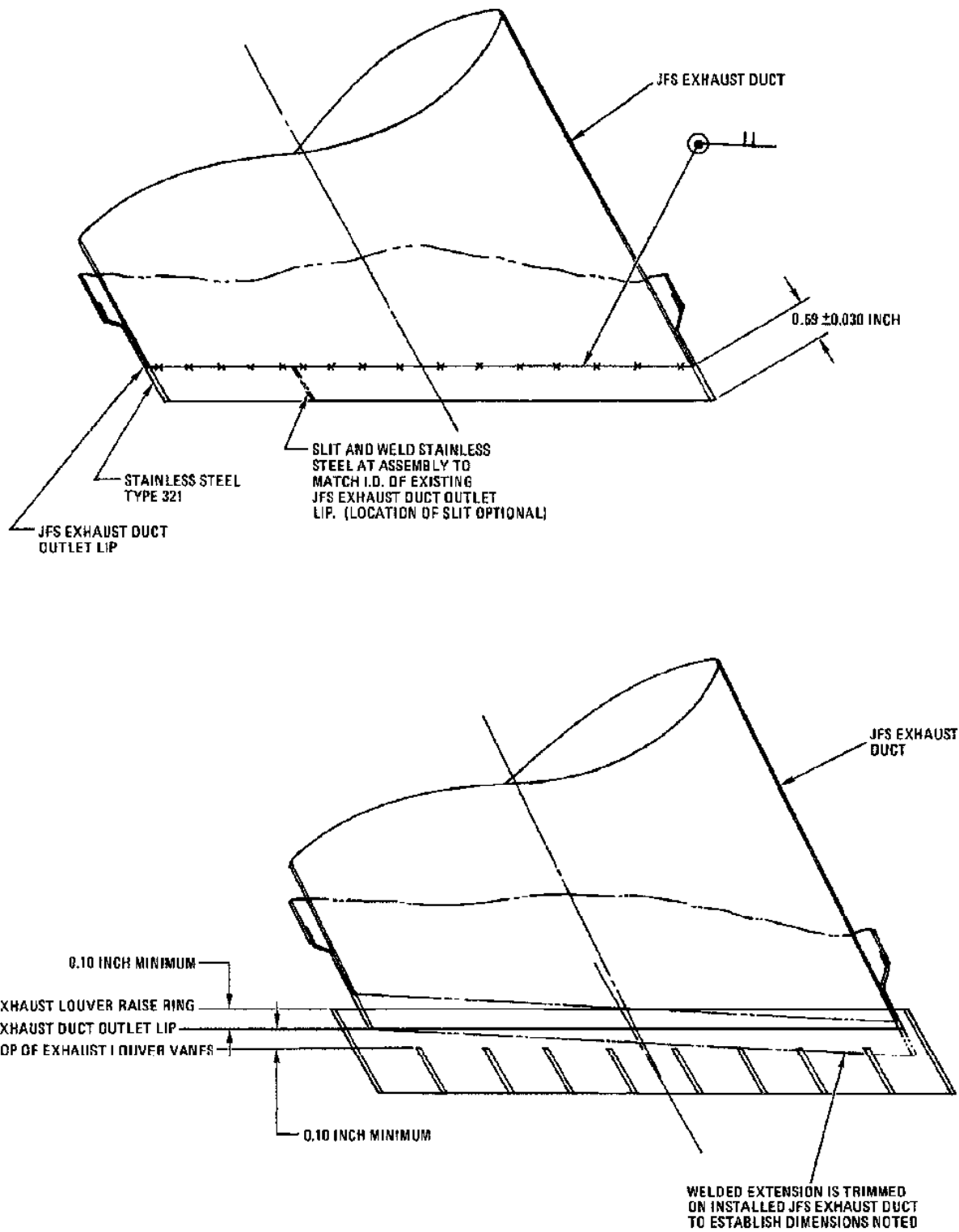
Be sure all spot welds are close together to form a continuous weld line.

g. If foil is being replaced at blanket edges, spotweld the foil to base duct material. Refer to TO 1-1A-9.

h. Spotweld replacement foil to existing foil in 1/4 inch overlap areas. Refer to TO 1-1A-9.

i. Be sure all weld surfaces are clean.

J. Install JFS exhaust duct (80-11-44).



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Figure 3-4. JFS Exhaust Duct Repair - BEFORE TO SRIF-15-1253

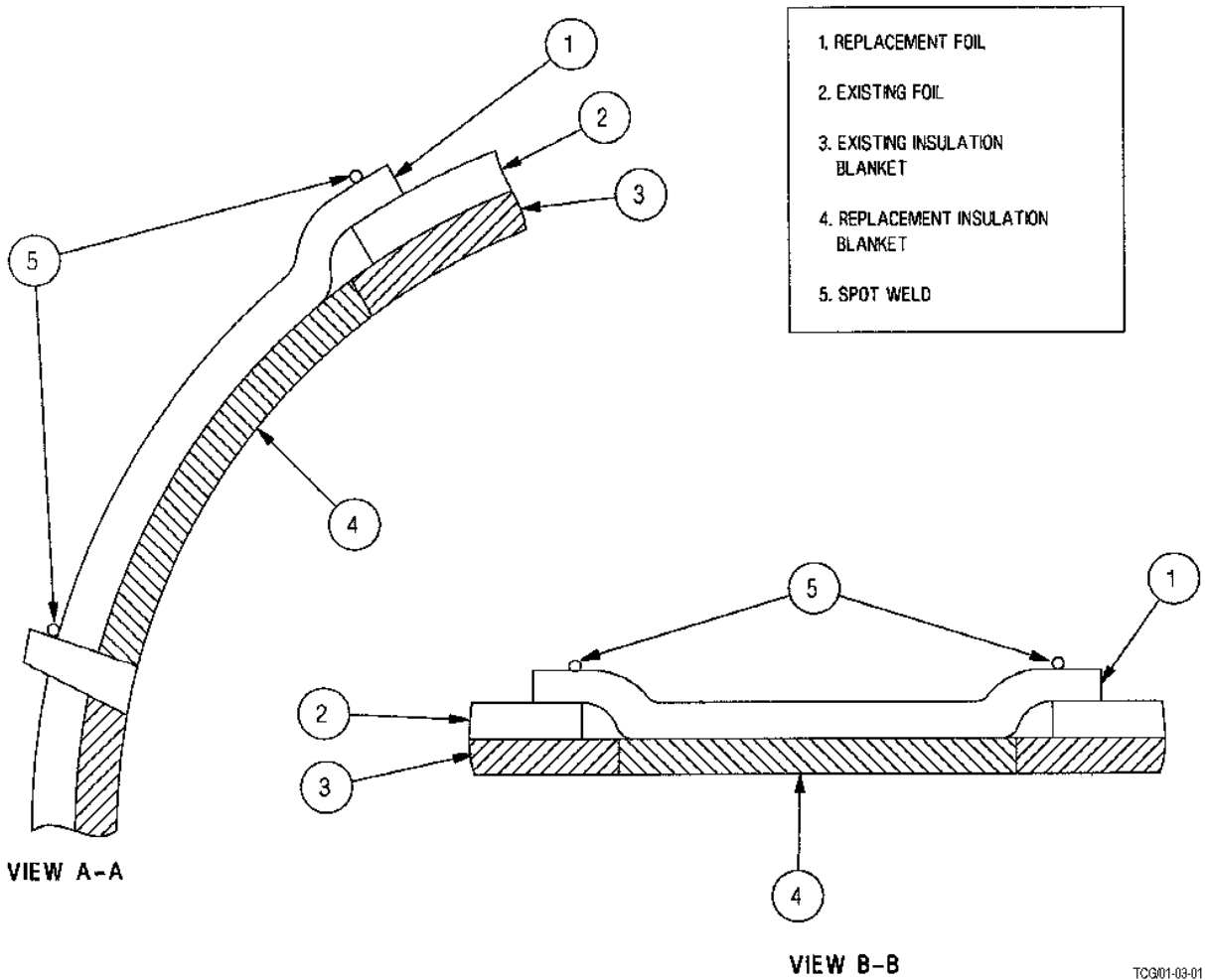
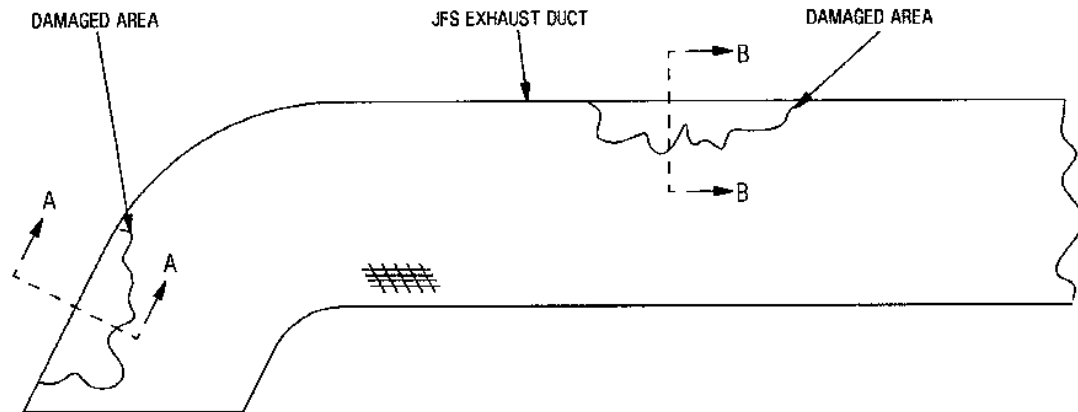


Figure 3-5. JFS Exhaust Duct Insulation Blanket and/or Foil Repair - BEFORE TO SR1F-15-1253

TC901-03-01

3-53. **JFS EXHAUST DUCT ASSEMBLY INSULATION AND BRACKET REPAIR - AFTER TO SRIF-15-1253.** See figure 3-6 AND 5-7.

3-54. **INPUT CONDITIONS.**

3-55. **Required Conditions:**

- Aircraft safe for maintenance (05-00-01)

3-56. **Support Data:**

- 80-11-50

3-57. **Applicable Torque Values:**

- 12 inch-pounds
- 18 inch-pounds

3-58. **Supplies (Consumable):**

Acetone, technical, 0A51 (81348)
Adhesive, RTV 732 CLEAR (71948)
Cheesecloth, CCC-C-440 (81348)
Clamp, hose, NAS 1922-0750-3H (62727)
Kit, repair, 30A48

3-59. **Personal Safety Equipment:**

- Gloves, protective
- Goggles, Safety
- Mask, Dust

3-60. **Repair of Missing or Deteriorated Insulation Material.** See figure 3-6 (view A-A).

- a. Remove JFS exhaust duct assembly (80-11-50).

WARNING

MIN-K insulation products are composed of powdered and fibrous glass materials. These materials can cause temporary irritation, if spilled or released from insulation blanket. During handling, gloves are not required, however, goggles and dust masks are recommended.

- b. Trim rough edges of damaged area.

WARNING

Acetone is highly flammable. Do not use near open flame or sparks. Use only in well ventilated areas.

- c. Clean repair area with a clean cheesecloth moistened with acetone.

- d. Cut replacement insulation material to match damaged area.

- e. Position replacement insulation material in damaged area.

- f. Cut skin patch to overlap damaged area approximately 1 inch on all sides.

- g. Clean skin patch with a clean cheesecloth moistened with acetone. Allow patch to dry.

WARNING

Adhesive is toxic to skin, eyes, and respiratory tract. Skin and eye protection required. Avoid repeated or prolonged contact. Good general ventilation is normally enough.

- h. Apply a thin layer of adhesive to mating surfaces of skin patch and duct.

- i. Position patch on damaged area and apply enough pressure to remove trapped air bubbles, but not enough to force adhesive out of bonded area.

- j. Cover patched area with tape.

- k. Allow to cure 1 hour above 70 percent relative humidity or 2 hours below 70 percent relative humidity.

- l. Remove tape and inspect for a good bond.

- m. Install JFS exhaust duct assembly (80-11-50).

3-61. **Repair of Cracked or Split Insulation Material.** See figure 3-6 (view B-B).

- a. Remove JFS exhaust duct assembly (80-11-50).

WARNING

MIN-K insulation products are composed of powdered and fibrous glass materials. These materials can cause temporary irritation, if spilled or released from insulation blanket. During handling, gloves are not required, however, goggles and dust masks are recommended.

- b. Trim rough edges of damaged area.

WARNING

Acetone is highly flammable. Do not use near open flame or sparks. Use only in well ventilated areas.

- c. Clean repair area with a clean cheesecloth moistened with acetone.
- d. Cut replacement insulation material to match damaged area.
- e. Position replacement insulation material in damaged area.
- f. Cut skin patch to overlap damaged area approximately 1 inch on all sides.
- g. Clean skin patch with a clean cheesecloth moistened with acetone. Allow patch to dry.

WARNING

Adhesive is toxic to skin, eyes, and respiratory tract. Skin and eye protection required. Avoid repeated or prolonged contact. Good general ventilation is normally enough.

- h. Apply a thin layer of adhesive to mating surfaces of skin patch and duct.
- i. Position patch on damaged area and apply enough pressure to remove trapped air bubbles, but not enough to force adhesive out of bonded area.
- j. Cover patched area with tape.

k. Allow to cure 1 hour above 70 percent relative humidity or 2 hours below 70 percent relative humidity.

- l. Remove tape and inspect for a good bond.
- m. Install JFS exhaust duct assembly (80-11-50).

3-62. Repair of Loose Insulation Blanket on Elbow. See figure 3-6 sheet 2.

- a. Remove JFS exhaust duct assembly (80-11-50).
- b. To secure loose shell cloth on forward end of elbow, do Repair of Loose Bracket on Elbow, paragraph 3-62 b. through d.
- c. To secure a ballooning insulation blanket, install a hose clamp in the mid section, aft of the identification plate.
- d. Torque insulation hose clamp worm screw 12 inch-pounds maximum.

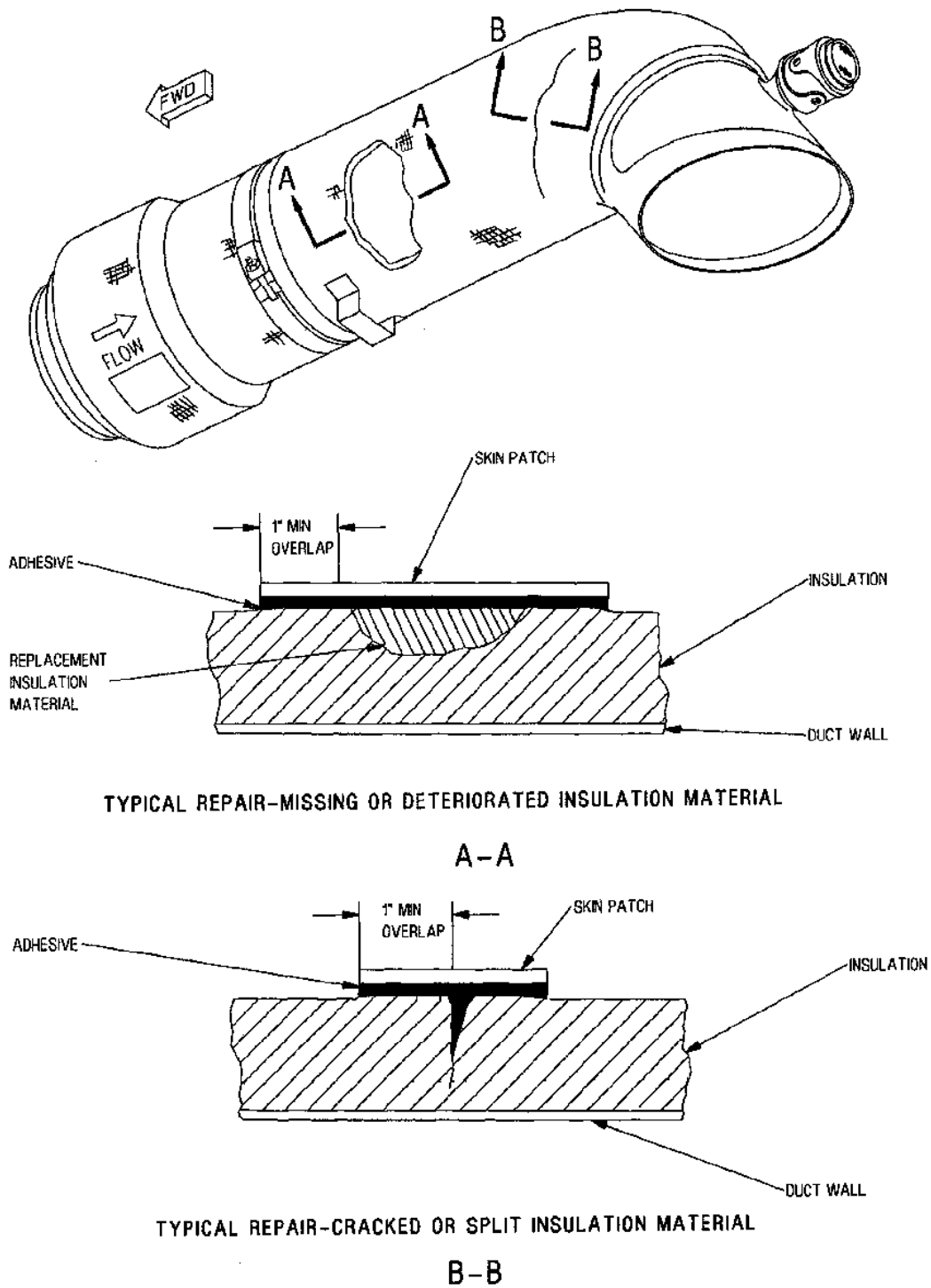
- e. Install JFS exhaust duct assembly (80-11-50).

3-63. Repair of Loose Bracket on Elbow. See figure 3-6 sheet 2 and 3-7.

- a. Remove JFS exhaust duct assembly (80-11-50).
- b. Make a bracket retainer. See figure 3-7.
- c. Install bracket retainer by securing with hose clamp installed over the insulation standoff. See figure 3-6 sheet 2.

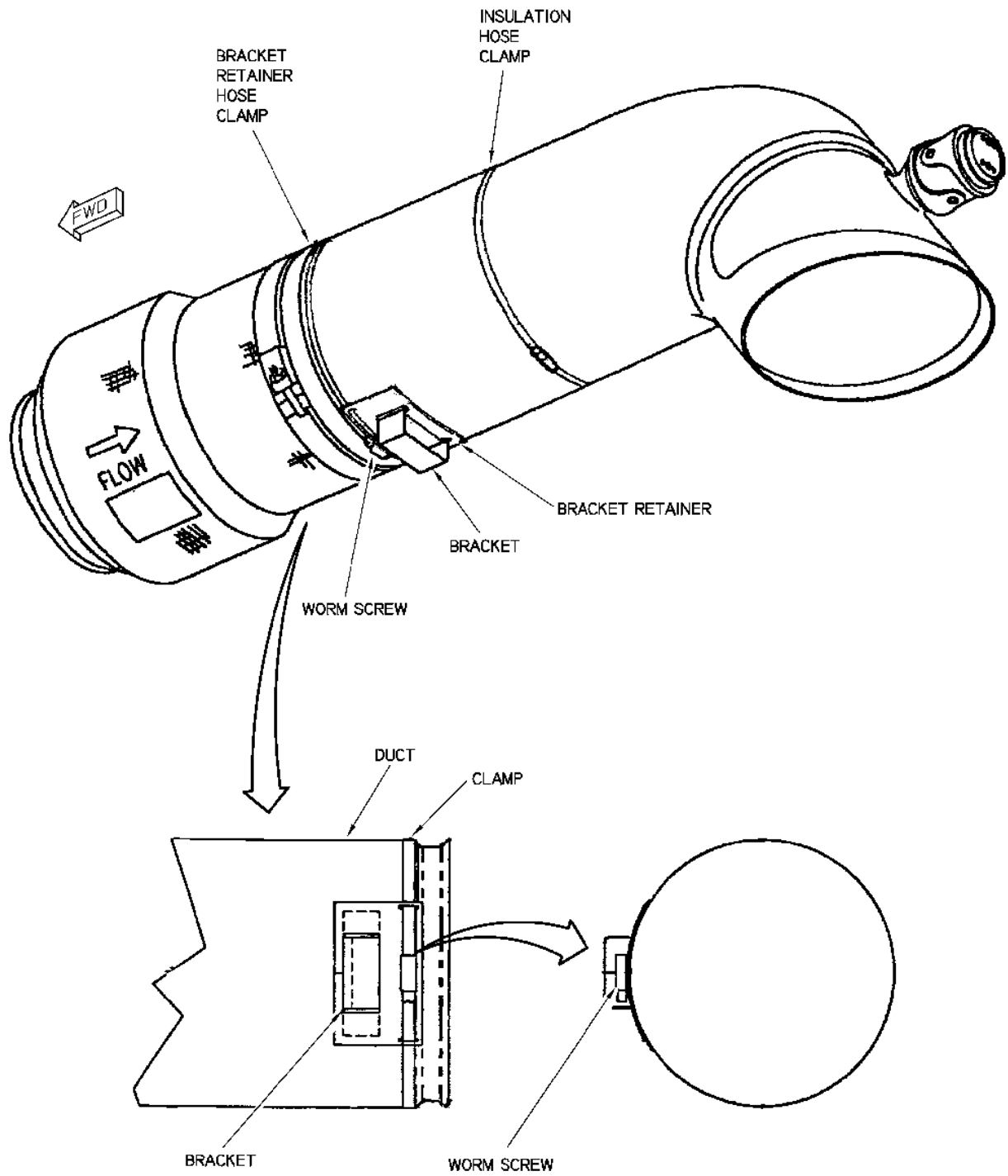
- d. Torque bracket retainer hose clamp worm screw 18 inch-pounds maximum. See figure 3-6 sheet 2.

- e. Install JFS exhaust duct assembly (80-11-50).



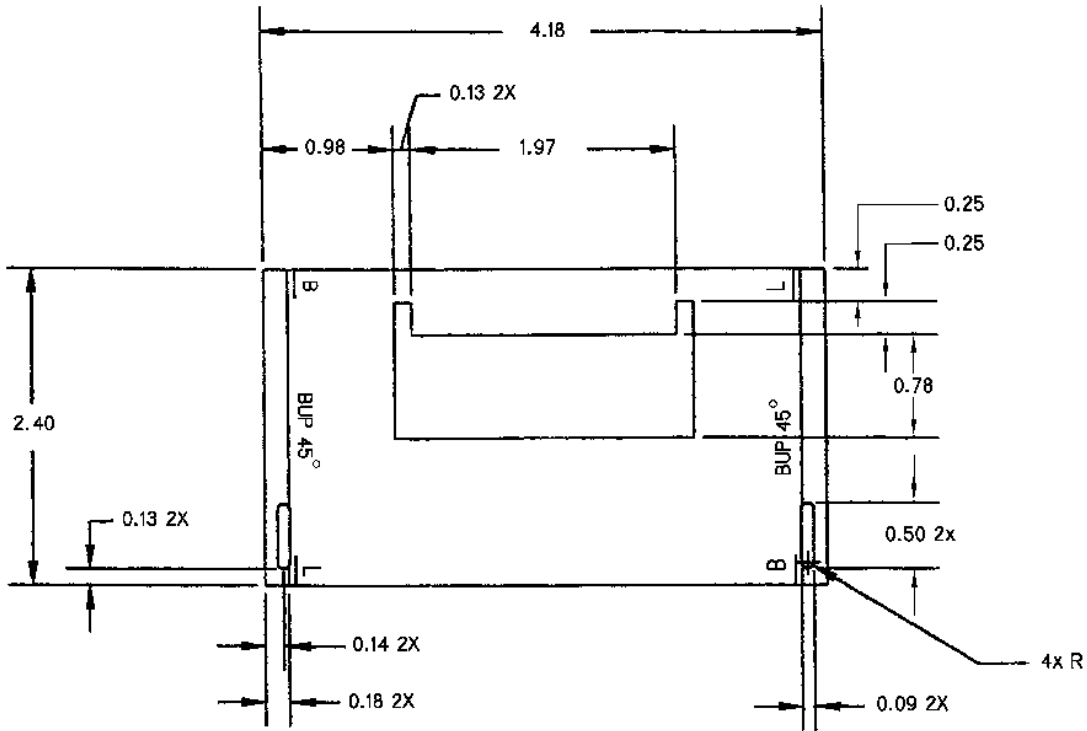
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Figure 3-6. JFS Exhaust Duct Assembly Insulation Repair (Sheet 1 of 2)

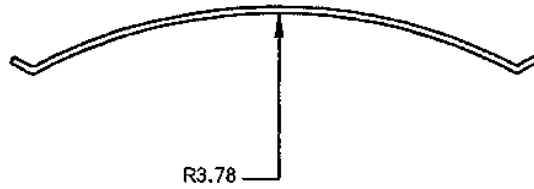


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Figure 3-6. JFS Exhaust Duct Assembly Insulation Repair (Sheet 2)



FLAT PATTERN VIEW



FORMED VIEW

LEGEND

1. ALL DIMENSIONS IN INCHES.
2. MATERIAL: 0.032, 321 STAINLESS STEEL,
1/2 HARD (AMS 5510).

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Figure 3-7. JFS Exhaust Duct Bracket Retainer

3-64. **CONSUMABLE MATERIALS LIST.**

maintenance of the jet fuel starter system is provided in table 3-3.

3-65. **SUPPLIES (CONSUMABLES).** A list of supplies required to support the organizational

Table 3-3. Supplies (Consumables)

Nomenclature	Material	Part Number (CAGE)
Compound, antisieze		FELPROC300 (73165)
Compound, antisieze		MIL-T-5544 (81349)
Compound, antisieze		MIL-A-907 (81349)
Compound, antisieze		51026 (73165)
Gasket		MS35769-11 (96906)
Gloves, rubber disposable		MIL-G-36592 (81349)
Insulation tape		MIL-T-23594 TYPE 1 (81349)
Insulator		367511-1 (99193)
Kaowool, 1/4 inch thick, 8 pounds per cubic foot density		19740
Lockwire		MS20995NC20 (96906)
Lockwire		MS20995NC32 (96906)
Lockwire		MS20995NC40 (96906)
Lubricant		MIL-L-46010 (81349)
Lubricating oil		MIL-L-7808 (81349)
Lubricating oil		WD40-15OZ (09137)
Methyl ethyl ketone		ASTM D 740 (81346)
Packing		S9413-010 (99193)
Packing		S9413-012 (99193)
Packing		S9413-013 (99193)
Packing		S9413-014 (99193)
Packing		S9413-021 (99193)
Packing		S9413-137 (99193)
Packing		S9412-011 (99193)
Packing		S9412-012 (99193)

Table 3-3. Supplies (Consumables) (CONT)

Nomenclature	Material	Part Number (CAGE)
Packing		S9412-014 (99193)
Packing		S9412-140 (99193)
Packing		S9412-212 (99193)
Packing		S9412-552 (99193)
Packing		S9412-554 (99193)
Packing		S9412-558 (99193)
Packing		S9413-010 (99193)
Packing		S9413-024 (99193)
Packing		S8990-606 (99193)
Packing		M25988-1-908
Packing		M25988-1-906
Petrolatum, technical		VV-P-236 (81348)
Primer, epoxy		MIL-P-23377 (80244)
Sealing compound		PR1750A1 (82574)
Stainless Steel		AMS5510 or AMS5512
Stainless Steel		MILS6721 COMP T1, Type 321, 0.032. inch

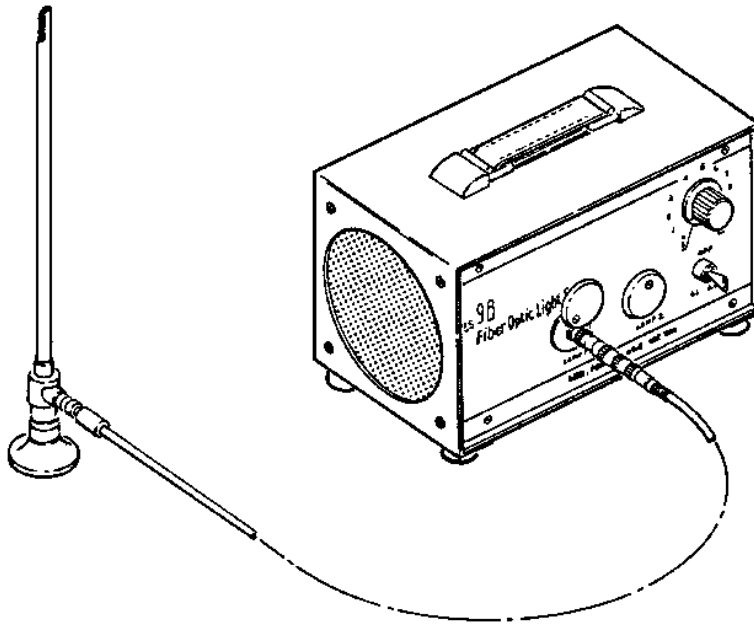
3-66. **SUPPORT EQUIPMENT LIST.**

table 3-4. Special test equipment is shown in figure 3-8. References in the Use and Application column indicate only one of the possible uses of this equipment.

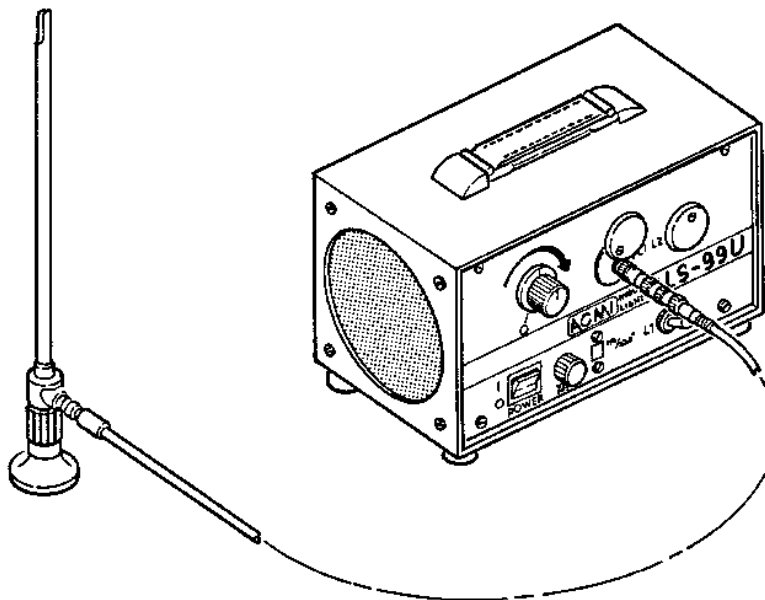
3-67. **TEST EQUIPMENT.** Test equipment required for maintenance of the jet fuel starter system is listed in

Table .3-4. Test Equipment List

Equipment Number	Nomenclature	Use and Application
GG-G-531	Goggles, safety	Used for eye protection.
68D170008-1001 or 68D170008-1003	Kit, Jet Fuel Starter Borescope	Used for inspection and troubleshooting.



JET FUEL STARTER BORESCOPE KIT
68D170008-1001



JET FUEL STARTER BORESCOPE KIT
68D170008-1003

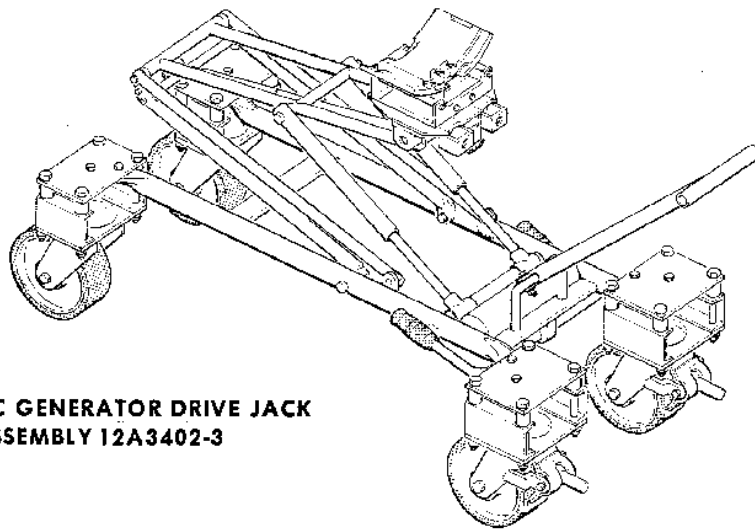
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.Figure 3-8. Test Equipment

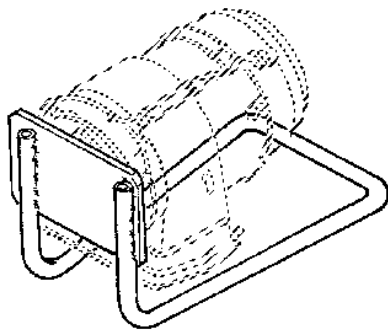
3-68. **SPECIAL TOOLS.** Special tools required for maintenance of the jet fuel starter system are listed in table 3-5. Special tools are shown in figure 3-9.

Table 3-5. Special Tools List

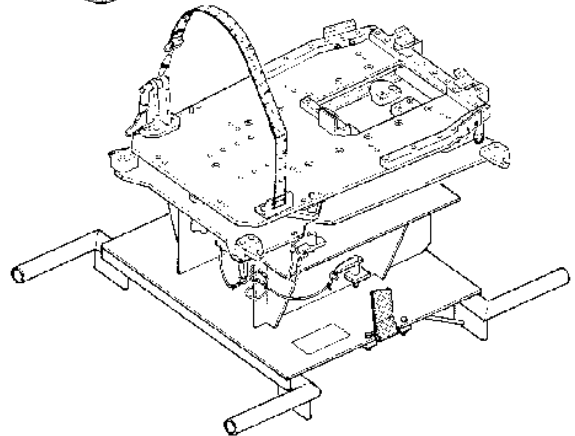
Tool Number	Nomenclature	Use and Application
12A3402-3	Jack assembly, AC generator drive	Used for JFS removal and installation.
289365-1	Stand, portable starter	Used for JFS transportation.
294549-1	Puller Set, Mechanical	Used for JFS oil pressure inlet line transfer tube removal and installation.
68D170001-1005	Adapter, Jet Fuel Starter Handling	Used for JFS removal and installation.
68D170003-1003	Alignment Adapter - Jet Fuel Starter/Central Gearbox	Used for JFS/CGB alignment.
68D170015-1001	Stand, JFS/CGB Maintenance	Used for JFS/CGB maintenance.
68D230027-1001	Adapter, Electrical Generator, Jack Hydraulic	Used for JFS removal and installation.



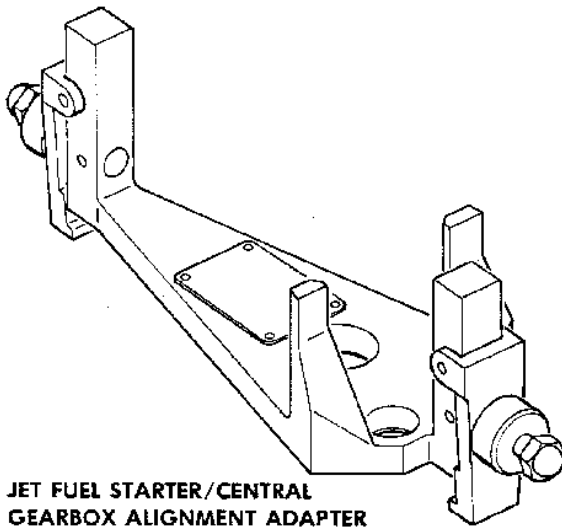
**AC GENERATOR DRIVE JACK
ASSEMBLY 12A3402-3**



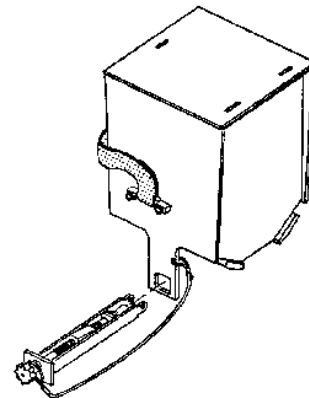
PORTABLE STARTER STAND 289365-1



**JET FUEL STARTER HANDLING
ADAPTER 68D170001-1005**



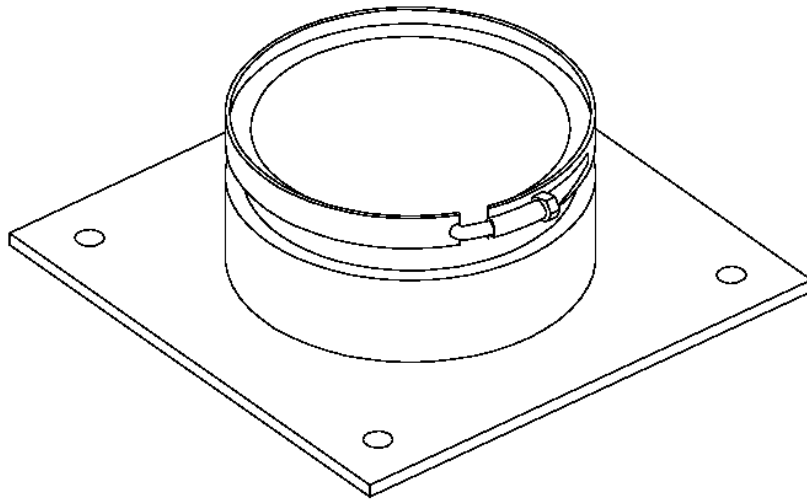
**JET FUEL STARTER/CENTRAL
GEARBOX ALIGNMENT ADAPTER
68D170003-1003**



**ELECTRICAL GENERATOR JACK
ADAPTER-HYDRAULIC 68D230027-1001**

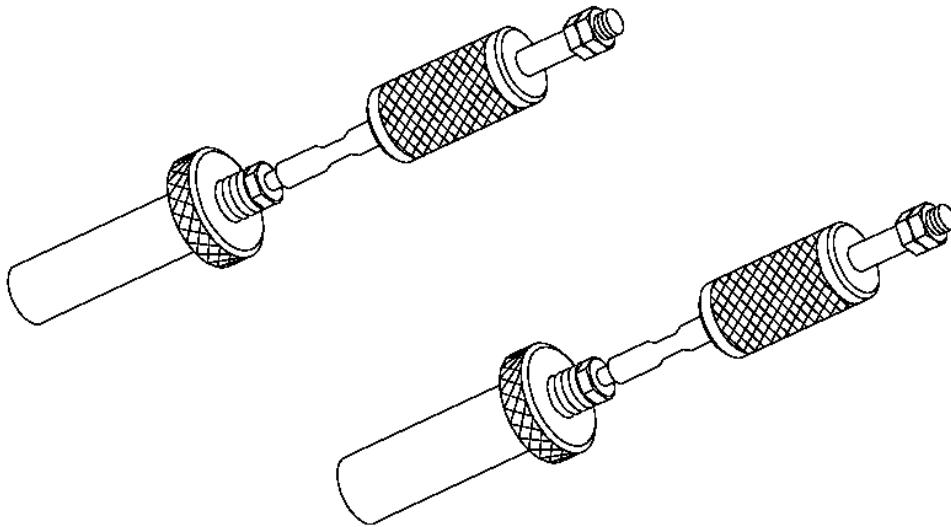
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Figure 3-9. Special Tools (Sheet 1 of 2)



JFS/CGB MAINTENANCE STAND

68D170015-1001



MECHANICAL PULLER SET

294549-1

TCG01-03-01

Figure 3-9. Special Tools (Sheet 2)

SECTION IV

CENTRAL GEARBOX SYSTEM

4-1. SYSTEM FUNCTIONAL DESCRIPTION.

4-2. **DESCRIPTION.** This section contains description and principles of operation for the central gearbox system shown in figure 4-1, and is made up of equipment listed in table 4-1 for the F-15C and F-15D aircraft.

4-3. The central gearbox (CGB) transfers power from the jet fuel starter (JFS) to the airframe mounted accessory drive (AMAD) gearboxes for engine starting and limited duty mode operation. It also provides power during the start cycle to the JFS gas generator until self continuing speed and supplies the electrical power from the Permanent Magnet Generator (PMG) required to operate the engine starting system.

4-4. **CGB Mounting.** The CGB, in door 83, is attached to the aircraft through a top link mount and two lower bearing mounts. The CGB is coupled to the JFS with a V-band clamp. At the JFS/CGB interface are the gas generator and power turbine shaft splines and four oil transfer tubes that integrate the CGB lube system with the JFS.

4-5. **CGB Components.** The CGB provides mounting for CGB fan and clutch, JFS hydraulic start motor, power turbine overspeed switch and pump, permanent magnet generator, CGB right decoupler position switch, CGB isolation decouplers and an CGB hydraulic clutch control valve, and a right decoupler position switch (CGB 386720-4-1). An air/oil cooler and bypass valve are mounted on the central gearbox to provide cooling of the lube and control oil. An isolation decoupler for engagement with the AMAD is on each side of the central gearbox. A multiple disc clutch transmits JFS torque to the isolation decouplers. A brake prevents the clutch from rotating when the clutch disengages and provides rapid sequential engine starts.

4-6. **CGB Fan and Clutch (80-12-11).** The clutch that engages the isolation decouplers is part of the power turbine gear train. The clutch transmits JFS rotational power to the AMAD gearboxes for engine starting. Though the decouplers and the clutch operate on 350 psi control oil pressure from the lube pump, a hydraulic time delay in the CGB hydraulic clutch control valve allows the isolation decoupler to extend into the AMAD pawl carrier before the clutch is engaged.

4-7. **JFS Hydraulic Start Motor (80-12-12).** The hydraulic start motor provides power through an overrunning clutch and the gas generator drive train to motor the JFS for starting. The start motor is a fixed displacement, piston type hydraulic motor. The overrunning clutch is a pawl and ratchet type start clutch that engages the motor to the CGB drive train.

4-8. **Power Turbine Overspeed Switch and Pump (80-12-13).** The power turbine overspeed switch is mounted in the lube pump housing on the CGB and rotates from the same shaft. The switch provides an electrical safety cutoff of the JFS if the power turbine should accelerate to a 110 percent overspeed condition. The three element lube pump provides the lubrication system pressurized oil flow requirements and returns scavenge oil from the rear JFS bearings and CGB sump to the reservoir.

4-9. **Permanent Magnet Generator (80-12-14).** The PMG is a single phase, double stator unit installed on the CGB. The stator is made up of a high voltage (start) winding and a low voltage (load) winding. The PMG rotor has 10 poles and uses Alnico IX permanent magnets. The PMG is cooled by CGB oil and provides an air/oil separator and a case vent tube for the CGB.

4-10. **CGB Right Decoupler Position Switch - CGB 386720-4-1 (80-12-15).** The right decoupler position switch is installed on the top of the right isolation decoupler and senses decoupler position. The dual pole switch supplies a holding voltage to the limited duty solenoid and CGB hydraulic clutch control valve when the right isolation decoupler is extended. When the decoupler is retracted, the switch supplies power to the JFS fuel control acceleration control valve.

4-11. **CGB Isolation Decouplers (80-12-16).** For engine starting the CGB isolation decouplers are extended and transfer JFS power to the AMAD gearboxes. For JFS starting and shutdown, the decouplers are retracted and isolate the AMAD gearboxes from the central gearbox. Each decoupler contains a beveled ratchet coupler wheel mounted on a stub shaft. The decouplers are extended hydraulically and springloaded to retract when the hydraulic pressure is removed. Both decouplers rotate when the CGB clutch is engaged, whether extended or retracted. To prevent extension while rotating, each decoupler shaft has fly weights.

4-12. **CGB Hydraulic Clutch Control Valve (80-12-46).** The CGB hydraulic clutch control valve is an electrohydraulic control unit that controls the action of the clutch and isolation decouplers for engine starting. The valve contains an electrically energized motor, a flapper valve and control nozzles, a three spool director valve, a primary shuttle valve, a limited duty solenoid (CGB 386720-4-1) and a limited duty shuttle valve (CGB 386720-4-1), a clutch programmer orifice and bellows, and a drain check valve. The torque motor controls the decoupler selection by actuating the flapper valve and moving the normally centered director spool to open the decoupler port to the 350 psi supply pressure. The primary shuttle valve provides a hydraulic interlock to prevent both isolation decouplers from being pressurized simultaneously. The clutch programmer orifice and bellows restricts the pressure to the clutch and fuel control port to make sure the isolation decouplers are extended before the CGB clutch is engaged or the fuel control pressure switch is actuated. If installed, the limited duty solenoid and the limited duty shuttle valve provide a hydraulic bypass of the primary shuttle valve to pressurize the right decoupler simultaneously with the left decoupler.

4-13. **CGB Lube Oil System.** The lube oil system provides lubricating oil to the gear meshes and bearings of the CGB and JFS, scavenges oil from bearings and sumps, and uses the same filters, pressure pumps and reservoir as the control oil system. The reservoir is part of the CGB housing and has a pressure fill port, an overflow drain, and a liquid level sight gage for servicing. The reservoir is serviced with MIL-L-7808 lubricating oil.

4-14. The three element gerotor type pump is driven by the power turbine and drives the power turbine overspeed switch. One element of the pump provides oil flow for lubrication and control operation, one element returns scavenge oil from the CGB sump to the reservoir, and the third returns scavenge oil from the rear JFS bearings to the reservoir. Working with the primary lube pump is the gerotor type differential speed lube pump. This pump is an integral part of the CGB gear train and operates during start, acceleration, and when power turbine varies in reference to the gas generator speed.

4-15. **CGB Oil Filter Element (80-12-19) and CGB Oil Filter DP Indicator (80-12-18).** The oil filter on the left side of the CGB has a disposable 10 micron element. A pressure regulator in the filter housing bypasses oil when the differential pressure across the element is 60 psi. A differential pressure indicator in the filter housing gives a visual indication when filter replacement is required. The differential pressure indicator measures pressure on both sides of the filter and extends at 60 psid.

4-16. Oil pressure in the lube oil system is controlled by a pressure regulator valve. The valve opens at 60 psi and bypasses excess oil to the reservoir. Oil tubes are at the JFS/CGB coupling interface. The tubes provide a sealed passage way through the interface for the 60 psi lubricating and cooling oil to the JFS bearings and gears. Lubrication and cooling is provided to the rear JFS bearings from the CGB lube pump, and returned through the distribution tubes to the CGB reservoir. The forward JFS bearings and gears are supplied from the lube pump and gravity drained to the CGB sump.

4-17. **CGB control Oil System.** See figure 4-2. The control oil system contains a JFS/CGB clutch pressure switch, fuel control clutch pressure switch, control oil pressure regulator valve and an CGB hydraulic clutch control valve.

4-18. **JFS/CGB Clutch Pressure Switch - JFS 384238-5-1 (80-11-21).** The JFS/CGB clutch pressure switch is on the forward side of the JFS intake duct. This switch actuates at 60 psi (control oil pressure) to close a circuit to the limited duty select relay and JFS time delay relay.

4-19. **Fuel Control Clutch Pressure Switch.** The fuel control clutch pressure switch is in the JFS fuel control and, when actuated, allows the JFS to accelerate to 100 percent gas generator speed.

4-20. **Control Oil Pressure Regulator Valve (80-12-25).** The control pressure regulator valve is downstream of the oil filter in the primary lube pump pressure line. The regulator bypasses oil to the inlet side of the pump when the oil pressure arrives at 350 psi. The oil that passes through the valve flows into the JFS/CGB lubrication system where another regulator valve controls lube pressure.

4-21. **CGB Hydraulic Clutch Control Valve (80-12-46).** The CGB hydraulic clutch control valve is an electrohydraulic control unit. The valve has two electrical components, the torque motor and the limited duty solenoid (CGB 386720-4-1). Hydraulic components include the director valve, limited duty shuttle valve (CGB 386720-4-1), orifice check and drain valve and clutch programmer. The valve controls the operation of the clutch and isolation decouplers through the regulation of control oil flow.

4-22. **CGB Geartrain.** During a JFS start, the CGB gear train disperses power from the hydraulic start motor to the permanent magnet generator, differential speed lube pump, fuel control, two speed switch and JFS gas generator. After the start, the hydraulic start motor is disengaged and the power turbine and gas generator power is transferred to the CGB through two splined input shafts.

4-23. The power turbine input shaft is slightly below center of the JFS/CGB mounting flange. Power turbine rotational power is transferred through this shaft to the gear train to drive the cooling fan, primary lube pump and power turbine overspeed switch, and when the CGB clutch is engaged, the isolation decouplers.

4-24. The gas generator input shaft is above and to the right of center of the JFS/CGB mounting flange. Gas generator rotational power is transferred through this shaft to the PMG, fuel control and two speed switch. A gerotor-type differential speed lube pump is contained within the CGB gear train. During normal operation both sections of the pump rotate in the same direction. However, during start, acceleration, or when the rpm of the gas generator varies in reference to the power turbine rpm, the differential speed causes the pump to activate and aid the primary lube pump in supplying the requirements of the JFS/CGB oil system.

4-25. The gas generator and power turbine gear trains are coupled by a one way sprague clutch when power turbine speed starts to overrun gas generator speed. This clutch engagement also aids the gas generator acceleration.

4-26. **CGB Electrical System.** The permanent magnet generator provides electrical power to the JFS ignition exciter unit and the JFS electrical control

circuits. The PMG has a center tapped winding. During JFS start, the complete PMG winding provides power for the ignition system and the electrically controlled JFS fuel system components. When the start part of the PMG output arrives at 25vac, the GCU start sequence relay removes that half of the PMG winding from the circuit. The load winding provides power to the JFS and all related circuits during starting and run operation.

4-27. **CGB Air/Oil Cooler (80-12-48).** Oil in the CGB/JFS system is cooled by an air/oil heat exchanger on the right forward side of the CGB. The CGB oil cooler transfers oil heat to the circulating airflow and includes a bypass if the cooler becomes clogged.

4-28. **PRINCIPLES OF OPERATION.** The hydraulic start motor, mounted on the CGB, receives a pressure from the JFS accumulators in door 88L. Starter rotation is transmitted through the overrunning clutch in the CGB. The activated CGB drive train rotates the PMG, the gas generator, the differential speed lube pump, the JFS fuel control and the gas generator two speed switch. When accumulator pressure drops and cutoff occurs, the control valve closes and the start motor overrunning clutch uncouples the CGB. The clutch pawls attached by the CGB are held out from the ratchet wheel by centrifugal force as the CGB continues to rotate. As the JFS accelerates, the power turbine shaft starts to rotate and drives a gear train in the CGB which rotates the air/oil heat exchanger cooling fan. The fan circulates cooling air through the heat exchanger and ventilates the JFS and CGB compartments.

4-29. To reduce starting requirements to a minimum, the CGB high pressure oil pump is deactivated initially and the gears and bearings are supplied from the differential speed lube pump. When the power turbine activates the CGB high pressure pump, oil is circulated through the system. When the pressure arrives at 330 psi in the primary system, the control pressure regulator opens and oil flows through the secondary system to lubricate the JFS/CGB gears bearings. When the primary pressure arrives at 350 psi, the control oil pressure regulator maintains this pressure level and the secondary system is controlled to 60 psi by the lubrication pressure regulator valve. These pressures are controlled from idle to maximum speed.

4-30. **CGB/ Engine Starting Sequence.** With the JFS running at idle, and the L ENG MASTER switch set to ON, raising the left throttle fingerlift momentarily energizes the left coil in the CGB hydraulic clutch control valve (on AMAD 386706-3-1 or 386706-3-2 by way of the manual decoupler switch). In the CGB, hydraulic control oil pressure extends the left isolation decoupler. The pressure is applied through a restrictor to the CGB clutch and the fuel control pressure switch. With this sequence, the clutch and fuel switch are required to operate after the isolation decoupler has extended and engaged in the left AMAD. The JFS power turbine is connected to the left AMAD/engine and the JFS accelerates to maximum speed. When start cutout speed is arrived at, the left start cutout switch is actuated and electrical power is removed from the CGB hydraulic clutch control valve. Hydraulic pressure is cut off from the CGB clutch, the JFS fuel control pressure switch and the left isolation decoupler. The JFS decelerates, the springloaded decoupler is retracted and the JFS returns to idle.

4-31. When the R ENG MASTER switch is set to ON, raising the right throttle fingerlift momentarily energizes the right coil in the CGB hydraulic clutch control valve. Hydraulic control oil pressure extends the right isolation decoupler. This pressure is applied through a restrictor to the CGB clutch and the fuel

control pressure switch. With this sequence, the clutch and fuel switch are required to operate after the isolation decoupler has extended and engaged in the right AMAD. The JFS power turbine is connected to the right AMAD/engine and the JFS accelerates to maximum speed. When the second engine start cutout speed is arrived at, the start cutout switch is actuated. This removes 28vdc from the CGB hydraulic clutch control valve which deenergizes, cutting off hydraulic control pressure from the CGB clutch, the fuel control pressure switch, and the right isolation decoupler. The JFS decelerates, the springloaded decoupler is retracted and, with loss of control voltage, the JFS fuel valves are closed and JFS shuts down.

4-32. **Cooling System.** Compartment ventilation and cooling is provided for the system through a louvered opening in door 85R, and inlet scoop in door 85L, and two inlet holes in door 83. Air is pulled through the two inlets in door 83 by the reverse flow fan in the CGB. The air is exhausted out through the CGB air/oil cooler into the AMAD compartments where it is mixed with air coming in from the louvered opening and inlet scoop and vented through a hole in the bulkhead into the JFS compartment. The reverse flow fan provides enough airflow to limit the JFS compartment temperature to 250°F, and to cool the AMAD gearboxes and CGB during engine starting operation.

Table 4-1. Line Replaceable Units

Common Name	S/S/SN	Ref Des	Nomenclature
Central Gearbox (CGB)	80-12-10	52Z-R193	Gearbox Assembly
CGB Air/Oil Cooler	80-12-48	11U-R647	Cooler, Oil
CGB Bleed Plug	80-12-36	11U-T633	Plug
CGB Case Drain Plug	80-12-21	11U-P625	Plug
CGB Chip Detector	80-12-20	11U-P502	Plug, Magnetic
CGB Control Oil Pressure Test Port			
1 2 Plug	80-12-23	11U-P592	Plug
3 Quick Disconnect	80-12-23	11U-P592	Quick Disconnect
CGB Fan and Clutch	80-12-11	11MPR503	Fan and Clutch Assembly
CGB Hydraulic Clutch Control Valve	80-12-46	11VAP645	Valve, Clutch Control Hydraulic
CGB Lube Oil Pressure Test Port Plug	80-12-28	11U-R506	Plug

Table 4-1. Line Replaceable Units (CONT)



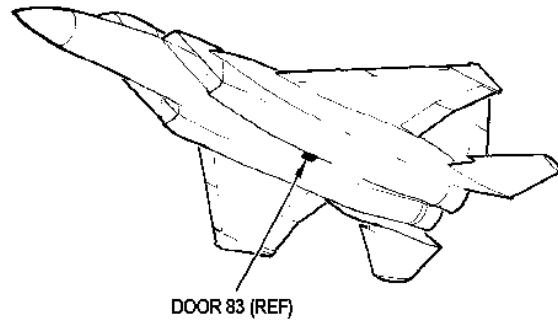
Common Name	S/S/SN	Ref Des	Nomenclature
CGB Oil Cooler Bypass Valve	80-12-29	11VAR507	Valve Bypass
CGB Oil Cooler Pressure Line	80-12-40	11U-T635	Tube, Oil Cooler
CGB Oil Filler Restrictor Check Valve	80-12-32	11VAP508	Valve, Restrictor Check
CGB Oil Filter Bypass Valve	80-12-26	11VAP509	Valve, Bypass
CGB Oil Filter Element	80-12-19	11FAP510	Filter, Element
CGB Pressure Fill Fitting	80-12-31	11VAP511	Disconnect
CGB Pressure Fill Fitting Disconnect Cap	80-12-30	11U-P505	Cap
CGB Reservoir Drain Plug	80-12-22	11U-T636	Plug
CGB Reservoir Oil Level Sight Gage	80-12-33	11DSP512	Indicator, Sight
 2 CGB Right Decoupler Position Switch	80-12-15	11S-R626	Switch Assy, Right-Hand Decoupler
CGB Sump Drain Valve	80-12-34	11VAP513	Cock, Poppet Drain, Gearbox Overfill
CGB Transfer Tube/Check Valve	80-12-47	11VAS647	Tube, Transfer Check Valve
 1 CGB Vent Housing	80-12-44	11U-R639	Housing, Vent
CGB Viton Sleeve	80-12-45	11MPR646	Sleeve
CGB Wash-By Oil Filter	80-12-24	11FAP515	Filter, Oil
Control Oil Pressure Regulator Valve	80-12-25	11VAP516	Valve, High Pressure Relief
JFS Hydraulic Start Motor	80-12-12	11U-P521	Starter, Hydraulic
Left Isolation Decoupler Ratchet Wheel	80-12-16	11MPP517	Coupler, Ratchet
Left Isolation Decoupler Shear Shaft	80-12-16	11MPP519	Stub Shaft
Lubrication Pressure Regulator Valve	80-12-27	11VAP522	Valve, Regulator
Oil Filter DP Indicator	80-12-18	11DSP523	Pressure Indicator
Permanent Magnet Generator (PMG)	80-12-14	11MGR524	Generator Assy, Alternating Current

Table 4-1. Line Replaceable Units (CONT)

Common Name	S/S/SN	Ref Des	Nomenclature
Permanent Magnet Generator Pressure Inlet Line	80-12-42	11U-T632	Tube Assy, Metal
PMG Overboard Vent Line Adapter	80-12-43	11U-T634	Adapter
Power Turbine Overspeed Switch and Pump	80-12-13	11BAR525	Switch Assembly, Oil Pump and Power Turbine Overspeed
Power Turbine Overspeed Switch and Pump Line Adapter	80-12-38	11U-S629	Fitting, Adapter
Power Turbine Overspeed Switch and Pump Scavenge Inlet Line	80-12-37	11U-S630	Tube Assy, Gearbox Scavenge
Power Turbine Overspeed Switch and Pump Scavenge Outlet Line	80-12-41	11U-S631	Tube Assy, Metal
Reverse Flow Fan Inlet Duct	80-12-17	11MPR591	Duct, Inlet, Reverse Flow Fan
Right Isolation Decoupler Ratchet Wheel	80-12-16	11MPR518	Coupler, Ratchet
Right Isolation Decoupler Shear Shaft	80-12-16	11MPR520	Stub Shaft
Scavenge Inlet Tube	80-12-39	11U-S628	Tube Assembly, Scavenge Inlet
Sump Drain Adapter Fitting	80-12-35	11U-S627	Fitting, Adapter
<p>1 ▶ On CGB 386720-3-2 and 386726-4-2.</p> <p>2 ▶ CGB 386720-4-1.</p> <p>3 ▶ CGB 386720-6-1.</p>			

LEGEND

- 1** CGB HAS EITHER VERTICAL TUBE OR ROUND TYPE RESERVOIR SIGHT GAGE.
- 2** CGB 386720-3-2 AND 386720-4-2.
- 3** CGB 386720-4-1.
- 4** CGB 386720-6-1.



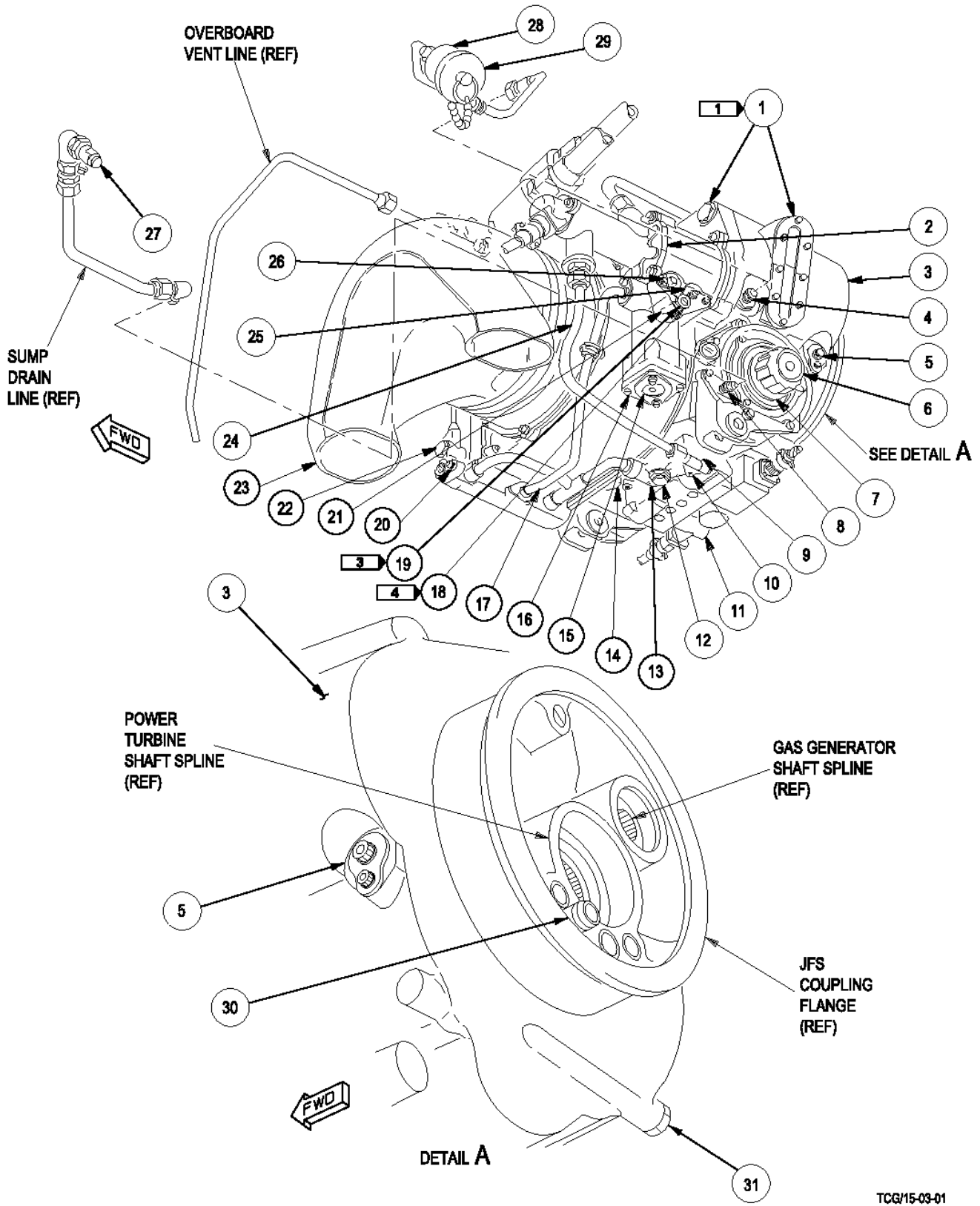
INDEX NO.	COMMON NAME	S/S/SN	REF DES	ACCESS
1 1	CGB RESERVOIR OIL LEVEL SIGHT GAGE	80-12-33	11DSP512	DOOR 83
2	POWER TURBINE OVERSPEED SWITCH AND PUMP	80-12-13	11BAR525	DOOR 83
3	CENTRAL GEARBOX (CGB)	80-12-10	52Z-R193	DOOR 83
4	CGB OIL FILLER RESTRICTOR CHECK VALVE	80-12-32	11VAP508	DOOR 83
5	LUBRICATION PRESSURE REGULATOR VALVE	80-12-27	11VAP522	DOOR 83
6	ISOLATION DECOUPLER RATCHET WHEEL	80-12-16	11MPP517 (LEFT) 11MPR518 (RIGHT)	DOOR 83 DOOR 83
7	ISOLATION DECOUPLER SHEAR SHAFT	80-12-16	11MPP519 (LEFT) 11MPR520 (RIGHT)	DOOR 83 DOOR 83
8	SUMP DRAIN ADAPTER FITTING	80-12-35	11U-S627	DOOR 83
9	SCAVENGE INLET TUBE	80-12-39	11U-S628	DOOR 83
10	POWER TURBINE OVERSPEED SWITCH AND PUMP LINE ADAPTER	80-12-38	11U-S629	DOOR 83
11	CGB HYDRAULIC CLUTCH CONTROL VALVE	80-12-46	11VAP645	DOOR 83
12	CGB CHIP DETECTOR	80-12-20	11U-P502	DOOR 83
13	CGB CASE DRAIN PLUG	80-12-21	11U-P625	DOOR 83
14	CGB RESERVOIR DRAIN PLUG	80-12-22	11U-T636	DOOR 83
15	OIL FILTER DP INDICATOR	80-12-18	11DSP523	DOOR 83
16	CGB OIL FILTER ELEMENT	80-12-19	11FAP510	DOOR 83
17	CGB OIL COOLER PRESSURE LINE	80-12-40	11U-T635	DOOR 83
3 18	CGB CONTROL OIL PRESSURE TEST PORT PLUG	80-12-23	11U-P592	DOOR 83
4 19	CGB CONTROL OIL PRESSURE TEST PORT QUICK DISCONNECT	80-12-23	11U-P592	DOOR 83
20	CGB OIL COOLER BYPASS VALVE	80-12-29	11VAR507	DOOR 83
21	CGB WASH-BY OIL FILTER	80-12-24	11FAP515	DOOR 83
22	CGB LUBE OIL PRESSURE TEST PORT PLUG	80-12-28	11U-R506	DOOR 83
23	REVERSE FLOW FAN INLET DUCT	80-12-17	11MPR591	DOOR 83
24	POWER TURBINE OVERSPEED SWITCH AND PUMP SCAVENGE INLET LINE	80-12-37	11U-S630	DOOR 83
25	CGB OIL FILTER BYPASS VALVE	80-12-26	11VAP509	DOOR 83
26	CONTROL OIL PRESSURE REGULATOR VALVE	80-12-25	11VAP516	DOOR 83
27	CGB SUMP DRAIN VALVE	80-12-34	11VAP513	DOOR 86L
28	CGB PRESSURE FILL FITTING	80-12-31	11VAP511	DOOR 86L
29	CGB PRESSURE FILL FITTING DISCONNECT CAP	80-12-30	11U-P505	DOOR 86L
30	CGB TRANSFER TUBE/CHECK VALVE	80-12-47	11VAS647	DOOR 83
31	CGB BLEED PLUG	80-12-36	11U-T633	DOOR 83
32	POWER TURBINE OVERSPEED SWITCH AND PUMP SCAVENGE OUTLET LINE	80-12-41	11U-S631	DOOR 83
2 33	CGB VENT HOUSING	80-12-44	11U-R639	DOOR 83
34	PERMANENT MAGNET GENERATOR (PMG)	80-12-14	11MGR524	DOOR 83
35	JFS HYDRAULIC START MOTOR	80-12-12	11U-P521	DOOR 83
36	CGB FAN AND CLUTCH	80-12-11	11MPR503	DOOR 83
37	PMG OVERBOARD VENT LINE ADAPTER	80-12-43	11U-T634	DOOR 83
38	PERMANENT MAGNET GENERATOR PRESSURE INLET LINE	80-12-42	11U-T632	DOOR 83
39	CGB AIR/OIL COOLER	80-12-48	11U-R647	DOOR 83
3 40	CGB RIGHT DECOUPLER POSITION SWITCH	80-12-15	11S-R626	DOOR 83

TCG/01-03-01

Figure 4-1. Central Gearbox System Component Locator (Sheet 1 of 3)

80-12-00

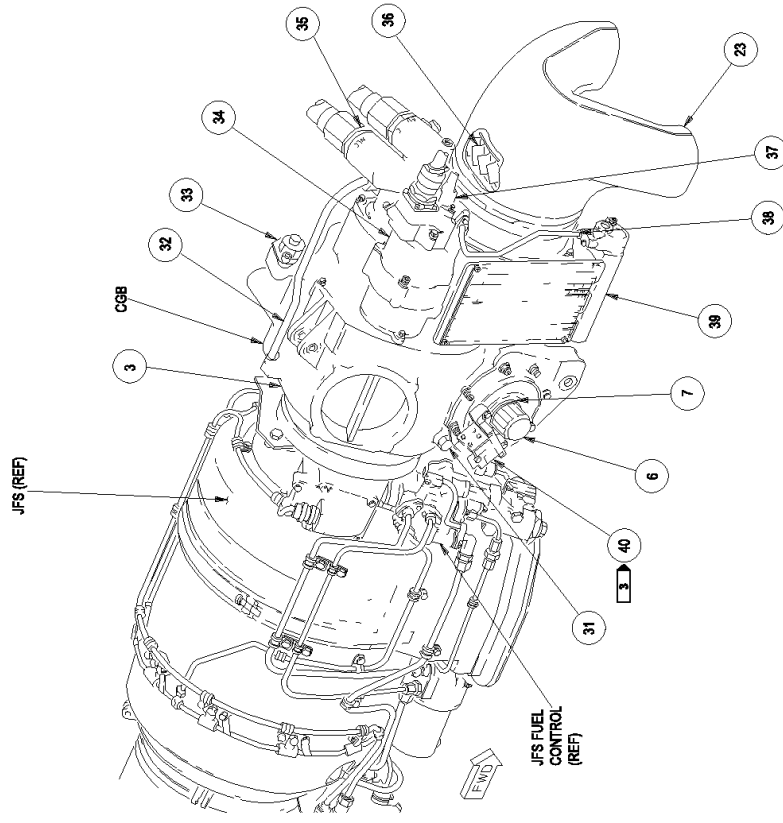
4-7



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**Figure 4-1. Central Gearbox System Component Locator
(Sheet 2)**

**80-12-00
4-8**



TC696-02-01

80-12-00
4-9

Figure 4-1. Central Gearbox System Component Locator
(Sheet 3)

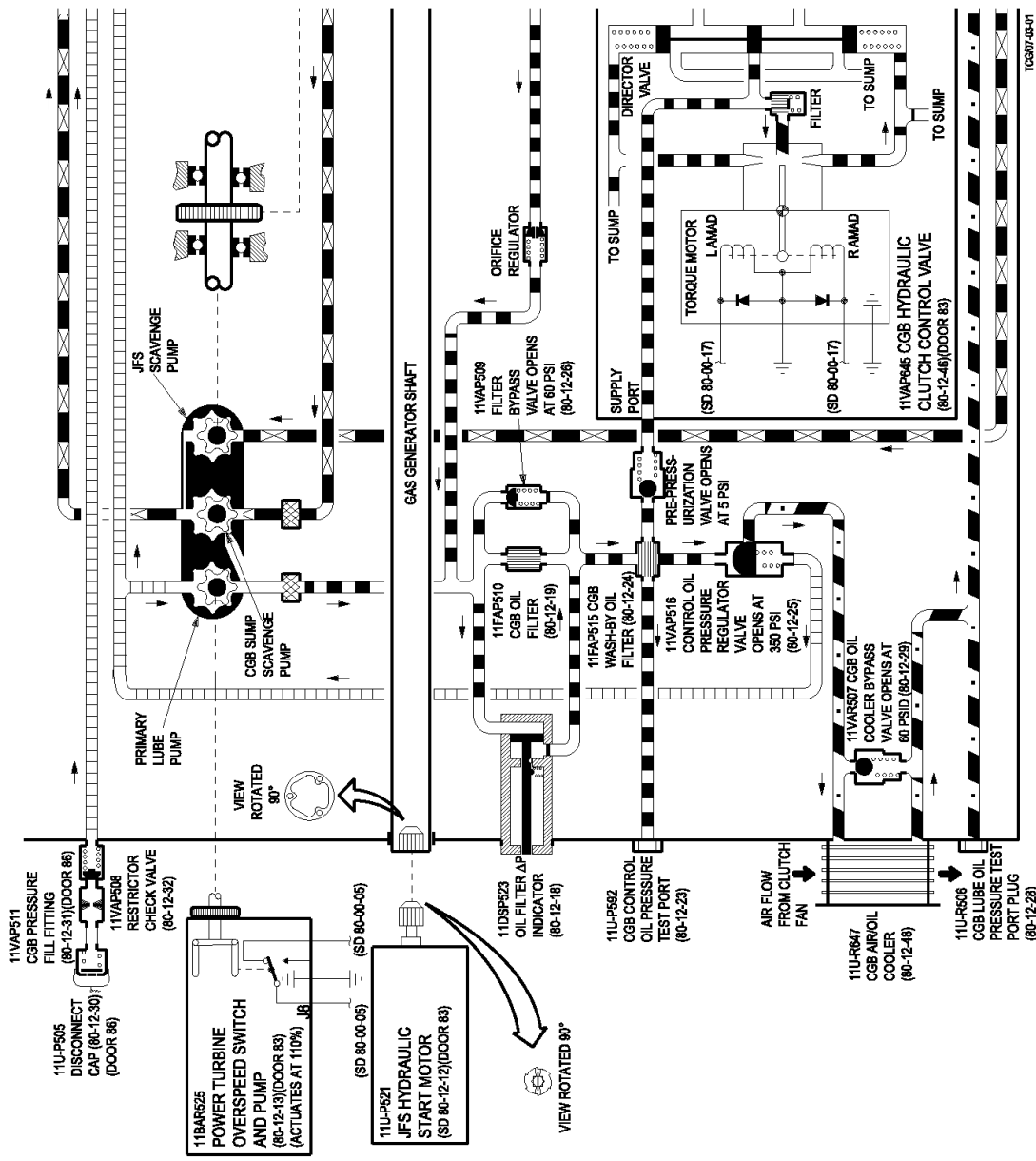


Figure 4-2. CGB/JFS Lube and Control Oil System Schematic (Sheet 1 of 3)

80-12-00
4-10

LEGEND

- LUBE OIL PRESSURE
- CONTROL OIL PRESSURE
- SCAVENGE OIL PRESSURE
- OIL SUPPLY (TANK OIL)
- BREATHER PRESSURE
- AIR
- FUEL

1. CGB RESERVOIR WILL HAVE VERTICAL TUBE SIGHT GAGE OR CIRCULAR SIGHT GAGE, BUT NOT BOTH.
2. FUNCTION OF DIFFERENTIAL SPEED LUBE PUMP IS TO SUPPLY CONTROL OIL PRESSURE WHEN DIFFERENTIAL RPM OF GAS GENERATOR AND POWER TURBINE OCCURS UPON ENGINE START.
3. OPENS AT 285 PSI TO PREVENT HIGH OIL CONSUMPTION DURING MAIN ENGINE STARTING.
4. GAS GENERATOR SHAFT IS DRIVEN BY WAY OF JFS HYDRAULIC START MOTOR DURING START; DRIVING PMG, JFS FUEL CONTROL AND TWO SPEED SWITCH.
5. AFTER GAS GENERATOR HAS SELF SUSTAINING SPEED, JFS HYDRAULIC START MOTOR DECOUPLES; CAUSING GAS GENERATOR TO DRIVE PMG, JFS FUEL CONTROL AND TWO SPEED SWITCH.
6. FUNCTION OF FLY WEIGHTS IS TO PREVENT ISOLATION DECOUPLER FROM EXTENDING WHILE ROTATING.
7. CGB 386720-4-1.
8. CGB 386720-6-1.
9. JFS 384238-5-1.

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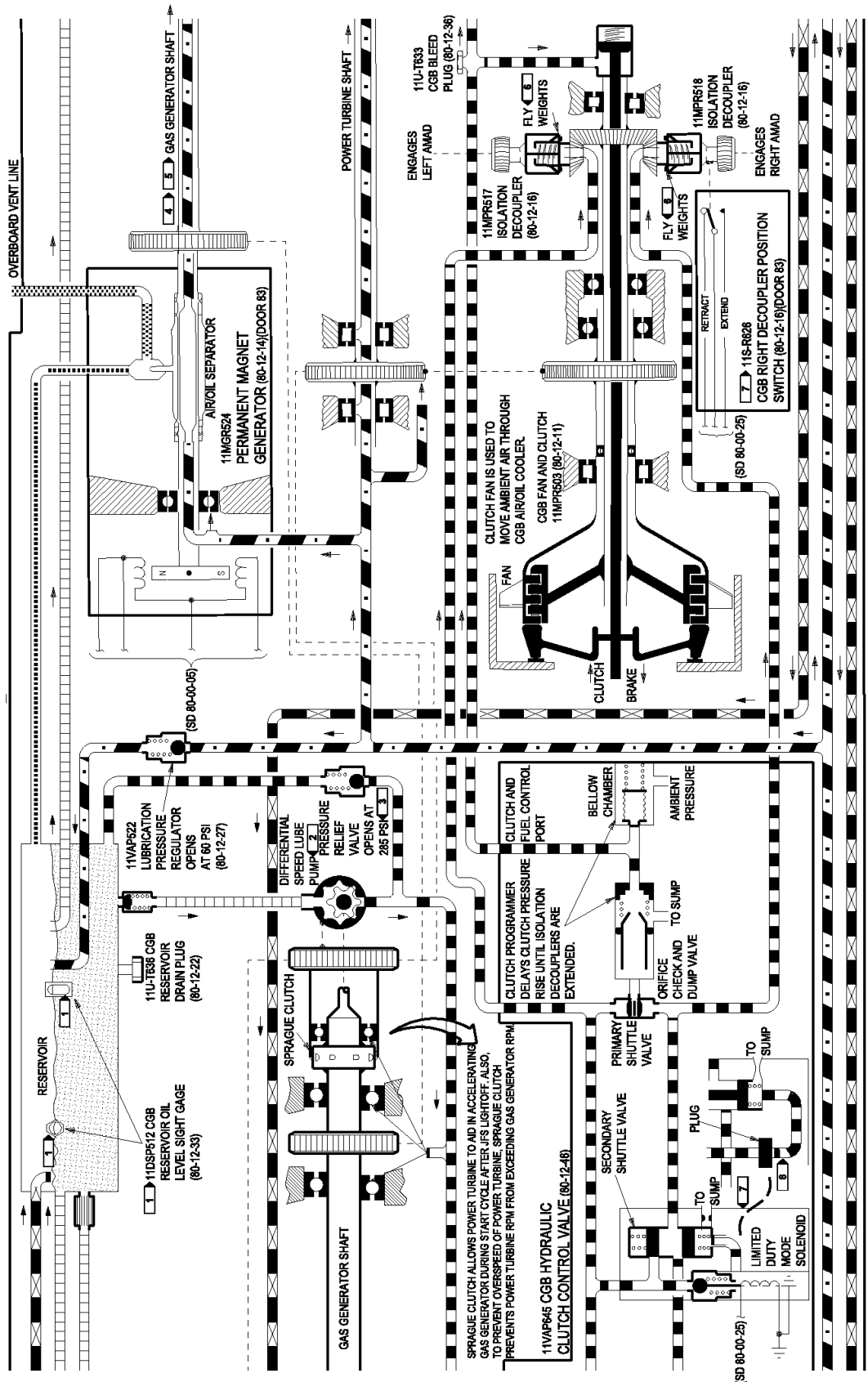


Figure 4-2. CGB/JFS Lube and Control Oil System Schematic (Sheet 2)

SPRAGUE CLUTCH ALLOWS POWER TURBINE TO AID IN ACCELERATING GAS GENERATOR DURING START CYCLE AFTER JFS LIGHTOFF. ALSO TO PREVENT OVERSPEED OF POWER TURBINE. SPRAGUE CLUTCH PREVENTS POWER TURBINE RPM FROM EXCEEDING GAS GENERATOR RPM

11WAP65 CGB HYDRAULIC CLUTCH CONTROL VALVE (80-12-48)

CLUTCH PROGRAMMER DELAYS CLUTCH PRESSURE RISE UNTIL ISOLATION DECOUPLERS ARE EXTENDED.

CLUTCH AND FUEL CONTROL BELLOW CHAMBER AMBIENT PRESSURE

ORIFICE CHECK AND TO SUMP DUMP VALVE

PRIMARY SHUTTLE VALVE

SECONDARY SHUTTLE VALVE

PLUG TO SUMP

TO SUMP

LIMITED DUTY MODE SOLENOID

(SD 80-00-25)

CLUTCH FAN IS USED TO MOVE AMBIENT AIR THROUGH CGB AIR/OIL COOLER 11MPS63 (80-12-11)

FAN

CLUTCH

BRAKE

FLY WEIGHTS

11MPS17 ISOLATION DECOUPLER (80-12-16)

ENGAGES LEFT AMAD

11MPS18 ISOLATION DECOUPLER (80-12-16)

ENGAGES RIGHT AMAD

RETRACT EXTEND

11S-R628 CGB RIGHT DECOUPLER POSITION SWITCH (80-12-16)(DOOR 83)

(SD 80-00-25)

POWER TURBINE SHAFT

11UTR38 CGB BLEED PLUG (80-12-36)

ENGAGES LEFT AMAD

ENGAGES RIGHT AMAD

TC607-00-01

OVERBOARD VENT LINE

RESERVOIR

11WAP522 LUBRICATION PRESSURE REGULATOR OPENS AT 60 PSI (80-12-27)

11UTR38 CGB RESERVOIR DRAIN PLUG (80-12-22)

11DSR612 CGB RESERVOIR OIL LEVEL SIGHT GAGE (80-12-33)

DIFFERENTIAL SPEED LUBE PUMP

PRESSURE RELIEF VALVE OPENS AT 285 PSK (3)

SPRAGUE CLUTCH

GAS GENERATOR SHAFT

AIR/OIL SEPARATOR 11MGR524 PERMANENT MAGNET GENERATOR (80-12-14)(DOOR 83)

(SD 80-00-05)

POWER TURBINE SHAFT

ENGAGES LEFT AMAD

ENGAGES RIGHT AMAD

FLY WEIGHTS

11MPS17 ISOLATION DECOUPLER (80-12-16)

ENGAGES LEFT AMAD

11MPS18 ISOLATION DECOUPLER (80-12-16)

ENGAGES RIGHT AMAD

RETRACT EXTEND

11S-R628 CGB RIGHT DECOUPLER POSITION SWITCH (80-12-16)(DOOR 83)

(SD 80-00-25)

POWER TURBINE SHAFT

11UTR38 CGB BLEED PLUG (80-12-36)

ENGAGES LEFT AMAD

ENGAGES RIGHT AMAD

FLY WEIGHTS

11MPS17 ISOLATION DECOUPLER (80-12-16)

TC607-00-01

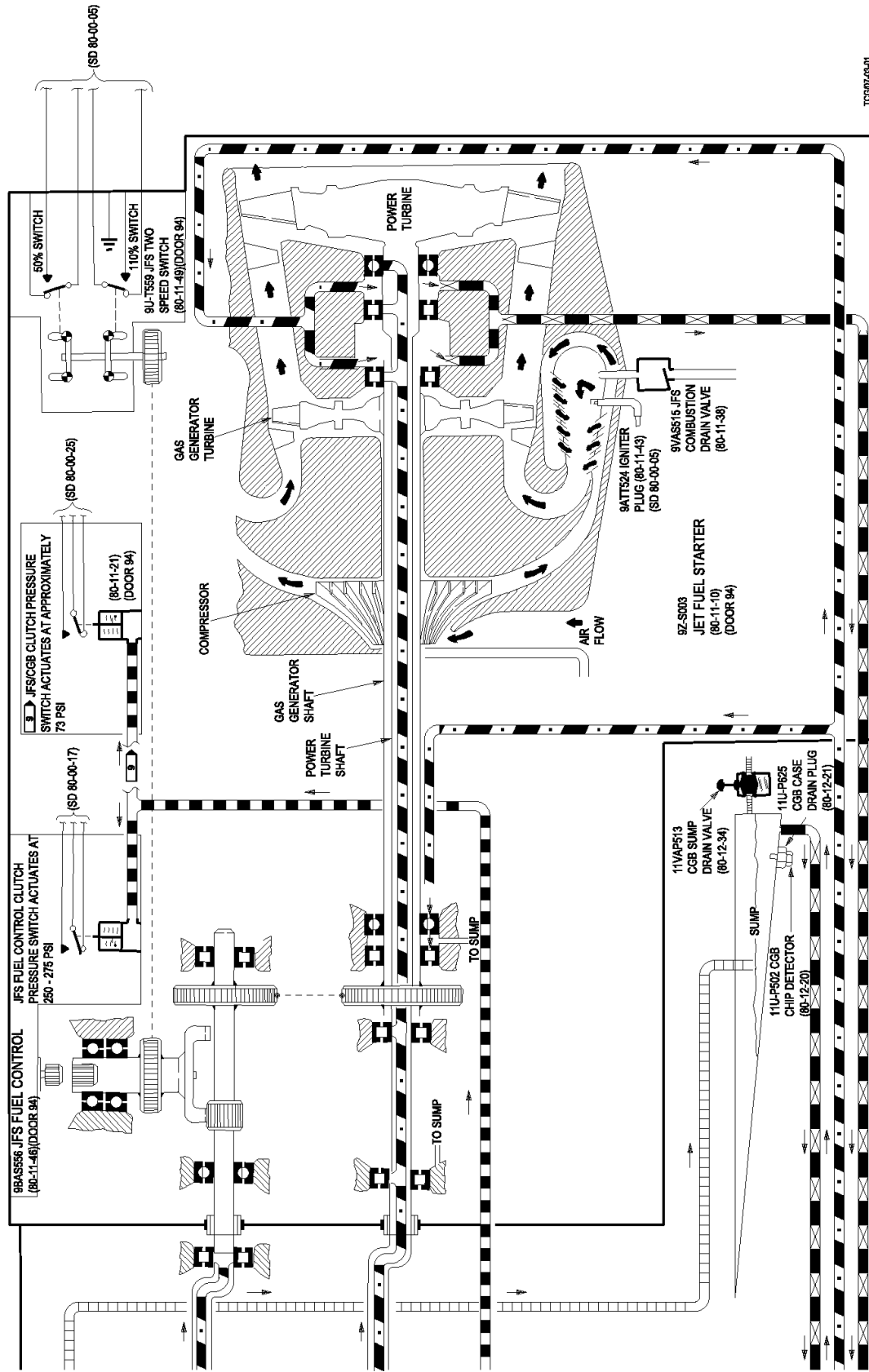


Figure 4-2. CGB/JFS Lube and Control Oil System Schematic (Sheet 3)

80-12-00
4-12

4-33. **SPECIAL MAINTENANCE REQUIREMENTS.**

4-34. **CENTRAL GEARBOX SYSTEM PERTINENT DATA.** Data pertinent to the operation and properties of the central gearbox are found in table 4-2.

Table 4-2. Pertinent Data

CENTRAL GEARBOX	
Characteristics (Approximate)	
Dry Weight	71 pounds
Length	18 inches
Width	12 inches
Height	13 inches
Input Speed (100 percent from power turbine)	59,432 rpm (approximately)
Input Speed (100 percent from JFS gas generator)	62,402 rpm (approximately)
Output Speed (100 percent to isolation decoupler)	12,129 rpm (approximately)
Compartment Temperature	
Operating	-65 to 280°F
Non-operating	-65 to 250°F continuous 343°F (10 min) 418°F (1 min)
Control System	Electrically started, hydraulically activated isolation decoupler, and clutch engagement and disengagement
Lubrication System	
Type	Self-contained, integrated system for JFS and CGB
Lubricant	MIL-L-7808
Total System Capacity	2900 cc (6.1 pts) dry
Pump Type	Gerotor, 4.44 gpm
Lube Pressure	60 psi
Case Pressure	3 to 5 psi
Control Pressure	350 psi
Scavenge System	
CGB	Gerotor pump
JFS	Gerotor pump
Cooling	Air/oil cooler
Overboard Drain and Leakage Limits	
PMG	No leakage allowed
Isolation Decoupler Seal	24 Drops per minute

4-35. **CONSUMABLE MATERIALS LIST.**

4-36. **SUPPLIES (CONSUMABLES).** A list of supplies required to support the organizational maintenance of the central gearbox system is provided in table 4-3.

Table 4-3. Supplies (Consumables)

Nomenclature	Material	Part Number MFG Code
Adhesive, Silicone		MIL-A-46106 (81349)
Dry Cleaning Solvent		PD680 TYPE 2 (81348)
Gasket		361418-1 (81349)
Gloves, Protective		
Grease, Molybdenum		MIL-G-21164 (81349)
Hydraulic, Fluid		MIL-H-83282 (81349)
Lockwire		MS20995NC20 (96906)
Lockwire		MS20995NC32 (96906)
Lubricating Oil		MIL-L-7808 (81349)
Methyl Ethyl Ketone		ASTM D 740 (81346)
Packing		S9413-008 (99193)
Packing		S9413-009 (99193)
Packing		S9413-010 (99193)
Packing		S9413-011 (99193)
Packing		S9413-012 (99193)
Packing		S9413-013 (99193)
Packing		S9413-014 (99193)
Packing		S9413-015 (99193)
Packing		S9413-016 (99193)
Packing		S9413-017 (99193)
Packing		S9413-019 (99193)
Packing		S9413-024 (99193)
Packing		S9413-035 (99193)

Table 4-3. Supplies (Consumables) (CONT)

Nomenclature	Material	Part Number MFG Code
Packing		S9413-036 (99193)
Packing		S9413-037 (99193)
Packing		S9413-124 (99193)
Packing		S9413-216 (99193)
Packing		S9413-552 (99193)
Packing		S9413-553 (99193)
Packing		S9413-554 (99193)
Packing		S9413-555 (99193)
Packing		S9413-557 (99193)
Packing		S9413-558 (99193)
Packing		S9413-559 (99193)
Packing		S9413-562 (99193)
Packing		S9413-590 (99193)
Painting Compound		219-189-9001
Petrolatum, Technical		VVP236
Pin, Cotter		MS24665-153
Pin, Cotter		ST9M552-1A
Primer, Epoxy		MIL-P-23377
Sealing Compound		PR1750A1
Washer		S8157BV383-125

4-37. **SUPPORT EQUIPMENT LIST.**

table 4-4. References in the Use and Application column indicate only one of the possible uses of this equipment.

4-38. **TEST EQUIPMENT.** Test equipment required for maintenance of the central gearbox system is listed in

Table 4-4. Test Equipment List

Equipment Number	Nomenclature	Use and Application
GG-G-531	Goggles, safety	Used for eye protection

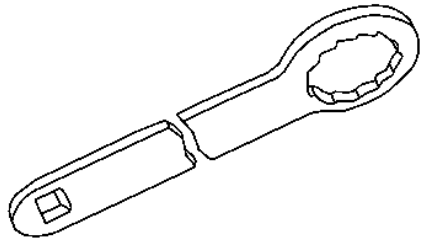
4-39. **SPECIAL TOOLS.** Special tools required for maintenance of the central gearbox system are listed in the table 4-5. Special tools are shown in figure 4-3.

NOTE

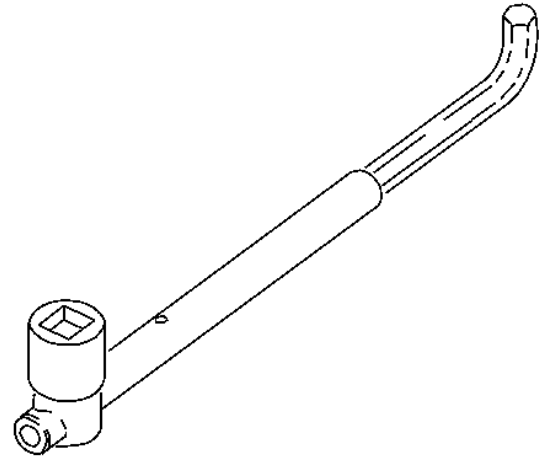
Contact WR-ALC/LFI 296 COCHRAN STREET, Robins AFB, GA 31098-1622 for information regarding modification of standard tools.

Table 4-5. Special Tools List

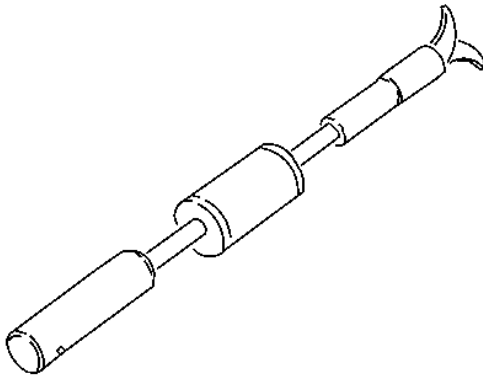
Tool Number	Nomenclature	Use and Application
289607-1	Wrench, spanner, internal ratchet	Used for holding isolation decouplers.
291428-1	Adapter set, torque wrench	Used for isolation decoupler removal and installation.
291656-1	Puller, mechanical, bearing race	Used for PMG rac removal.
291868-1	Puller, mechanical, clutch fan	Used for clutch input member removal.
291907-1	Puller, mechanical, adapter clutch	Used for clutch output member removal.
293157-1	Holder and adapter, clutch	Used for CGB fan and clutch removal and installation.
293158-1	Holder and adapter, clutch	Used for CGB fan and clutch removal and installation.
294549-1	Puller Set, Mechanical	Used for CGB transfer tube/check valve removal and installation.
296806-1	Puller set, AMAD/CGB	Used for CGB valves removal and installation.
296808-1	Wrench set, nut torquing	Used for CGB fan and clutch removal and installation.
296811-1	Wrench, splined	Used for PMG installation/ rotation of CGB gas generator spline shaft.
68D170011-1001	Ballpoint driver 3/16 inch, special	Used for isolation decoupler removal and installation.
68D170014-1001	Tool set, retainer bolt, CGB ratchet wheel	Used for isolation decoupler removal and installation.
GGGK275	Key, socket head screw 5120001985410 Modified per V-134-1 drawings 022 and 023	Used for isolation decoupler removal and installation.



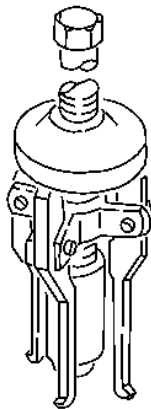
SPANNER INTERNAL RATCHET WRENCH
289607-1



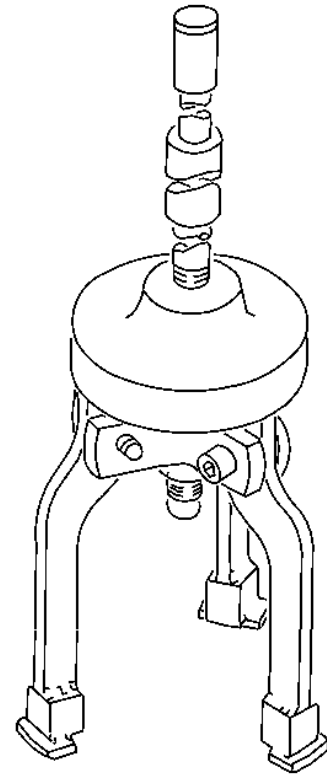
TORQUE WRENCH ADAPTER SET
291428-1



MECHANICAL BEARING RACE PULLER
291656-1



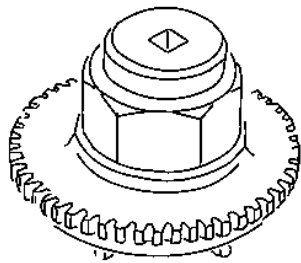
MECHANICAL CLUTCH ADAPTER PULLER
291907-1



MECHANICAL CLUTCH FAN PULLER
291868-1

TCG/15-03-01

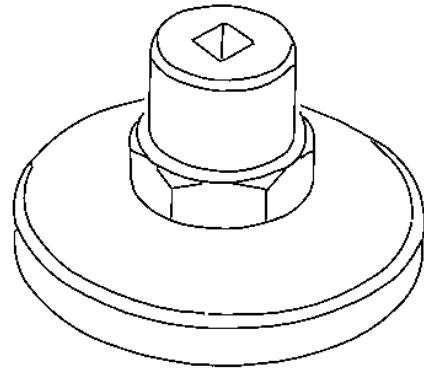
Figure 4-3. Special Tools (Sheet 1 of 2)



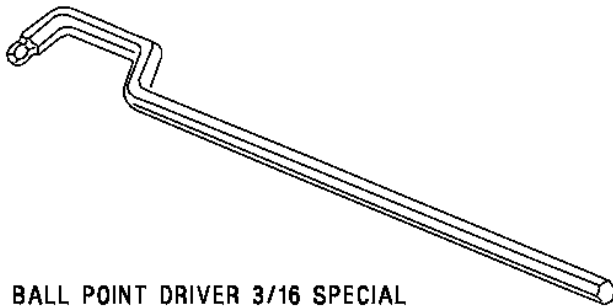
CLUTCH HOLDER AND ADAPTER
293157-1



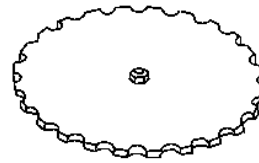
AMAD/CGB PULLER SET
296806-1



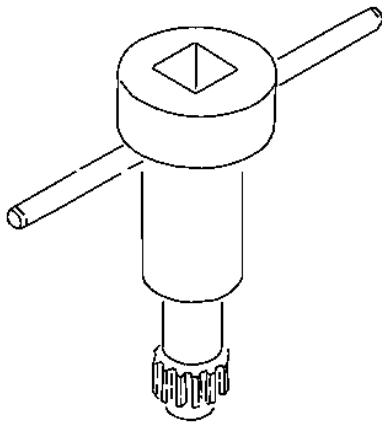
CLUTCH HOLDER AND ADAPTER
293158-1



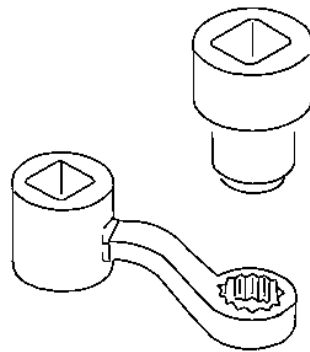
BALL POINT DRIVER 3/16 SPECIAL
68D170011-1001



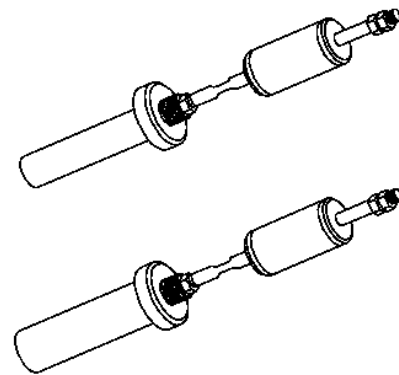
CGB RATCHET WHEEL RETAINER
BOLT TOOL SET
68D170014-1001



SPLINED WRENCH
296811-1



NUT TORQUING
WRENCH SET
296808-1



MECHANICAL PULLER SET
294549-1
TCG15-03-01

Figure 4-3. Special Tools (Sheet 2)

SECTION V

AIRFRAME MOUNTED ACCESSORY DRIVE SYSTEM

5-1. SYSTEM FUNCTIONAL DESCRIPTION.

5-2. **DESCRIPTION.** This section contains description and principles of operation for the airframe mounted accessory drive system shown in figure 5-1, and is made up of equipment listed in table 5-1 for the F-15C and F-15D aircraft.

5-3. **Airframe Mounted Accessory Drive (AMAD 83-20-10).** The AMAD gearboxes transmit jet fuel starter (JFS) power from the central gearbox (CGB) for operation of all aircraft accessories and provide the mechanical power transmission for engine starting. The gearboxes also provide rotation at the applicable speed ratio for transmission of engine power to the aircraft accessories during flight.

5-4. **AMAD Mounting.** The AMAD gearboxes, in door 85L and 85R, are individually attached to the aircraft with an upper mount and two lower bearing mounts. The mounts prevent transmitting of aircraft structural loads and deflections to the gearboxes.

5-5. **AMAD Components.** Each AMAD provides mounting for a utility hydraulic pump, a power control hydraulic pump and an integrated drive generator. Also, each AMAD contains an AMAD driveshaft, AMAD oil pump and start cutout switch, AMAD pawl carrier, AMAD layshaft damper assembly and related valves.

5-6. **AMAD Driveshaft (83-10-10) and AMAD Driveshaft Cover (83-10-11).** Each AMAD provides a mounting pad for an AMAD driveshaft. The driveshaft extends through the aft AMAD compartment to the engine. The driveshaft is attached to a flanged driveshaft adapter at the gearbox and extends to an engine power takeoff shaft at the engine. A flexible coupling at each end of the shaft allows a slight misalignment under severe flexing condition between the AMAD gearbox and the engine. A two piece metal cover provides protection from driveshaft rotation.

5-7. **AMAD Oil Pump and Start Cutout Switch (83-20-13).** The start cutout switches are in the same housing with the oil pump and are on the forward section of each gearbox. Each cutout switch includes a flyweight governor, centrifugally actuated when the engines are between BEFORE TO 2JA16-3-506 50 to

54 percent N₂ RPM or AFTER TO 2JA16-3-506 41 to 43 percent N₂ RPM. The actuated switch removes electrical power from the CGB hydraulic clutch control valve in the CGB. The torque motor/director valve removes control oil pressure from the CGB clutch and isolation decoupler at the end of the engine start cycle and the JFS is returned to idle. When both engines are operating at approximately 50 percent, the start cutout switches stop JFS operation. The oil pump in the switch housing provides pressurized oil flow for AMAD gears and bearing lubrication, and provides an oil pressure to two injector pumps. One pump pressurizes the gearcase and the other scavenges the gearbox sump.

5-8. **AMAD Pawl Carriers (83-20-16).** Each AMAD gearbox provides a pawl and carrier ratchet for operation of the AMAD layshaft and gears. The CGB isolation decouplers extend and engage these pawl carriers and the CGB clutch transmits JFS/CGB power for rotation. Isolation decoupler engagement occurs only when the decouplers are not rotating. Shear sections are at each AMAD/aircraft accessory interface, AMAD spline shaft interface and AMAD/CGB interface. These shear sections protect the AMAD gearboxes by preventing a failure in one from affecting another.

5-9. **AMAD Layshaft (83-20-24) Assembly.** Radial misalignment of the CGB isolation decouplers to the AMAD pawl carriers is allowed by the AMAD layshaft damping assemblies. The damping assemblies receive radial displacement so that the pawl carrier will self-align itself with the CGB isolation decoupler during isolation decoupler engagement into the pawl carrier. When engaged, the layshaft damping assembly is hydraulically locked into place by the AMAD lubrication oil pressure.

5-10. **AMAD Geartrain.** The AMAD geartrain transfers CGB rotational power to the engines and accessories during start and transfers engine rotational power to the accessories during engine run. The gear train contains a pawl carrier, layshaft, layshaft damper, AMAD driveshaft, two idler gears, and drive gears for the utility and power control hydraulic pumps, the IDG and the oil pump and start cutout switch.

5-11. **AMAD Cooling System.** Each AMAD gearbox has an integral lubrication system with aircraft mounted heat exchangers for oil cooling. The two fuel/oil heat exchangers, in the engine fuel feed lines, are above the AMAD compartments and provide the cooling requirements.

5-12. **AMAD Oil System.** See figure 5-2. The AMAD lubrication system provides pressurized oil for gears and bearings, injector valves and decoupler damper. The system contains a high pressure gerotor AMAD oil pump which provides pressurized oil to the gears and bearings and the injector pumps for gearcase pressurization and sump scavenge. A pressure regulator maintains a pressure of approximately 55 psi in the oil supply to the lube jets and anti-blowback valve. An oil pressure relief valve controls oil pressure to approximately 230 psi for gearcase pressurization and sump scavenge. A gearcase pressure control valve limits the differential pressure across the outer gearcase wall in a positive and negative direction. An anti-blowback valve and gearcase pressurizing injector pressurizes the gearcase during normal operation through the gearcase pressure valve. The valve opens during AMAD operation and closes on shutdown in response to lube oil pressure. The injector pump scavenges the gearbox sump and returns the oil to the reservoir.

5-13. The AMAD lubrication pump is a direct driven element which starts operating on initial rotation of the gearbox to circulate system oil. The high pressure oil system is controlled by the pressure regulating relief valve which limits system pressure to 200 to 260 psi. The pump provides an oil flow to the gearcase pressurization injector and gearbox sump injector. This oil pressure is reduced through a cavitating venturi flow control valve and cooled through the heat exchanger. The output of the heat exchanger is passed through a filter to the AMAD gears and bearings. The lube pressure regulator maintains a pressure supply of 40 to 70 psi to the lube jets, and anti-blowback valve which provides gearcase pressurization.

5-14. Each AMAD has a pressure actuated valve assembly between the reservoir and sump, a calibrated oil level sight gage, oil pressure fill fitting and drain valve are in each AMAD oil system and are accessible through doors 86L and 86R. Each system is self pressurized and venting is done through a breather unit in each AMAD. The gearcase pressure control valve limits the gearcase pressure across the outer gearcase for a positive or negative pressure. The oil filter bypass

valve provides oil flow around a clogged filter. The ΔP indicator provides a premature indication of filter failure before the bypass valve is activated. The oil coolers are connected in series for fuel cooling and circulating aircraft fuel is returned to the wing for more cooling. The oil cooling bypass valve provides a supply of oil around the heat exchanger when the pressure across the exchanger exceeds 55 to 65 psig. An oil filler check valve is in the filler port to prevent loss of oil. The filler connector and gage are accessible through door 86L or 86R.

5-15. **AMAD/Engine Starting System.** With the JFS running at standby controlled speed, a right or left engine start can be done. When an AMAD pawl carrier is engaged by the CGB isolation decoupler, JFS shaft power is transmitted through the AMAD to the engine PTO shaft to accelerate the engine. When the engine arrives at BEFORE TO 2JA16-3-506 50 to 54 percent N_2 RPM or AFTER TO 2JA16-3-506 41 to 43 percent N_2 RPM, the start cutout switch removes power to the torque motor in the CGB hydraulic clutch control valve. This causes a loss of control oil pressure in the CGB so that the AMAD is decoupled and the JFS returns to idle speed. After both engines are started, their respective starter cutout switches are open and the JFS automatically shuts down.

5-16. **PRINCIPLES OF OPERATION.** During engine starting the AMAD gearboxes received input rotational power from the CGB through the self-centering pawl carriers. When the engines are at self-continuing speed and CGB disengages, the engines provide the power to drive the AMAD through the AMAD driveshaft. Both power inputs drive through the same internal gear train to rotate the IDG, the PC and utility hydraulic pumps, and the AMAD oil pump and start cutout switch. When the AMAD is rotated, the oil pump supplies lubrication pressure to the internal bearings and gear meshes, the oil cooler, the oil filter, and layshaft damper. Looking at the pads, all input and output rotation is in the clockwise direction.

5-17. **AMAD Geartrain.** When the CGB isolation decoupler is extended, the ratchet wheel is engaged to the pawl carrier on the inboard side of each AMAD. The pawls grip the ratched wheel until the main engine speed overruns the CGB speed. At this time, the pawls disengage and are retracted to the inner face of the pawl carrier by centrifugal force. The pawl carrier is attached to the layshaft which transmits the input rotational power across the AMAD to the AMAD/engine driveshaft on the outboard end of the gearbox.

The layshaft is supported by a ball and a roller bearing on each end and meshes the driveshaft with a bevel gear. The AMAD driveshaft mates with the engine PTO shaft and transfers power from the AMAD to the engine when the JFS is operating or from the engine to the AMAD when the engine is operating.

5-18. The hydraulic power control drive gear meshes with a spur gear on the AMAD/engine driveshaft. This drive gear rotates an internally spline shaft and a spur gear in a clockwise direction to drive the PC hydraulic pump. The first idler gear is driven by the spur gear on the PC pump driveshaft. This idler rotates a dual roller bearing supported shaft and another spur gear and drives the lube pump and start cutout switch. The integrated drive generator drive gear meshes with the first idler gear and rotates an internally splined shaft in a clockwise direction to drive the IDG. The second idler gear meshes with the IDG drive gear and is internally supported by a roller bearing. This idler rotates counterclockwise and drives the utility hydraulic pump drive gear in a clockwise direction. The utility hydraulic pump drive gear rotates an internally splined shaft supported by two ball bearings. This spline shaft is the most inboard accessory drive shaft and drives the utility hydraulic pump.

5-19. **AMAD Oil System.** On each AMAD the reservoir and sump are connected by a valve assembly. During oil servicing the valve is open allowing oil to fill the reservoir and sump, increasing oil capacity approximately 500cc. During AMAD operation, the valve is closed and sump is pumped relatively dry, storing oil in the reservoir.

5-20. Oil from the AMAD reservoir flows to the inlet side of the AMAD oil pump. The oil pump pressure relief valve opens at approximately 230 psi and bypasses excess oil back to the inlet of the pump. The pressurized oil that is not bypassed flows to three flow control orifices. One orifice restricts the pressure to 80 psi to operate the jet scavenge pump in the AMAD pump. The pump causes a low pressure area in a ported passageway to pull the sump oil back to the reservoir. The second orifice controls the oil flow to the gearcase pressurization injector on the reservoir, to maintain a positive pressure at the inlet to the oil pump. The third orifice restricts the oil pressure to 45 psi to the lubrication and cooling part of the system. The oil cooling is done by an aircraft mounted fuel/oil heat exchanger. The oil flow to the heat exchanger is controlled by the heat exchanger bypass valve in the AMAD. The heat exchanger bypass valve opens at

approximately 60 psid to route oil on for lubrication or to the heat exchanger for cooling. After the oil is cooled, the flow is directed to the oil filter.

5-21. The oil passes through the 25 micron filter during normal operation. If the filter becomes clogged, a filter bypass valve opens at approximately 60 psid to allow the oil to flow on through the system. A differential pressure indicator in the filter housing extends when the pressure across the filter is approximately 45 psid. From the filter, oil flows to the lubrication system, the layshaft damper, the manual decoupler on the left AMAD 386706-3-1 or 386706-3-2, the pressure regulator and the reservoir. In the lubrication system, oil is sprayed and splashed on the gear meshes and bearings by orificed jets. The excess oil returns to the sump.

5-22. On the left AMAD 386706-3-1 or 386706-3-2 AFTER TO 2JA16-3-512, the manual decoupler handle is safetied in the coupled position to prevent disengagement of the AMAD/engine driveshafts. The manual decoupler has a hydraulic lock that prevents disengagement of the AMAD/engine driveshaft while the AMAD is operating. With the manual decoupler engaged, oil at 45 psi is directed to the forward side of the hydraulic lock and prevents disengagement. As oil pressure increases to 45 psi during start, damping plates in the layshaft damper assembly become compressed together to lock the layshaft in position with the alignment of the isolation decoupler. The damping plates allow a radial movement of the pawl carrier when lubrication oil pressure does not exist. The lubrication oil pressure is maintained by a pressure regulator which opens at 40 to 70 psi and bypasses excess oil to the reservoir.

5-23. **AMAD/Engine Starting Sequence.** With the JFS at idle, the engine starting sequence is started when the L or R ENG MASTER switch is set to ON and the coinciding throttle fingerlift is raised and released (start switch engaged). This applies 28vdc to the CGB hydraulic clutch control valve torque motor (on left AMAD 386706-3-1 or 386706-3-2, by way of manual decoupler switch for left engine starting) and the director valve provides high pressure control oil to the isolation decoupler and in sequence, the CGB clutch and the pressure switch in the JFS fuel control. The isolation decoupler extends, the clutch engages and rotates the decoupler and in turn the AMAD pawl carrier. The fuel pressure signal actuates the fuel switch, energizing the acceleration control valve and the gas generator accelerates to 100 percent. The JFS

power turbine is slowed with the AMAD/engine load and accelerates at a slower rate.

5-24. When the centrifugally actuated AMAD start cutout switch actuates, at approximately 50 to 54 percent N₂ RPM BEFORE TO 2JA16-3-506, 41 to 43 percent N₂ RPM AFTER TO 2JA16-3-506, the electrical circuit to the CGB hydraulic clutch control valve is opened, removing hydraulic control pressure from the isolation decoupler, CGB clutch and the fuel control pressure switch. The JFS decelerates, the springloaded decoupler retracts, and the JFS is returned to idle. The AMAD is isolated from the CGB and the aircraft accessories are driven through the AMAD driveshaft by the engine.

5-25. When the second engine is brought to starter cutout speed, the second start cutout switch is actuated centrifugally, removing hydraulic control oil from the second isolation decoupler, clutch and fuel control, causing the JFS to decelerate to idle. However, with both cutout switches open, electrical power is removed from the JFS control circuits, 28vdc is removed from the fuel shutoff valves, and the JFS shuts down. Alternately on single engine operation, when shutdown is requested, the STARTER switch is set to OFF, also removing 28vdc and closing the fuel shutoff valves, causing the JFS to shut down.

Table 5-1. Line Replaceable Units

Common Name	S/S/SN	Ref Des	Nomenclature
Left AMAD Case Drain Plug	83-20-22	11U-P595	Plug
Left AMAD Chip Detector	83-20-21	11U-P539	Plug, Magnetic
Left AMAD Drive Pad Drain Line	83-20-11	11U-P526	Tube Assembly
Left AMAD Drive Pad Drain Line	83-20-11	11U-P637	Tube Assembly
Left AMAD Drive Pad Drain Line Adapter	83-20-11	11U-P528	Union
Left AMAD Driveshaft	83-10-10	11MPP530	Shaft Assembly, Flexible
Left AMAD Driveshaft Carbon Seal	83-20-26	11MPP532	Seal
Left AMAD Driveshaft Cover	83-10-11	11MPP533	Cover Assy, Power Take-off Shaft
Left AMAD Driveshaft Scupper Assembly	83-10-12	11MPP641	Fireseal, Bulkhead PTO Shaft
Left AMAD End Cover	83-20-18	11MPP541	Cover, Gearbox End
Left AMAD Fill Fitting Disconnect Cap	83-20-44	11U-P537	Cap
Left AMAD Gearbox (AMAD)	83-20-10	52Z-P194	Gearbox, Accessory Drive
Left AMAD Gearcase Pressure Control Valve	83-20-34	11VAP543	Valve, Gearcase Pressure Control
Left AMAD High Oil Pressure Test Port Plug	83-20-47	11U-P611	Plug
Left AMAD Jet Ejector Pump Nozzle	83-20-52	11U-P617	Nozzle, Jet Ejector Pump
Left AMAD Jet Scavenge Pump Nozzle	83-20-53	11U-P615	Nozzle, Jet Scavenge Pump

Table 5-1. Line Replaceable Units (CONT)

Common Name	S/S/SN	Ref Des	Nomenclature
Left AMAD Layshaft	83-20-24	11MPP601	Layshaft Assy, Damping
Left AMAD Layshaft Lube Jet	83-20-60	11U-P603	Lube Jet, Layshaft Drive
Left AMAD Lower Mount	83-20-12	11MPP545	Bearing Unit, Plain Spherical Cartridge
Left AMAD Oil Cooler Bypass Valve	83-20-32	11VAP547	Valve, Pressure Regulator
Left AMAD Oil Filter Bypass Valve	83-20-35	11VAP551	Valve, Pressure Regulator
Left AMAD Oil Filter Differential Pressure (DP) Indicator	83-20-19	11DSP553	Pressure Indicator
Left AMAD Oil Filter Element	83-20-20	11FAP555	Filter, Oil
Left AMAD Oil Inlet Adapter	83-20-11	11U-P557	Fitting, Oil-In
Left AMAD Oil Level Sight Gage	83-20-40	11DSP559	Sight Indicator
Left AMAD Oil Outlet Adapter	83-20-11	11U-P561	Fitting, Oil-Out
Left AMAD Oil Pressure Regulator Valve	83-20-33	11VAP563	Valve, Pressure Regulator
Left AMAD Low Oil Pressure Test Port Plug	83-20-46	11U-P565	Plug
1 5 Left AMAD Manual Decoupler Handle Assembly	83-20-15	11MPP600	Handle Assembly, Manual Decoupler
5 Left AMAD Manual Decoupler Switch	83-20-14	11S-P599	Switch
Left AMAD Oil Pump Relief Valve	83-20-31	11VAP567	Valve, Pressure Regulator
Left AMAD Oil Pump and Start Cutout Switch	83-20-13	11U-P529	Pump, Oil and Switch Assy
Left AMAD Pressure Fill Fitting	83-20-45	11VAP571	Disconnect
Left AMAD Pump Cavitation Venturi	83-20-37	11U-P621	Venturi, Cavitation
Left AMAD Pump Valve Assembly	83-20-36	11U-P619	Valve Assembly
Left AMAD Reservoir Drain Plug	83-20-23	11U-P597	Plug
Left AMAD Seal Rotor	83-20-25	11MPP640	Rotor, Seal Assembly
Left AMAD Sight Gage Adapter	83-20-41	11U-P607	Adapter, Sight Glass
4 Left AMAD Sight Gage Adapter Fitting	83-20-42	11U-P605	Adapter, Oil Fill and Sight Gage
4 Left AMAD Upper Mount	83-20-12	11MPP573	Mount, Upper
Left AMAD Utility and Power Control Clamping Ring	83-20-49	11MPP623	Ring, Utility and Power Control Clamping

Table 5-1. Line Replaceable Units (CONT)

Common Name	S/S/SN	Ref Des	Nomenclature
4 ▶ Left AMAD Sight Gage Adapter Plug	83-20-43	11U-P609	Plug
Left AMAD Vent Screen	83-20-48	11FAP613	Filter Assy, Fluid Pressure
Left IDG Driveshaft Encased Seal	83-20-30	11MPP575	Encased Seal
Left Overflow Drain Valve	83-20-39	11VAP577	Cock Poppet Drain, Gearbox Overfill
Left PC Hydraulic Pump Driveshaft Encased Seal	83-20-28	11MPP579	Encased Seal
Left Pawl Carrier	83-20-16	11MPP581	Pawl Carrier
Left Pawl Carrier Carbon Seal	83-20-17	11MPP583	Seal, Air-Oil
Left Pawl Carrier Seal Rotor	83-20-56	11MPP648	Seal, Rotor
Left Pressure Injector and Anti-Blowback Valve	83-20-38	11VAP587	Valve Assembly, Gearcase Pressure Injector
Left Second Idler Lubricating Nozzle	83-20-51	11U-P593	Nozzle Assembly, Second Idler Lubricating
Left Utility Hydraulic Pump Driveshaft Encased Seal	83-20-29	11MPP589	Encased Seal
Right AMAD Case Drain Plug	83-20-22	11U-R596	Plug
Right AMAD Chip Detector	83-20-21	11U-R540	Plug, Magnetic
Right AMAD Drive Pad Drain Line	83-20-11	11U-R527	Tube Assembly
Right AMAD Drive Pad Drain Line	83-20-11	11U-R638	Tube Assembly
Right AMAD Drive Pad Drain Line Adapter	83-20-11	11U-R529	Union
Right AMAD Driveshaft	83-10-10	11MPR531	Shaft Assembly, Flexible
3 ▶ Right AMAD Bellows Mounted Seal Rotor	83-20-54	11MPR644	Rotor, Seal Assembly
3 ▶ Right AMAD Driveshaft Carbon Seal	83-20-55	11MPR643	Seal
Right AMAD Driveshaft Cover	83-10-11	11MPR534	Cover Assembly, Power Take-off Shaft
Right AMAD Driveshaft Scupper Assembly	83-10-12	11MPR642	Fireseal, Bulkhead PTO Shaft
2 ▶ Right AMAD Driveshaft Encased Seal	83-10-27	11MPR536	Encased Seal
Right AMAD End Cover	83-20-18	11MPR542	Cover, Gearbox End

Table 5-1. Line Replaceable Units (CONT)

Common Name	S/S/SN	Ref Des	Nomenclature
Right AMAD Fill Fitting Disconnect Cap	83-20-44	11U-R538	Cap
Right AMAD Gearbox (AMAD)	83-20-10	11Z-R005	Gearbox, Accessory Drive
Right AMAD Gearcase Pressure Control Valve	83-20-34	11VAR544	Valve, Gearcase, Pressure Control
Right AMAD High Oil Pressure Test Port Plug	83-20-47	11U-R612	Plug
Right AMAD Jet Ejector Pump Nozzle	83-20-52	11U-R618	Nozzle, Jet Ejector Pump
Right AMAD Jet Scavenge Pump Nozzle	83-20-53	11U-R616	Nozzle, Jet Scavenge Pump
Right AMAD Layshaft	83-20-24	11MPR602	Layshaft Assy, Damping
Right AMAD Layshaft Lube Jet	83-20-50	11U-R604	Lube Jet, Layshaft Drive
Right AMAD Lower Mount	83-20-12	11MPR546	Bearing Unit, Plain Spherical Cartridge
Right AMAD Oil Cooler Bypass Valve	83-20-32	11VAR548	Valve, Pressure Regulator
Right AMAD Oil Filter Bypass Valve	83-20-35	11VAR552	Valve, Pressure Regulator
Right AMAD Oil Filter Differential Pressure (DP) Indicator	83-20-19	11DSR554	Pressure Indicator
Right AMAD Oil Filter Element	83-20-20	11FAR556	Filter, Oil
Right AMAD Oil Inlet Adapter	83-20-11	11U-R558	Fitting, Oil-In
Right AMAD Oil Level Sight Gage	83-20-40	11DSR560	Sight Indicator
Right AMAD Oil Outlet Adapter	83-20-11	11U-R562	Fitting, Oil-Out
Right AMAD Oil Pressure Regulator Valve	83-20-33	11VAR564	Valve, Pressure Regulator
Right AMAD Low Oil Pressure Test Port Plug	83-20-46	11U-R566	Plug
Right AMAD Oil Pump Relief Valve	83-20-31	11VAR568	Valve, Pressure Regulator
Right AMAD Oil Pump and Start Cutout Switch	83-20-13	11U-R570	Pump, Oil and Switch Assy
Right AMAD Pressure Fill Fitting	83-20-45	11VAR572	Disconnect
Right AMAD Pump Cavitation Venturi	83-20-37	11U-R622	Venturi, Cavitation
Right AMAD Pump Valve Assembly	83-20-36	11U-R620	Valve Assembly

Table 5-1. Line Replaceable Units (CONT)

Common Name	S/S/SN	Ref Des	Nomenclature
Right AMAD Reservoir Drain Plug	83-20-23	11U-R598	Plug
4 ▶ Right AMAD Sight Gage	83-20-41	11U-R608	Adapter, Sight Glass
4 ▶ Right AMAD Sight Gage Adapter	83-20-43	11U-R610	Plug
4 ▶ Right AMAD Sight Gage Adapter	83-20-42	11U-R606	Adapter Oil Fill and Sight Gage
Right AMAD Upper Mount	83-20-12	11MPR574	Mount, Upper
Right AMAD Utility and Power Control Clamping Ring	83-20-49	11MPR624	Ring, Utility and Power Control Clamping
Right AMAD Vent Screen	83-20-48	11FAR614	Filter Assy, Fluid Pressure
Right IDG Driveshaft Encased Seal	83-20-30	11MPR576	Encased Seal
Right Overflow Drain Valve	83-20-39	11VAR578	Cock, Poppet Drain, Gearbox Overfill
Right PC Hydraulic Pump Driveshaft Encased Seal	83-20-28	11MPR580	Encased Seal
Right Pawl Carrier	83-20-16	11MPR582	Pawl Carrier
Right Pawl Carrier Carbon Seal	83-20-17	11MPR584	Seal, Air-Oil
Right Pawl Carrier Seal Rotor	83-20-56	11MPR649	Seal, Rotor
Right Pressure Injector and Anti-Blowback Valve	83-20-38	11VAR588	Valve Assembly, Gearcase Pressure Injector
Right Second Idler Lubricating Nozzle	83-20-51	11U-R594	Nozzle Assy, Second Idler Lubricating
Right Utility Hydraulic Pump Driveshaft Encased Seal	83-20-29	11MPR590	Encased Seal
1 ▶ AFTER TO 2JA16-3-512, manual decoupler handle is safetied in the coupled position.			
2 ▶ RIGHT AMAD 386704-3-1.			
3 ▶ RIGHT AMAD 386704-3-2 AND 386704-3-3.			
4 ▶ LEFT AMAD 386706-3-1, 386706-3-2 and right AMAD 386704-3-3.			
5 ▶ LEFT AMAD 386706-3-1 AND 386706-3-2.			

LEGEND

- 1 LEFT AMAD ONLY
- 2 RIGHT AMAD 387704-3-1
- 3 AFTER TO 2, 16, 5, 12, MANUAL DECOUPLER HANDLE IS SAFETIED IN THE COUPLED POSITION
- 4 RIGHT AMAD 387704-5-2 AND 387704-3-3
- 5 LEFT AMAD 387705-3-1, 387706-5-2 AND 387704-3-5
- 6 LEFT AMAD 387705-3-1 AND 387705-3-2

INDEX NO.	COMMON NAME	SS/ISN	REF DES	ACCESS
1	AMAD GEARBOX	83-20-10	5ZP194 (LEFT)	85L
2	AMAD UTILITY AND POWER CONTROL CLAMPING RING	83-20-49	11Z-R005 (RIGHT)	85R
3	AMAD OIL COOLER BYPASS VALVE	11MPR622 (LEFT)	11MPR622 (LEFT)	85L
4	AMAD OIL INLET ADAPTER	83-20-32	11WAP54 (LEFT)	85R
5	AMAD OIL OUTLET ADAPTER	83-20-11	11UR526 (RIGHT)	85L
6	AMAD SIGHT GAGE ADAPTER PLUG	83-20-11	11UR561 (RIGHT)	85R
7	PRESSURE INJECTOR AND ANTI-BLOW BACK VALVE	83-20-43	11UR562 (LEFT)	85L
8	MANUAL DECOUPLER SWITCH	83-20-38	11WAP57 (LEFT)	85R
9	PC HYDRAULIC PUMP SHAFT ENCASED SEAL	83-20-14	11SPF598 (LEFT)	85L
10	AMAD DRIVE PAD DRAIN LINE ADAPTER	83-20-28	11MPF579 (LEFT)	85L
11	AMAD DRIVE PAD DRAIN LINE	83-20-11	11UP239 (LEFT)	85R
12	AMAD OIL PUMP RELIEF VALVE	93-20-11	11UR529 (RIGHT)	85L
13	AMAD JET EJECTOR PUMP NOZZLE	83-20-31	11UR530 (LEFT)	85R
14	AMAD JET SCAVENGE PUMP NOZZLE	83-20-52	11WAP568 (RIGHT)	85L
15	AMAD OIL PUMP AND START CUTOFF SWITCH	83-20-53	11UR817 (LEFT)	85R
16	AMAD CASE DRAIN PLUG	03-20-13	11UR818 (RIGHT)	85L
17	AMAD PUMP VALVE ASSEMBLY	83-20-22	11UR815 (LEFT)	85R
18	AMAD PUMP CAVITATION VENTURI	83-20-36	11UR816 (RIGHT)	85L
19	CHIP DETECTOR	83-10-21	11UR566 (LEFT)	85R
20	AMAD HIGH OIL PRESSURE TEST PORT PLUG	83-10-47	11UR566 (LEFT)	85L
21	IDG DRIVE SHAFT SEAL	83-20-30	11UR566 (LEFT)	85R
22	AMAD RESERVOIR DRAIN PLUG	83-20-23	11UR566 (LEFT)	85L
23	MANUAL DECOUPLER HANDLE ASSEMBLY	83-20-15	11UR566 (LEFT)	85R
24	AMAD OIL FILTER DIFFERENTIAL PRESSURE INDICATOR	83-20-19	11UR566 (LEFT)	85L

Figure 5-1. AMAD System Component Locator (Sheet 1 of 4)

INDEX NO.	COMMON NAME	SS/ISN	REF DES	ACCESS
25	AMAD OIL FILTER ELEMENT	83-20-20	11FAP55 (LEFT)	85L
26	AMAD OIL LEVEL SIGHT GAGE	83-20-40	11FAP56 (RIGHT)	85R
27	OVERFLOW DRAIN VALVE	83-20-39	11UR560 (RIGHT)	85L
28	AMAD SIGHT GAGE ADAPTER	83-20-41	11WAP57 (LEFT)	85R
29	SIGHT GAGE ADAPTER FITTING	83-20-42	11UR807 (LEFT)	85L
30	AMAD LOW OIL PRESSURE TEST PORT PLUG	83-20-46	11UR808 (LEFT)	85R
31	AMAD FILL FITTING DISCONNECT CAP	83-20-44	11UR565 (LEFT)	85L
32	AMAD PRESSURE FILL FITTING	83-20-45	11UR566 (RIGHT)	85R
33	AMAD DRIVE PAD DRAIN LINE	83-20-11	11UR538 (RIGHT)	85L
34	PAWL CARRIER CARBON SEAL	83-20-17	11VAR571 (LEFT)	85R
35	AMAD PAWL CARRIER SEAL ROTOR	93-20-56	11UR638 (LEFT)	85L
36	PAWL CARRIER	83-20-16	11MPR649 (RIGHT)	85R
37	UTILITY HYDRAULIC PUMP DRIVESHAFT ENCASED SEAL	83-20-29	11MPR681 (LEFT)	85L
38	AMAD LAYSHAFT	83-20-24	11MPR682 (RIGHT)	85R
39	SECOND IDLER LUBRICATING NOZZLE	03-20-51	11MPR690 (RIGHT)	85L
40	AMAD OIL FILTER BYPASS VALVE	83-20-35	11MPR602 (RIGHT)	85R
41	AMAD LOWER MOUNT	83-20-12	11UR564 (LEFT)	85L
42	AMAD DRIVESHAFT COVER	83-10-11	11VAR551 (RIGHT)	85R
43	AMAD DRIVESHAFT	83-10-10	11MPR646 (RIGHT)	85L
44	AMAD DRIVESHAFT CARBON SEAL	83-10-55	11MPR630 (LEFT)	85R
45	AMAD DRIVESHAFT ENCASED SEAL	83-20-27	11MPR631 (RIGHT)	95R
46	AMAD DRIVESHAFT SCUPPER ASSEMBLY	83-20-12	11MPR635 (LEFT)	95L
47	AMAD DRIVESHAFT CARBON SEAL	83-20-26	11MPR641 (LEFT)	95L
48	AMAD BELLOW MOUNTED SEAL ROTOR	83-20-54	11MPR642 (RIGHT)	95L
49	AMAD SEAL ROTOR	83-20-25	11MPR643 (RIGHT)	95R
50	AMAD END COVER	83-20-18	11MPR644 (RIGHT)	85L
51	AMAD LAYSHAFT LUBE-JET	83-20-50	11MPR640 (LEFT)	85L
52	AMAD OIL PRESSURE REGULATOR VALVE	83-20-33	11UR603 (LEFT)	85R
53	AMAD GEARCASE PRESSURE CONTROL VALVE	83-20-34	11UR604 (RIGHT)	85R
54	AMAD VENT SCREEN	83-20-48	11VAR564 (RIGHT)	85L
55	AMAD UPPER MOUNT	83-20-12	11FAP613 (LEFT)	85R
			11FAP614 (RIGHT)	85L
			11MPR573 (LEFT)	85R
			11MPR574 (RIGHT)	85R

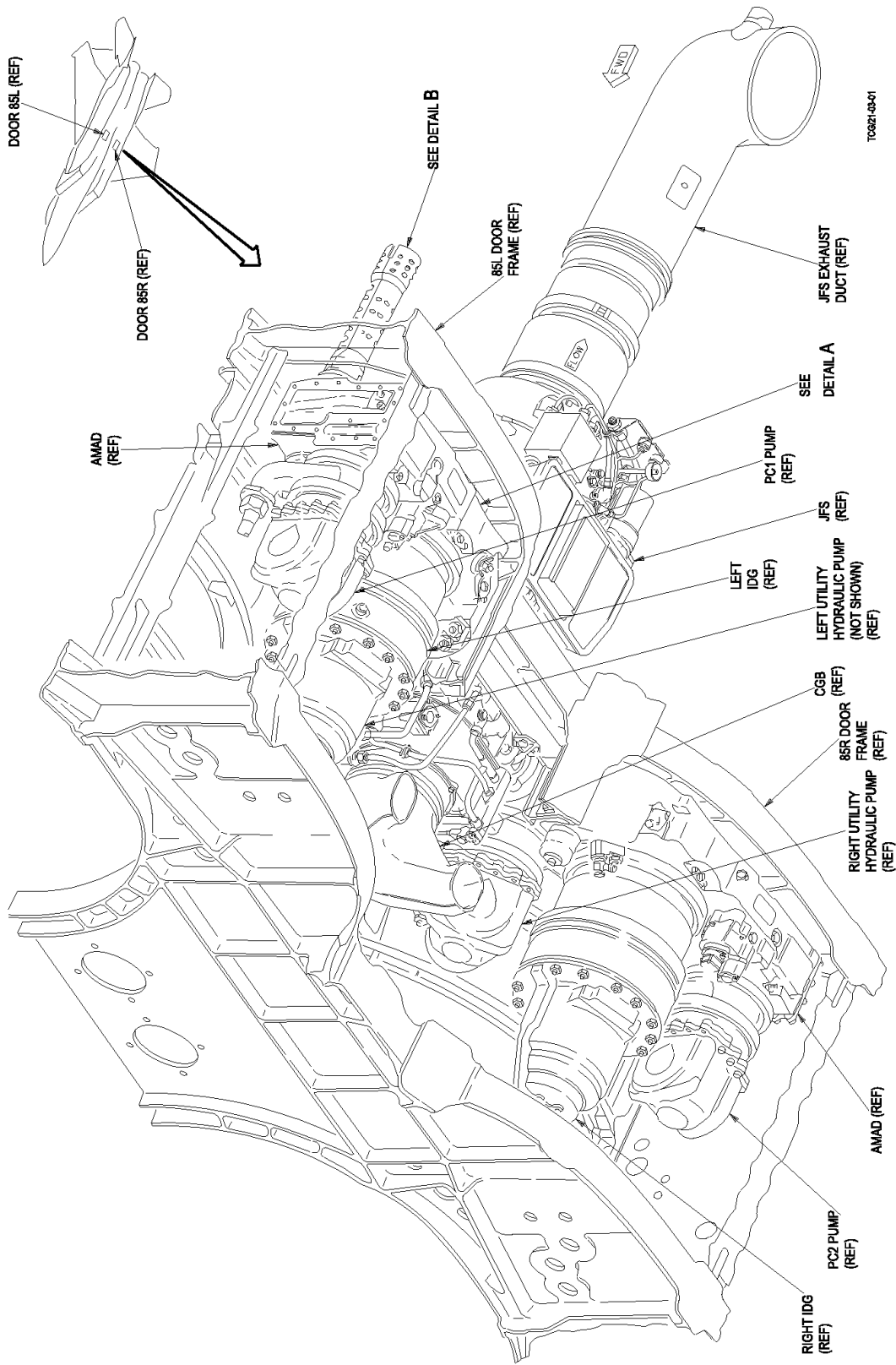
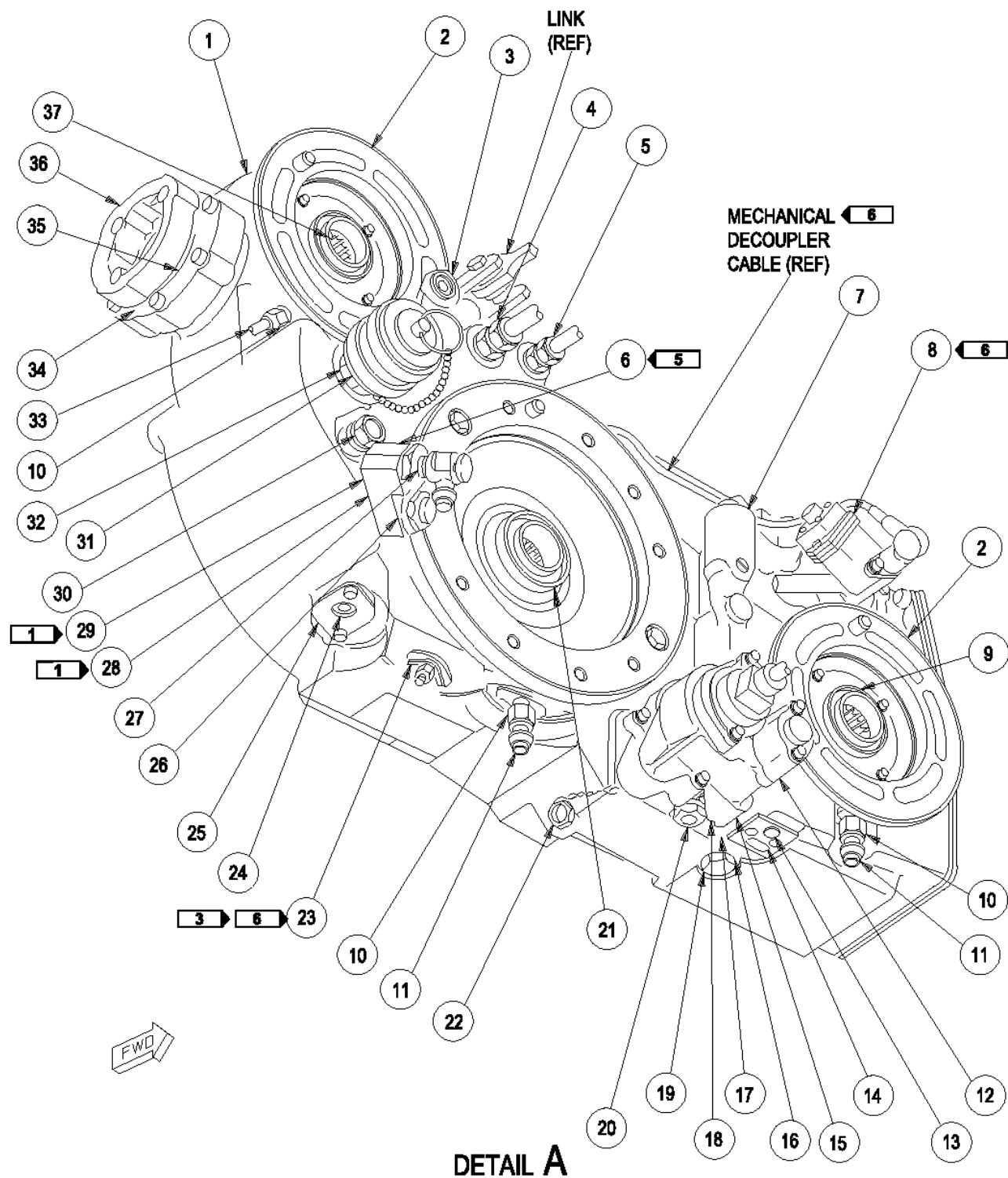


Figure 5-1. AMAD System Component Locator (Sheet 2)

83-00-00
5-10



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Figure 5-1. AMAD System Component Locator (Sheet 3)

83-00-00
5-11

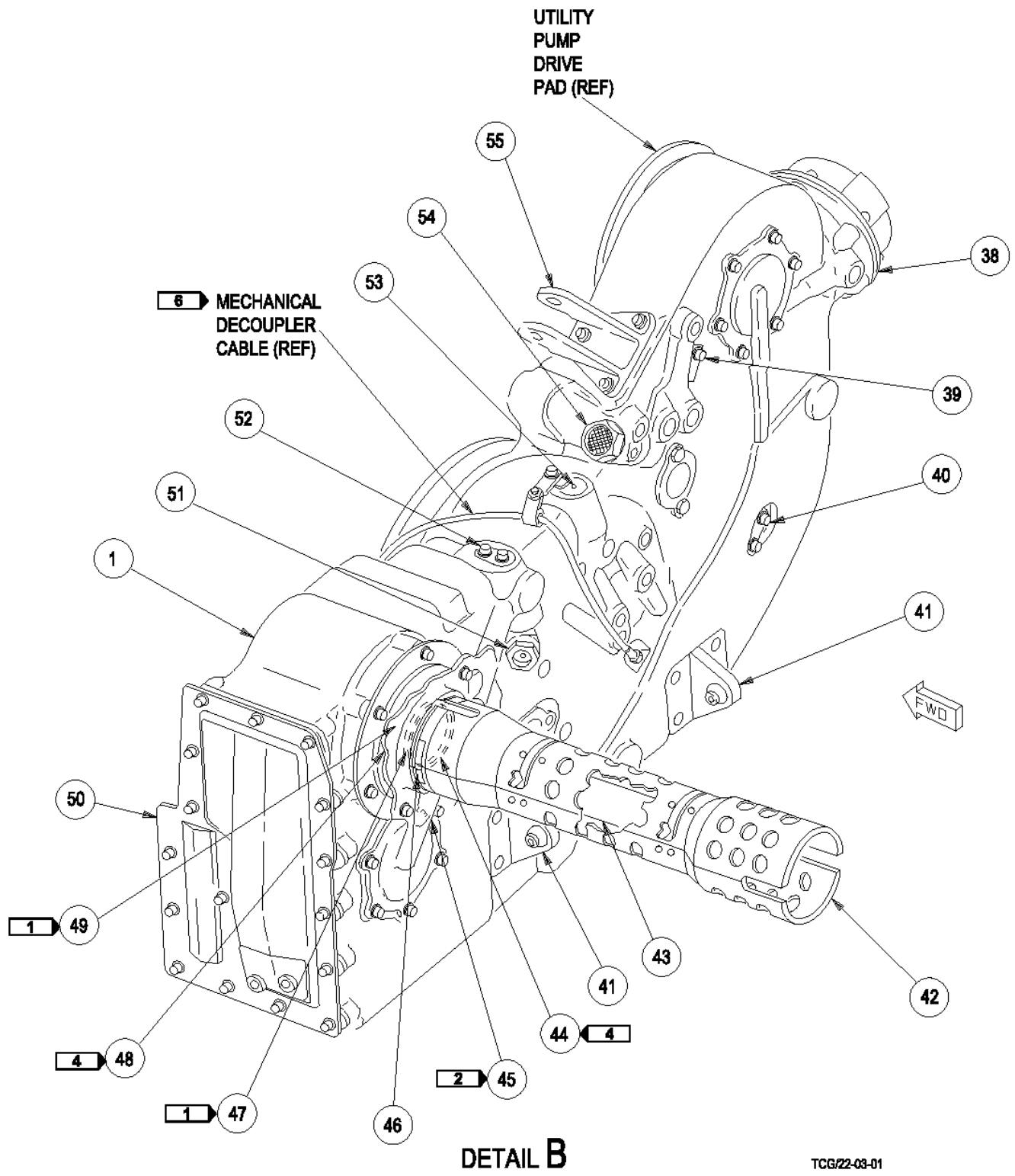


Figure 5-1. AMAD System Component Locator (Sheet 4)

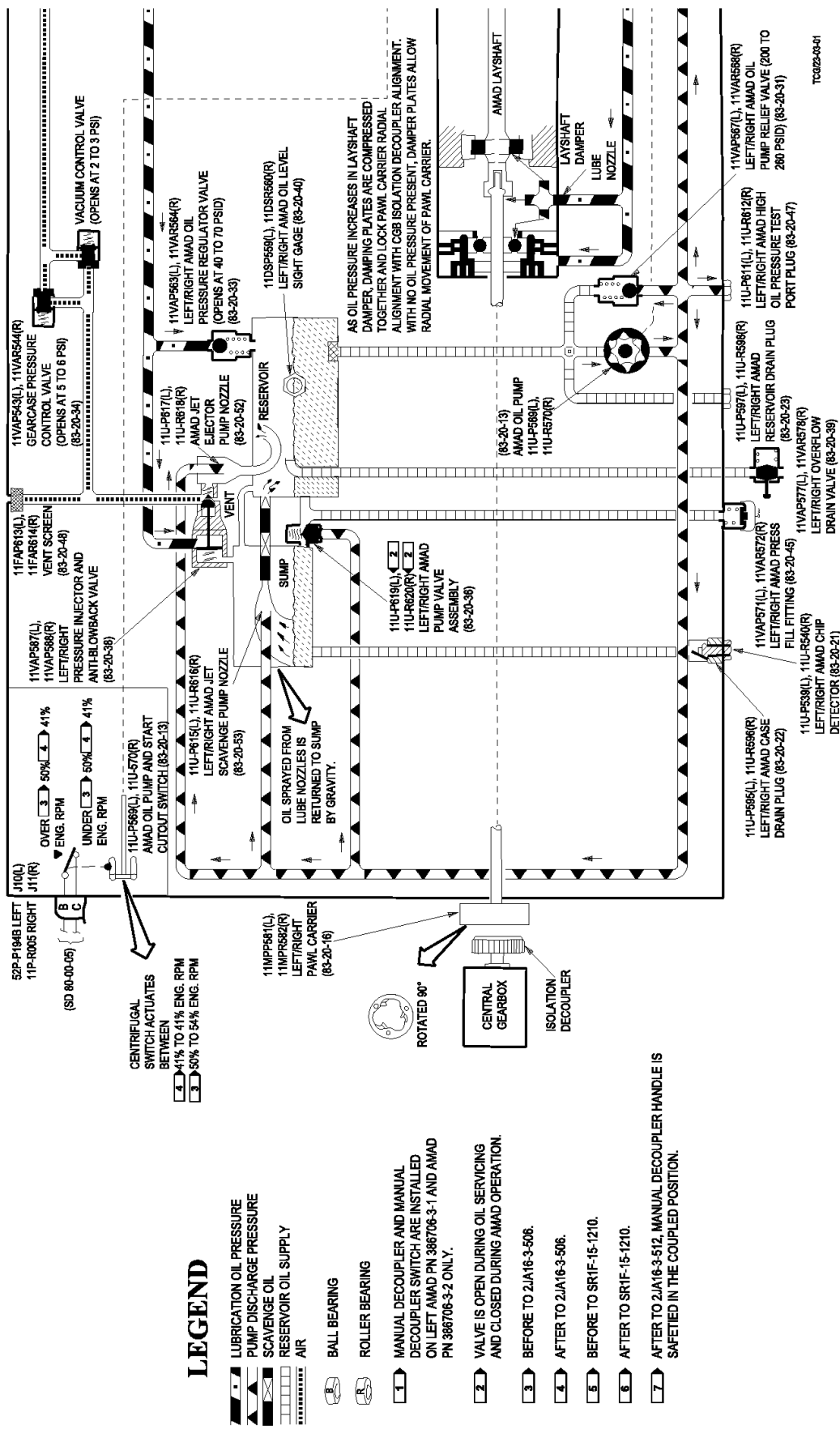


Figure 5-2. AMAD System Schematic (Sheet 1 of 2)

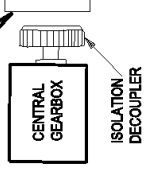
LEGEND

- LUBRICATION OIL PRESSURE
- PUMP DISCHARGE PRESSURE
- SCAVENGE OIL
- RESERVOIR OIL SUPPLY
- AIR

- BALL BEARING
- ROLLER BEARING

MANUAL DECOUPLER AND MANUAL DECOUPLER SWITCH ARE INSTALLED ON LEFT AMAD PN 386706-3-1 AND AMAD PN 386706-3-2 ONLY.

- VALVE IS OPEN DURING OIL SERVICING AND CLOSED DURING AMAD OPERATION.
- BEFORE TO 2JA16-3-506.
- AFTER TO 2JA16-3-506.
- BEFORE TO SR1F-15-1210.
- AFTER TO SR1F-15-1210.
- AFTER TO 2JA16-3-512, MANUAL DECOUPLER HANDLE IS SAFETIED IN THE COUPLED POSITION.



CENTRIFUGAL SWITCH ACTUATES BETWEEN
 41% TO 41% ENG. RPM
 30% TO 54% ENG. RPM

52P-P194B LEFT
11P-R005 RIGHT
 (SD 80-00-05) B C
 OVER 50% 41% ENG. RPM
 UNDER 50% 41% ENG. RPM

11U-P569(L), 11U-570(R) AMAD OIL PUMP AND START CUTOFF SWITCH (83-20-13)

11VAP587(L), 11VAR588(R) LEFT/RIGHT PRESSURE INJECTOR AND ANTI-BLOWBACK VALVE (83-20-38)

11FAP613(L), 11FAR614(R) VENT SCREEN (83-20-46)

11VAP543(L), 11VAR544(R) GEARCASE PRESSURE CONTROL VALVE (OPENS AT 5 TO 6 PSI) (83-20-54)

VACUUM CONTROL VALVE (OPENS AT 2 TO 3 PSI)

11U-P617(L), 11U-R618(R) AMAD JET EJECTOR PUMP NOZZLE (83-20-52)

11U-P619(L), 11U-R618(R) LEFT/RIGHT AMAD JET PUMP NOZZLE (83-20-53)

11U-P619(L), 11U-R618(R) LEFT/RIGHT AMAD JET PUMP VALVE ASSEMBLY (83-20-36)

11MP584(L), 11MP582(R) LEFT/RIGHT PAWL CARRIER (83-20-16)

RESERVOIR

SUMP

AS OIL PRESSURE INCREASES IN LAYSHAFT DAMPER, DAMPING PLATES ARE COMPRESSED TOGETHER AND LOCK PAWL CARRIER RADIAL ALIGNMENT WITH CGB ISOLATION DECOUPLER ALIGNMENT. WITH NO OIL PRESSURE PRESENT, DAMPER PLATES ALLOW RADIAL MOVEMENT OF PAWL CARRIER.

OIL SPRAYED FROM LUBE NOZZLES IS RETURNED TO SUMP BY GRAVITY.

11DPS568(L), 11DSR568(R) LEFT/RIGHT AMAD OIL LEVEL SIGHT GAUGE (83-20-40)

11U-P577(L), 11U-R578(R) AMAD OIL PUMP (83-20-13)

11U-P577(L), 11U-R578(R) LEFT/RIGHT AMAD RESERVOIR DRAIN PLUG (83-20-23)

11VAP577(L), 11VAR578(R) LEFT/RIGHT AMAD PRESSURE INJECTOR AND ANTI-BLOWBACK VALVE (83-20-38)

11U-P595(L), 11U-R596(R) LEFT/RIGHT AMAD CASE DRAIN PLUG (83-20-22)

11U-P589(L), 11U-R590(R) LEFT/RIGHT AMAD CHIP DETECTOR (83-20-39)

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5-26. SPECIAL MAINTENANCE REQUIREMENTS.

5-27. AIRFRAME MOUNTED ACCESSORY DRIVE SYSTEM PERTINENT DATA. Data pertinent to the operation and properties of the airframe mounted accessory drive system are found in table 5-2.

Table 5-2. Pertinent Data

AIRFRAME MOUNTED ACCESSORY DRIVE	
General	7 Left AMAD incorporates manual decoupler. Right AMAD does not.
AMAD Accessory Drive Pads	IDG Utility hydraulic pump PC hydraulic pump
Characteristics (Approximate)	
Dry Weight	
Left AMAD	62 pounds
Right AMAD	60 pounds
Length	24 inches
Width	6 inches
Height	10 inches
Isolation Decoupler	Pawl and ratchet clutch
Starter Cutout	1 50 to 54 2 41 to 43 percent engine rpm
PC Pad Drive Ratio	0.262 to 1.0
Utility Pump Pad Drive Ratio	0.292 to 1.0
IDG	
Drive Ratio	0.563 to 1.0
Direction of Rotation (looking at AMAD pad)	
PC Pad	cw
Utility Pump Pad	cw
IDG	cw
Engine Drive	cw
AMAD Driveshaft rpm	15,300 (maximum)
Compartment Temperature	
Operating	-65 to 250°F continuous 345°F (10 minutes) 420°F (1 minute)
Lubrication System	
Type	Self-contained
Lubricant	MIL-L-7808
Total System Capacity	3 Left AMAD 3221 cc (6.8 pts) dry 4 Left AMAD 3021 cc (6.4 pts) dry 5 Right AMAD 3513 cc (7.4 pts) dry 6 Right AMAD 3113 cc (6.6 pts) dry

Table 5-2. Pertinent Data (CONT)

AIRFRAME MOUNTED ACCESSORY DRIVE	
Pump Type Lube Pressure Case Pressure Control Pressure	Gerotor, 2.5 gpm 40 to 70 psi 4 to 8 psi 200 to 260 psi
Cooling	Fuel/oil heat exchanger
Overboard Drain and Leakage Limits Rotating Shaft Seal	5 Drops in 5 minutes
<ol style="list-style-type: none"> 1 ➤ BEFORE TO 2JA16-3-506 2 ➤ AFTER TO 2JA16-3-506 3 ➤ LEFT AMAD 386706-3-1. 4 ➤ LEFT AMAD 386706-3-2. 5 ➤ RIGHT AMAD 386704-3-1 AND 386704-3-2. 6 ➤ RIGHT AMAD 386704-3-3. 7 ➤ AFTER TO 2JA16-3-512, on AMAD 386706-3-1 or 386706-3-2, manual decoupler handle is safetied in the coupled position. 	

5-28. BULKHEAD FLANGE COVER PACKING REPAIR. See figure 5-3.

WARNING

5-29. INPUT CONDITIONS.

Cleaning compound may cause eye irritation. Avoid contact with skin or eyes. Wash thoroughly after handling.

5-30. Support Data:

- 83-10-11

c. Clean bulkhead flange cover (1) with cleaning compound.

5-31. Supplies (Consumables):

Compound, cleaning, SHOPMASTER LPH (0YG51)
Compound, rubber, RTV90 (01139)
Packing, MS9068-248
Primer, adhesive, SS4004 (01139)
Rubber, silicone, L24 (01139)

WARNING

Adhesive primer is flammable and toxic. Do not use near open flame or sparks. Avoid breathing vapors. Do not allow contact with skin or eyes. Use only in well ventilated areas.

5-32. Personal Safety Equipment:

- Gloves, protective
- Goggles, safety

d. Using brush, apply adhesive primer to bulkhead flange cover (1). See view A-A.

5-33. Procedure.

e. Allow primer to dry a minimum of 30 minutes.

a. Remove AMAD driveshaft cover (83-10-11).

WARNING

b. Remove packing (2) from bulkhead flange cover (1) and destroy.

Rubber compound and silicone rubber are toxic. Avoid breathing vapors. Avoid contact with skin or eyes. Use in a well ventilated area.

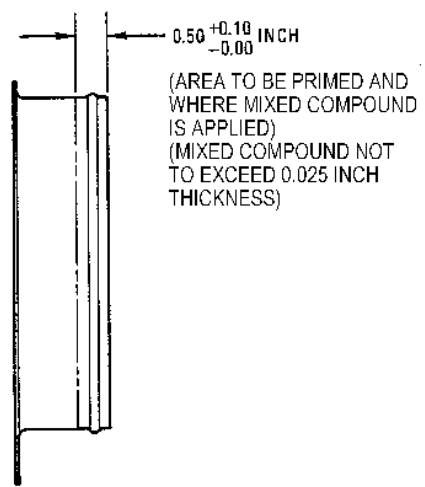
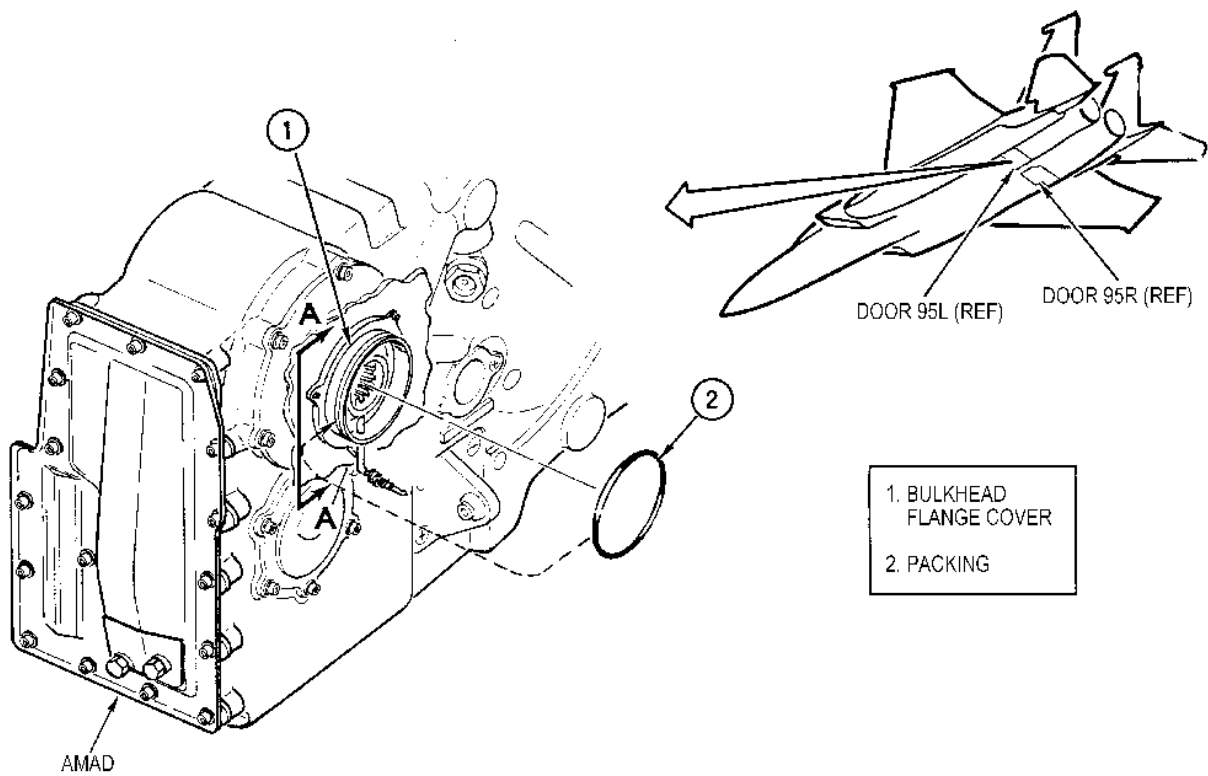
f. Mix rubber compound, in weight ratio of 1 percent silicone rubber catalyst to weight of base compound.

g. Using brush, apply compound into flange cover (1) groove. See view A-A.

h. Install new packing (2) in groove of flange cover (1).

i. Allow compound to dry a minimum of 8 hours.

j. Install AMAD driveshaft cover (83-10-11).



VIEW A-A

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Figure 5-3. Bulkhead Flange Cover Packing Repair

5-34. **AMAD OIL PUMP AND START CUTOUT SWITCH STUD REPAIR.** See figure 5-4.

5-35. **INPUT CONDITIONS.**

5-36. **Support Data:**

- 83-20-13

5-37. **Applicable Torque Values:**

- 25 to 30 inch-pounds

5-38. **Supplies (Consumables):**

Sealing Compound MILS22473 (81349)
Packing, S9413008

5-39. **Procedure.**

- Remove AMAD oil pump and start cutout switch (83-20-13).
- Remove stud (2) from AMAD.
- Remove packing (1) from stud (2).

NOTE

Stud provides one of three supports for an internal gear shroud. Shroud may have to be realigned in order to install stud.

d. Check alignment of shroud. If shroud is out of alignment, carefully insert hand in AMAD cavity and realign shroud.

e. Install packing (1) on stud (2).

WARNING

Lock compound is highly flammable and toxic. Do not use near open flame or sparks. Use only in well ventilated areas.

f. Using brush or swab, apply lock compound to stud (2) threads that interface gear shroud.

g. Install stud (2) and torque 25 to 30 inch-pounds.

h. Install AMAD oil pump and start cutout switch (83-20-13).

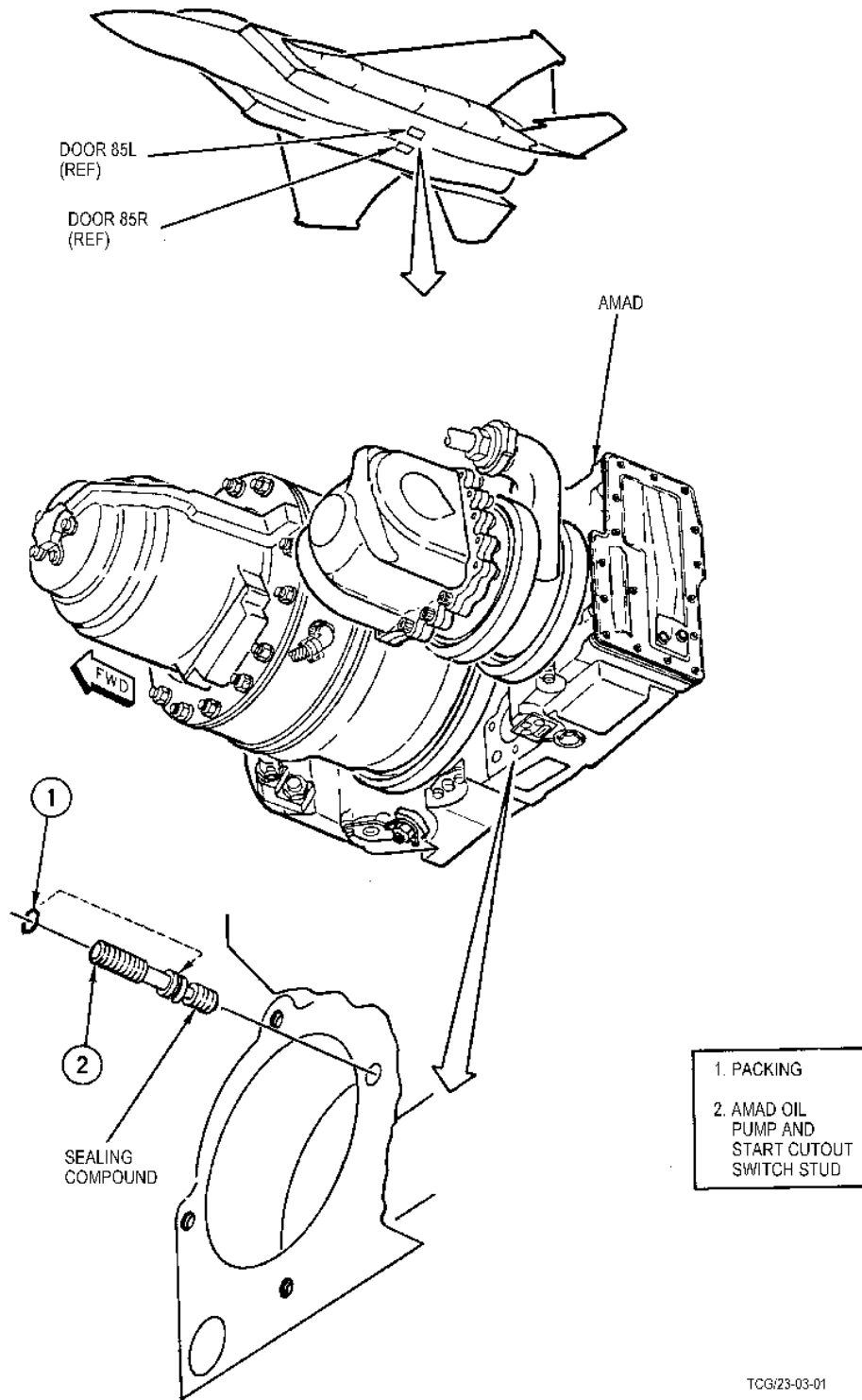


Figure 5-4. AMAD Oil Pump and Start Cutout Switch Stud Repair

5-40. UTILITY BEARING COVER PACKING REPAIR. See figure 5-5.

5-41. INPUT CONDITIONS.

5-42. Support Data:

- 83-20-10

5-43. Applicable Torque Values:

- 25 to 30 inch-pounds

5-44. Supplies (Consumables):

Lubricating oil, MIL-L-7808 (81349)
Methyl ethyl ketone, ASTM D 740 (81346)
Packing, S9413014
Packing, S9413143
Primer, epoxy, MIL-P-23377 (80244)

5-45. Personal Safety Equipment:

- Gloves, protective
- Goggles, safety

5-46. Procedure.

- Remove AMAD (83-20-10).
- Remove six bolts (3), washers (2) and utility bearing cover (1) from AMAD with packing (4).
- Remove packings (5 and 4) from utility bearing cover (1).
- Install protective covers on utility bearing cover and AMAD.

WARNING

Methyl ethyl ketone is flammable and toxic. Do not use near open flame or sparks. Avoid breathing vapors. Do not allow contact with skin or eyes. Use only in well ventilated area.

- Clean area around AMAD, utility bearing cover, bolts and washers with methyl-ethyl-ketone.

WARNING

Epoxy primer is highly flammable and toxic. Do not use near open flame or sparks. Use only in well ventilated areas.

- Prepare epoxy primer, by adding one volume of curing solution to one volume of base. Mix thoroughly.

- Lubricate packings (4 and 5) with lubricating oil and install on utility bearing cover (1).

CAUTION

To be sure of proper sealing, epoxy primer must not be applied to packing area.

- Using brush or swab, apply epoxy primer to chamfer and perimeter area of utility bearing cover. Do not apply to packing.

- Coat six bolts (3) and washers (2) completely with epoxy primer.

- Install utility bearing cover (1) with six bolts (3) and washers (2). Torque bolts 25 to 30 inch-pounds.

- Using brush or swab, apply epoxy primer to perimeter of cover and AMAD, 1/8 inch minimum on each side of parting line.

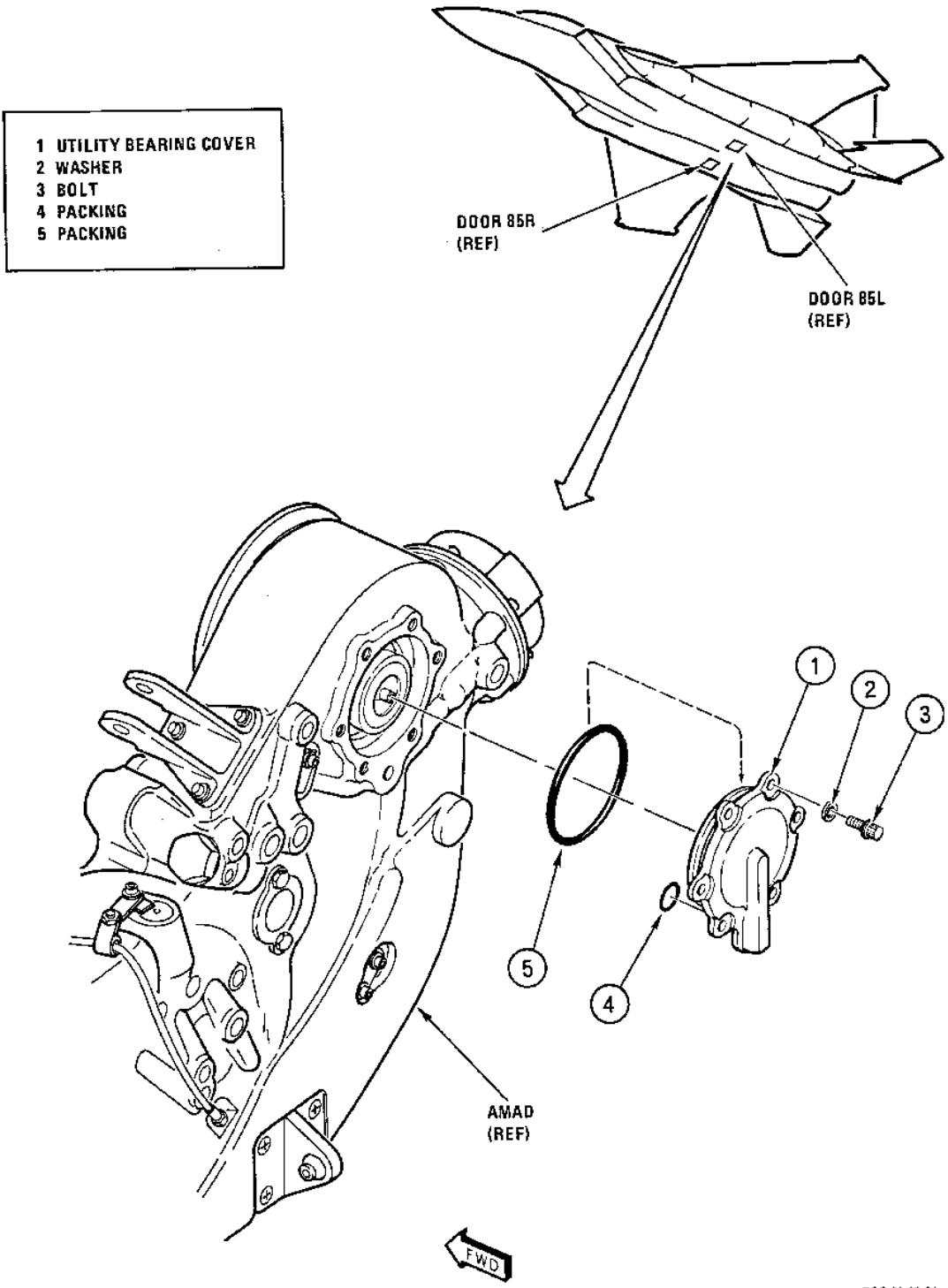
- Using brush or swab, apply epoxy primer 1/8 inch minimum around attaching bolt heads.

- Allow primer to air dry 15 minutes.

- Apply a second coat of epoxy primer to perimeter of cover and AMAD, 1/8 inch minimum on each side of parting line.

- Apply a second coat of epoxy primer 1/8 inch minimum around attaching bolt heads.

- Install AMAD (83-20-10).



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Figure 5-5. Utility Bearing Cover Packing Repair

5-47. **JFS INFLIGHT START CABLE INSTALLATION AND REMOVAL.** See figure 5-6.

5-48. **Input Conditions.**

5-49. **Applicability:** All

5-50. **Required Conditions:**

- Aircraft safe for maintenance (05-00-01)

5-51. **Installation.**

NOTE

Left AMAD oil pump start cutout switch shown, right AMAD oil pump start cutout switch similar.

a. If required, make JFS inflight start cable. See figure 5-6 sheet 1.

b. Open door 87L/R.

c. Disconnect electrical connector 52P-P194B (left AMAD oil pump start cutout switch) or 11P-R005 (right AMAD oil pump start cutout switch) from pump receptacle.

d. Connect JFS inflight start cable to pump receptacle J10 (left AMAD oil pump start cutout switch) or J11 (right AMAD oil pump start cutout switch).

e. Connect electrical connector to start cable.

f. Inspect area for foreign objects and close door 87L/R.

5-52. **Removal.**

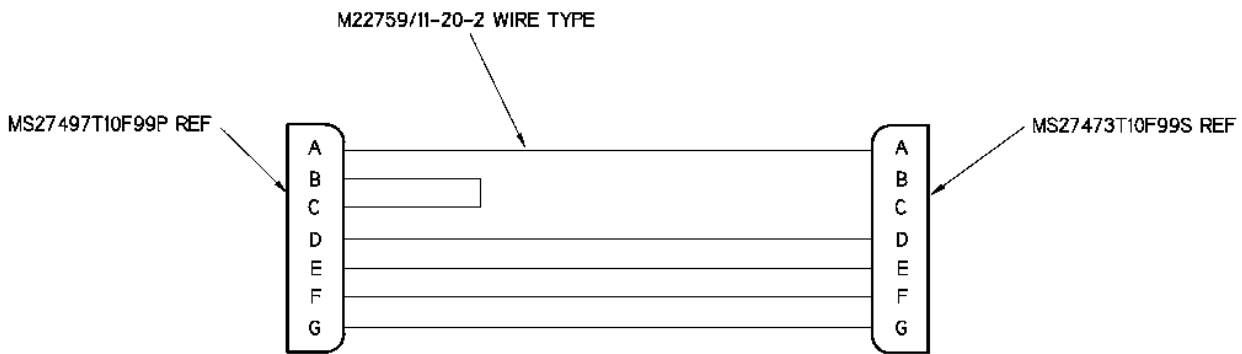
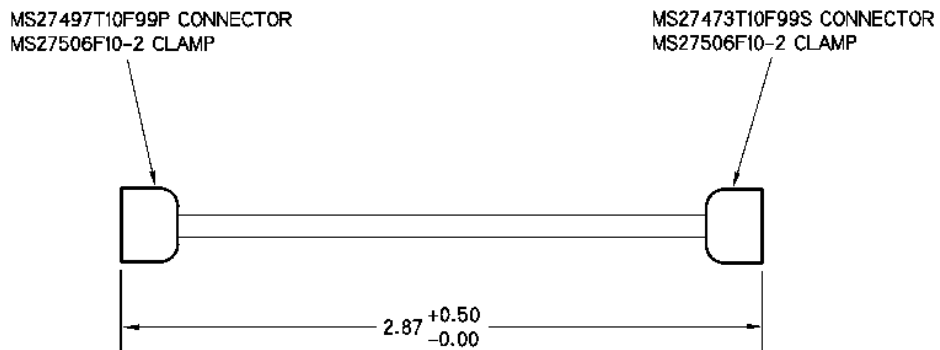
a. Open door 87L/R.

b. Disconnect JFS inflight start cable from pump receptacle J10 or J11.

c. Disconnect electrical connector from start cable.

d. Connect electrical connector 52P-P194B (left AMAD oil pump start cutout switch) to receptacle J10 or 11P-R005 (right AMAD oil pump start cutout switch) to receptacle J11.

e. Inspect area for foreign objects and close door 87L/R.



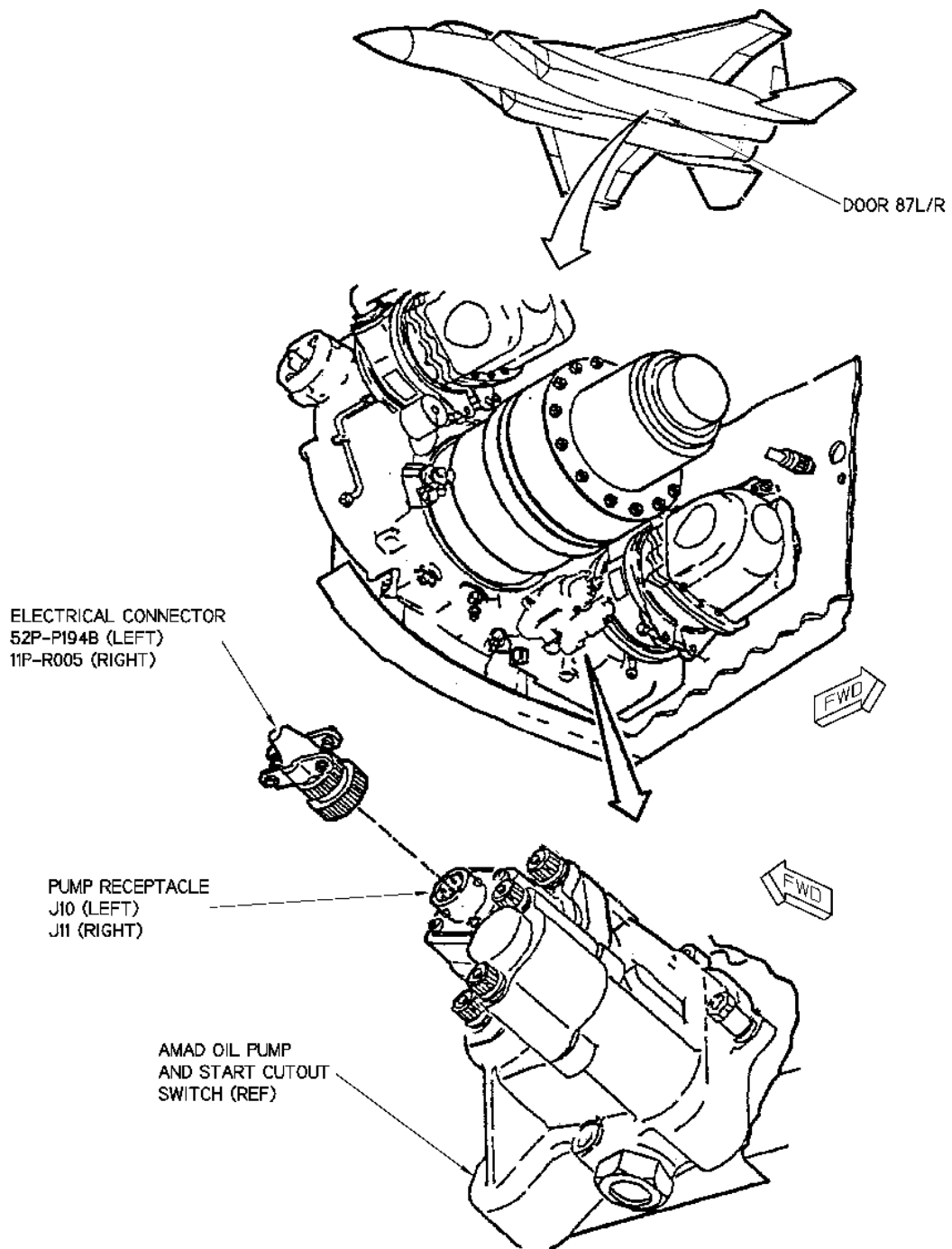
WIRING DIAGRAM

NOTES

1. USING MULTIMETER, TEST CABLE ASSEMBLY FOR CONTINUITY AND SHORT CIRCUITS BEFORE USE.
2. ANY OTHER COMMERCIAL PRODUCT MUST BE EQUAL TO AND INTERCHANGEABLE WITH PART NUMBER SHOWN.
3. FABRICATION OF CABLE ASSEMBLY SHALL BE PER TO SR1F-15C-2-00WD-20-1 AND TO I-1A-14.
4. ALL DIMENSIONS IN INCHES.

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Figure 5-6. JFS Inflight Start Cable (Sheet 1 of 2)



TCG23-03-01

Figure 5-6. JFS Inflight Start Cable (Sheet 2)

5-53. **CONSUMABLE MATERIALS LIST.**

5-54. **SUPPLIES (CONSUMABLES).** A list of supplies required to support the organizational maintenance of the airframe mounted accessory drive system is provided in table 5-3.

Table 5-3. Supplies (Consumables)

Nomenclature	Material	Part Number MFG Code
Adhesive		MMM-A-1617 TYPE 3 (81348)
Adhesive		MIL-A-46106 TYPE 1(81349)
Cleaning compound		SHOPMASTER LPH (0YG51)
Dry Cleaning Solvent		PD680 TYPE 2 (81348)
Gloves, protective		
Lockwire		MS20995NC32 (96906)
Lubricating Oil		MIL-L-7808 (81349)
Methyl Ethyl Ketone		ASTM D 740 (81346)
Packing		S9413-008 (99193)
Packing		S9413-009 (99193)
Packing		S9413-010 (99193)
Packing		S9413-011 (99193)
Packing		S9413-012 (99193)
Packing		S9413-013 (99193)
Packing		S9413-014 (99193)
Packing		S9413-016 (99193)
Packing		S9413-017 (99193)
Packing		S9413-020 (99193)
Packing		S9413-021 (99193)
Packing		S9413-022 (99193)
Packing		S9413-023 (99193)

Table 5-3. Supplies (Consumables) (CONT)

Nomenclature	Material	Part Number MFG Code
Packing		S9413-032 (99193)
Packing		S9413-036 (99193)
Packing		S9413-040 (99193)
Packing		S9413-118 (99193)
Packing		S9413-123 (99193)
Packing		S9413-124 (99193)
Packing		S9413-142 (99193)
Packing		S9413-151 (99193)
Packing		S9413-545 (99193)
Packing		S9413-552 (99193)
Packing		S9413-554 (99193)
Packing		S9413-555 (99193)
Packing		S9413-558 (99193)
Packing		Q4013-514AD
Packing		Q4018-514AD
Packing		MS299881908
Packing		MS9068-247
Packing		MS9068-248
Packing		M83248-1-022
Packing and Retainer		583-523-9002
Petrolatum, Tech		VVP236
Pin		MS24665-153
Primer, Epoxy		MIL-P-23377 TYPE 2 (80244)
Primer, bonding		SS4004

Table 5-3. Supplies (Consumables) (CONT)

Nomenclature	Material	Part Number CAGE
Rubber Compound		RTV90
Rubber, Silicone		L24
Seal		367032-1
Sealing Compound		MIL-S-22473 GRADE CV (81349)
Sealing Compound		MIL-S-84430 CLASS-1/2 (802044)

5-55. SUPPORT EQUIPMENT LIST.

Use and Application column indicate only one of the possible uses of this equipment.

5-56. TEST EQUIPMENT. Test equipment required for maintenance of the airframe mounted accessory drive system is listed in table 5-4. References in the

Table 5-4. Test Equipment List

Equipment Number	Nomenclature	Use and Application
AN/PSM-37 AN/PSM-6() alternate	Multimeter	Used to test manual decoupler switch rigging.
GG-G-531	Goggles, safety	Used for eye protection.

5-57. SPECIAL TOOLS. Special tools required for maintenance of the airframe mounted accessory drive system are listed in table 5-5. Special tools are shown in figure 5-7.

NOTE

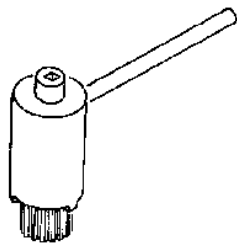
Contact WR-ALC/LFIT Robins AFB, GA 31098-1622 for information regarding modification of standard tools.

Table 5-5. Special Tools List

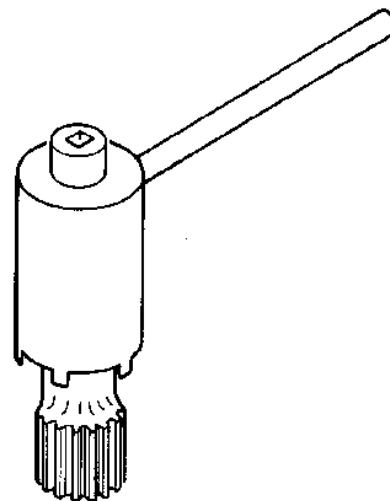
Tool Number	Nomenclature	Use and Application
287966-1	Adapter, Torque Wrench Spline	Used for AMAD driveshaft carbon seal removal and installation.
287966-2	Adapter, Torque Wrench Spline	Used for AMAD driveshaft carbon seal removal and installation.
287989-1	Pilot, Seal Installing	Used for IDG encased seal seal installation.
289639-2	Wrench, Holding, Shaft	Used for holding pawl carrier.

Table 5-5. Special Tools List (CONT)

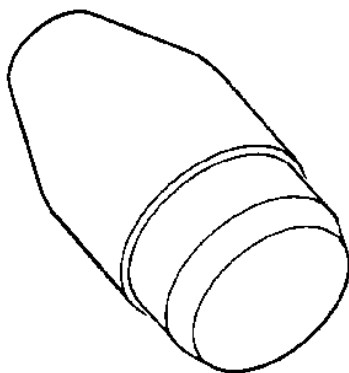
Tool Number	Nomenclature	Use and Application
291911-1	Puller, Mechanical Seal	Used for pawl carrier carbon seal removal.
1 291918-()	Wrench, Seal Installation and Removal	Used for AMAD driveshaft carbon seal removal and installation.
291919-1	Driver, Seal Installation and Removal	Used for AMAD carbon seal removal and installation.
291959-1	Wrench, Tang, Type Spanner	Used for AMAD sight gage adapter fitting removal and installation.
293043-1	Adapter, Torque Wrench	Used for AMAD sight gage adapter removal and installation.
293428-1	Fixture, Manual Decoupler Loading	Used for manual decoupler handle and assembly removal and installation.
293785-2	Driver Set, Seal, Installing and Removing	Used for AMAD seals removal and installation.
294547-1	Tool Set, Seal Rotor, Installation and Removal	Used for AMAD seal rotor removal and installation.
294557-1	Puller, Seal Rotor	Used for right AMAD carbon seal removal and installation.
296806-1	Puller Set, AMAD/CGB	Used for AMAD valves removal and installation.
GGGW641	Socket, Socket Wrench 5120001897921 Modified per V-134-1 drawing 030	Used for AMAD oil pump removal and installation
Locally Manufactured per TO SR1F-15C-3-2	Guide cap, bolt and pin, alignment	Used for AMAD installation.
1 291918-1NCM, 291918-1AM or 291918-1B.		



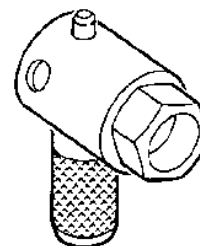
TORQUE WRENCH SPLINE ADAPTER
287966-1



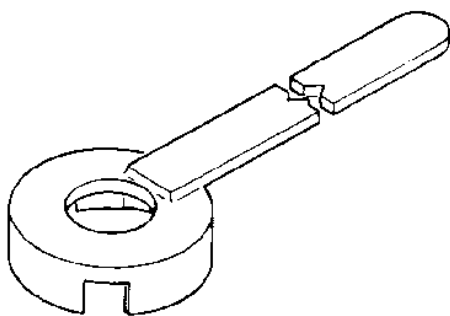
TORQUE WRENCH SPLINE ADAPTER
287966-2



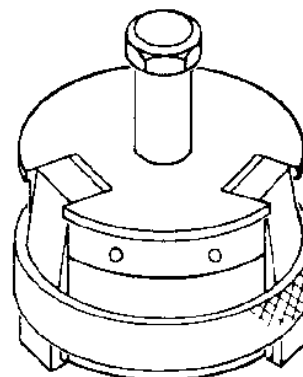
SEAL INSTALLING PILOT
287989-1



TORQUE WRENCH ADAPTER
298450-1



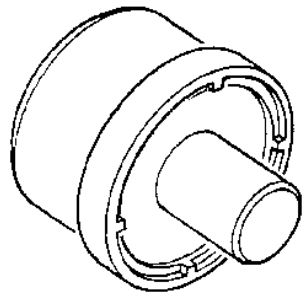
SHAFT HOLDING WRENCH
289639-2



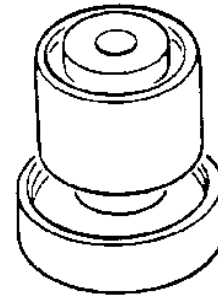
MECHANICAL SEAL PULLER
291911-1

1CG/26-03-01

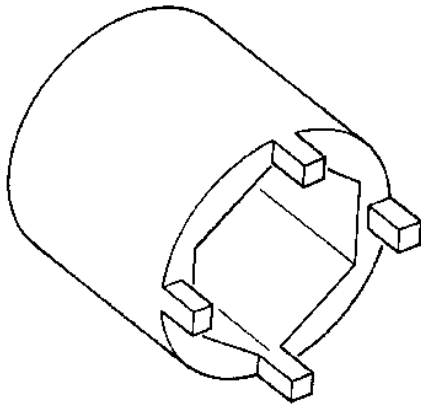
Figure 5-7. Special Tools (Sheet 1 of 3)



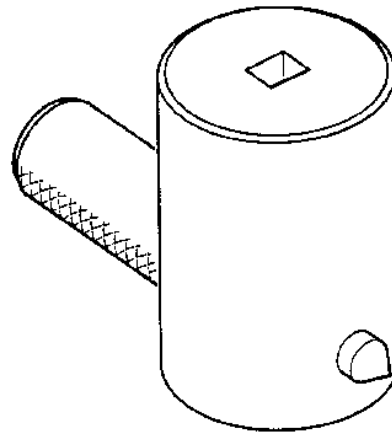
**SEAL INSTALLATION AND
REMOVAL WRENCH**
291918-1



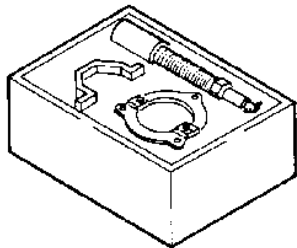
**SEAL INSTALLATION AND
REMOVAL DRIVER**
291919-1



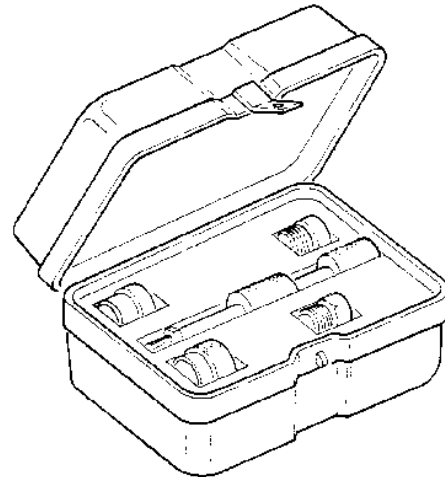
TANG TYPE SPANNER WRENCH
291959-1



TORQUE WRENCH ADAPTER
293043-1



MANUAL DECOUPLER LOADING FIXTURE
293428-1

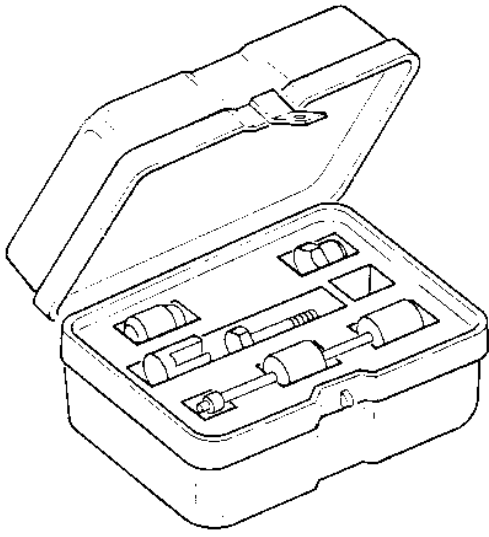


SEAL DRIVER SET INSTALLING AND REMOVING
293785-1

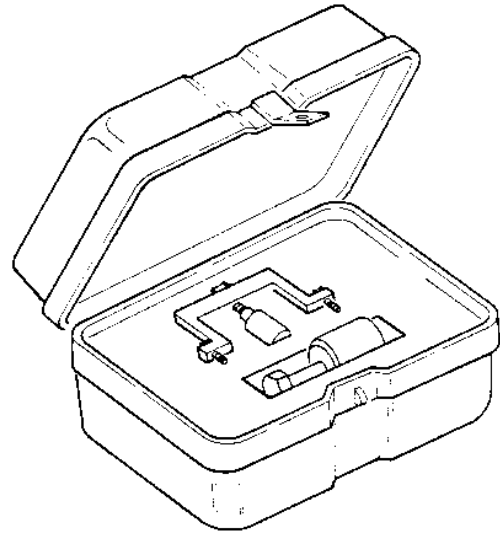
LEGEND
1 291918-1 NCM, 291918-1AM,
291918-1B.

TCE/76-03-01

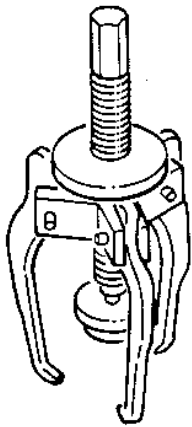
Figure 5-7. Special Tools (Sheet 2)



**SEAL DRIVER SET INSTALLING
AND REMOVING**
293785-2



**SEAL ROTOR INSTALLATION AND
REMOVAL TOOL SET**
294547-1



PULLER, SEAL ROTOR
294557-1



AMAD/CGB PULLER SET
296806-1

TCG/26-03-01

Figure 5-7. Special Tools (Sheet 3)