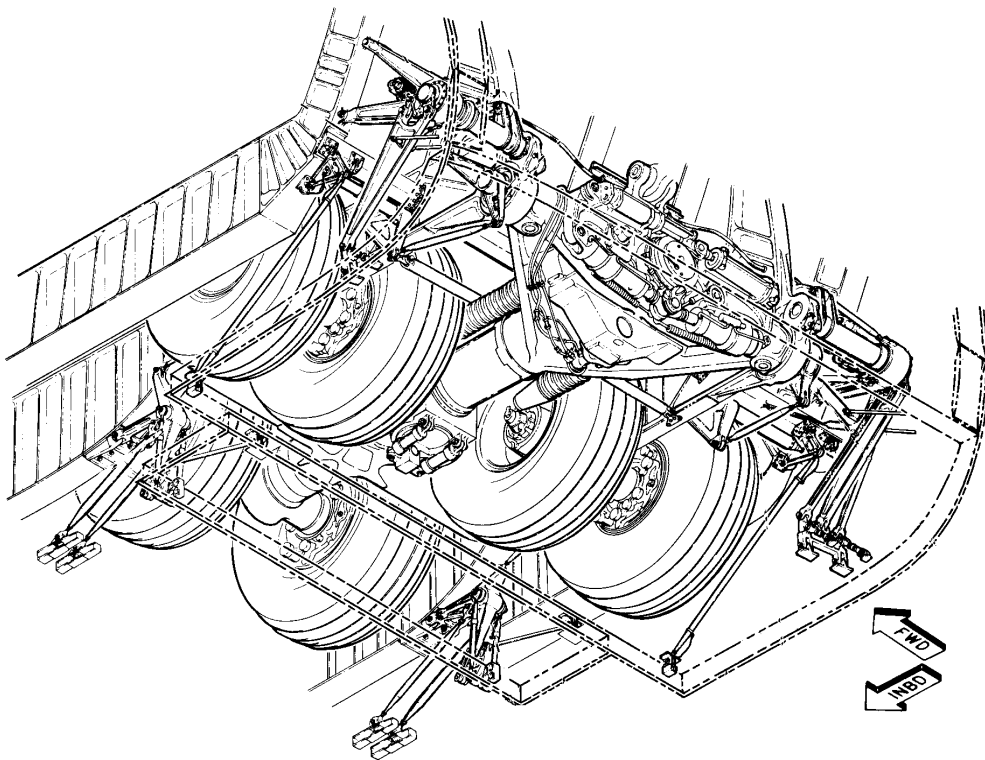


C-5 LANDING GEAR



Developed by
AIR FORCE ENGINEERING
and
TECHNICAL SERVICES
Dover AFB, Delaware

July 1997

PREFACE

This manual is designed to supplement classroom instruction. Text, diagrams, schematics, and illustrations were derived from the following sources:

LOCKHEED GEORGIA'S CUSTOMER TRAINING GUIDE	1984 EDITION
T.O. 1C-5A-2-10	CHG 28 JUL 92
T.O. 1C-5A-2-10FL-1-1	CHG 18 OCT 90
T.O. 1C-5A-2-10FL-1-2	CHG 27 APRIL 92

This manual is intended to be used as a *guide only*, and no part of this manual should be used as a technical manual.

NOTE TO THE READER

Every effort is made to keep this publication current and error free. Revisions, supplements, and corrections to this publication will be published when necessary. If you discover an error, it is essential that you let us know.

Please submit recommended changes to:

710 6th ST
Dover AFB DE, 19902-5710
ATTN: Mr. Joseph E. Sellars

Please include the following information with all suggestions:

- Date of Issue
- Page or figure number of suggested change(s)
- Suggested wording or figure
- List source(s) for your suggested change(s)
- Name, phone number, and return address

If you wish to converse with the authors the phone numbers are:

VOICE 302-677-2172 Mr. Sellars APG AFET

E-Mail Joseph.Sellars@dover.af.mil

VOICE 302-677-2171 Mr. Windsor Propulsion AFET

E-Mail Ronnie.Windsor@dover.af.mil

FAX 302-677-2173

DDN 445

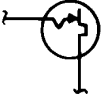

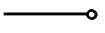
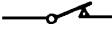
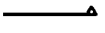
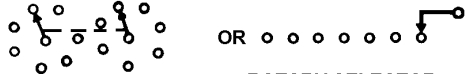



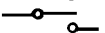

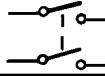

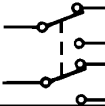
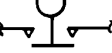
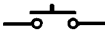
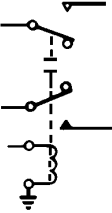


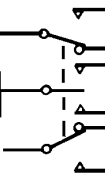
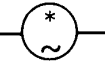
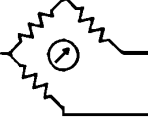
LANDING GEAR SYSTEMS
TABLE OF CONTENTS

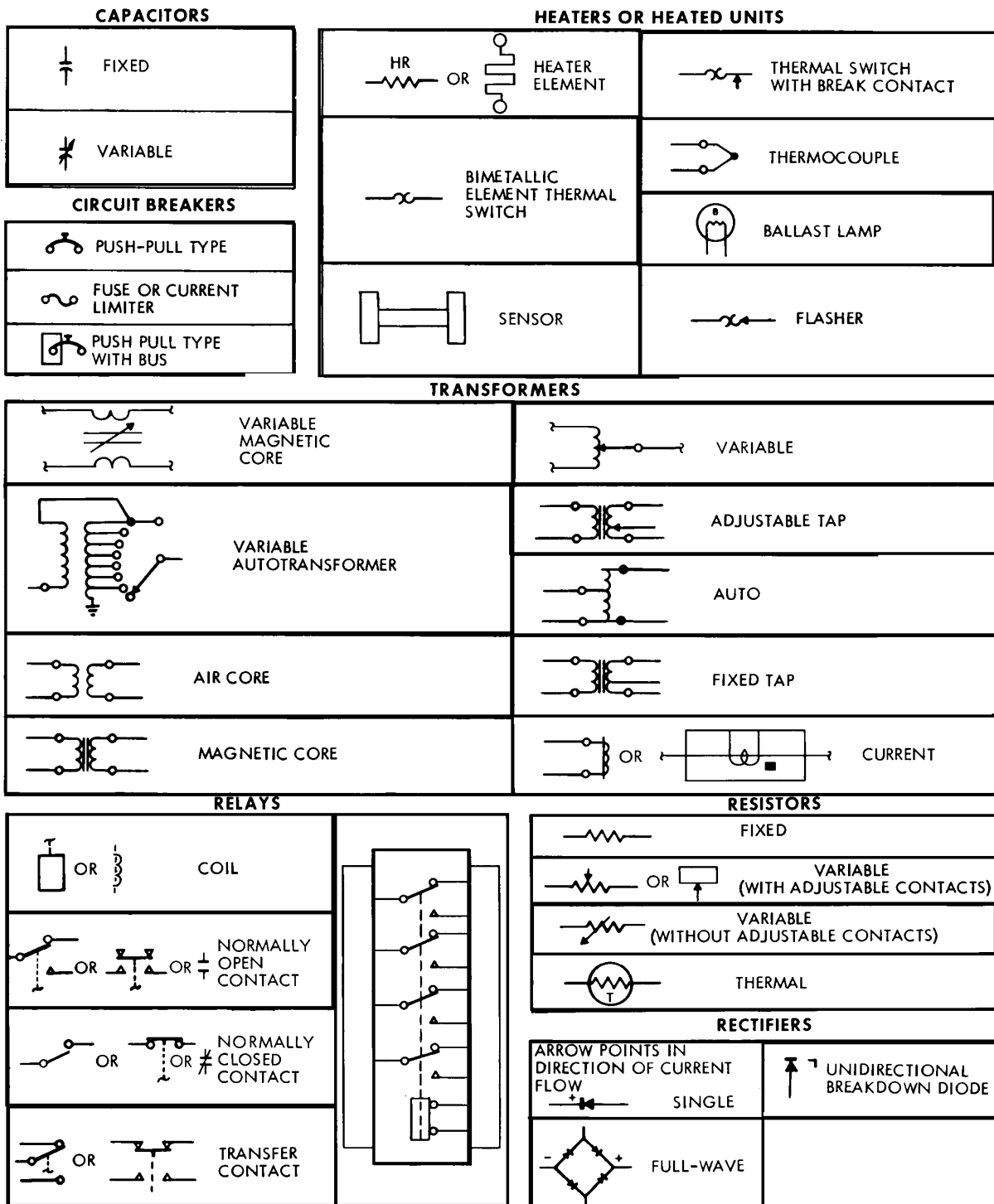
Landing Gear	1-1
General Information	1-1
MLG and Door Actuation	1-15
MLH Shock Strut	1-23
Proximity Switch System	1-37
MLG Sequence Control Panels Description	1-40
MLG Retraction and Extension	1-45
Operational Description of MLG Retraction and Extension	1-48
Nose Landing Gear (NLG) and Doors	2-1
NLG Mechanical Actuation	2-7
NLG Retraction and Extension	2-19
Operational Description of NLG Extension and Retraction	2-20
Position and Warning	2-30
Landing Gear Sequence Control Panel Lights	2-38
NLG Steering	3-1
Caster Powerback and Indication System	4-1
Kneeling System	5-1
Brake System	6-1
Anti-Skid System	6-5
Inflight Tire Deflation System	7-1

LANDING GEAR SYSTEMS
TABLE OF CONTENTS



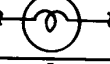


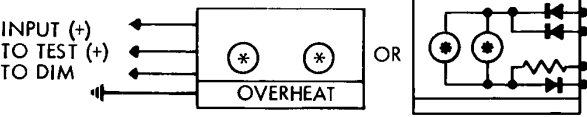
ELECTRICAL AND HYDRAULIC SCHEMATICS

Left Forward MLG Retraction Mode Electrical Schematic Diagram	F1
Left AFT MLG Retraction Mode Electrical Schematic Diagram.....	F2
Left Forward MLG Extension Mode Electrical Schematic Diagram	F3
Left AFT MLG Extension Mode Electrical Schematic Diagram	F4
Left Forward MLG Emergency Extension Mode Electrical Schematic Diagram	F5
Left AFT MLG Emergency Extension Mode Electrical Schematic Diagram	F6
Bogie Pitch Light Warning System Electrical Schematic Diagram	F7
Gear Handle Warning Light Electrical Schematic Diagram.....	F8
Landing Gear Warning Horn Electrical Schematic Diagram	F9
Aft MLG Retraction / Extension Hydraulic Schematic (Sheet 1 of 2).....	F10
Aft MLG Retraction / Extension Hydraulic Schematic (Sheet 2 of 2).....	F11
Nose Landing Gear Retraction Mode Electrical Schematic Diagram	F12
Nose Landing Gear Extension Mode Electrical Schematic Diagram.....	F13
Nose Landing Gear Emergency Extension Mode Electrical Schematic Diagram	F14
Nose Landing Gear System Hydraulic Schematic Diagram (Sheet 1 of 2)	F15
Nose Landing Gear System Hydraulic Schematic Diagram (Sheet 2 of 2)	F16
Brake and Skid Control Electrical (Sheet 1 of 2)	F17
Brake and Skid Control Electrical (Sheet 2 of 2)	F18
Wheel Anti-Rotation Electrical Schematic Diagram.....	F19
Brake and Skid Control Hydraulic Schematic Diagram (Sheet 1 of 3).....	F20
Brake and Skid Control Hydraulic Schematic Diagram (Sheet 2 of 3)	F21
Brake and Skid Control Hydraulic Schematic Diagram (Sheet 3 of 3)	F22
Caster / Power-back Electrical Schematic Diagram	F23
Caster / Power-back Electrical Schematic Diagram (Detail A)	F24
NLG Kneeling System Electrical Schematic Diagram	F25
MLG Kneeling System Electrical Schematic Diagram	F26
Kneeling System Indication Lights Electrical Schematic Diagram.....	F27
Rudder Pedal Disconnect Electrical Schematic Diagram.....	F28



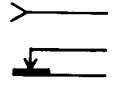




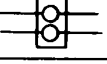

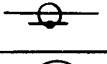

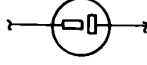

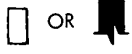

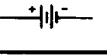








 <p>THERMAL SWITCH</p>	 <p>TOGGLE (MAKE)</p>
 <p>STEADY CONTACT</p>	 <p>TOGGLE (BREAK)</p>
 <p>MOMENTARY CONTACT</p>	 <p>OR </p> <p>ROTARY SELECTOR</p>
 <p>SINGEL POLE, SINGLE THROW</p>	 <p>SWITCH CAM</p>
 <p>SINGLE POLE, DOUBLE THROW</p>	 <p>SWITCH LOCK</p>
 <p>DOUBLE POLE, SINGLE THROW</p>	 <p>PRESSURE (LEGEND ON DIAGRAM INDIATES THE OPERATION OF SWITCH)</p>
 <p>DOUBLE POLE, DOUBLE THROW</p>	 <p>PULL MOMENTARY CONTACT</p>
 <p>PUSHBUTTON, MAKE</p>	 <p>MAGNETIC (ONE NORMALLY CLOSED CONTACT IS OPENED WHEN SWITCH IS MOVED FROM CENTER)</p>
 <p>PUSHBUTTON, BREAK</p>	
 <p>PUSHBUTTON, TWO-CIRCUIT</p>	
 <p>THREE POSITION ONE NORMALLY CLOSED CONTACT IS OPENED WHEN SWITCH IS MOVED FROM CENTER</p>	
METERS	
 <p>* INDICATES TYPE OF METER ~ INDICATES A-C METER</p> <p>A - AMMETER V - VOLTMETER W - WATTMETER VA - VOLT AMMETER CRO - OSCILLOSCOPE F - FREQUENCY METER</p>	 <p>TEMPERATURE INDICATOR</p> <p>SIGNAL</p>



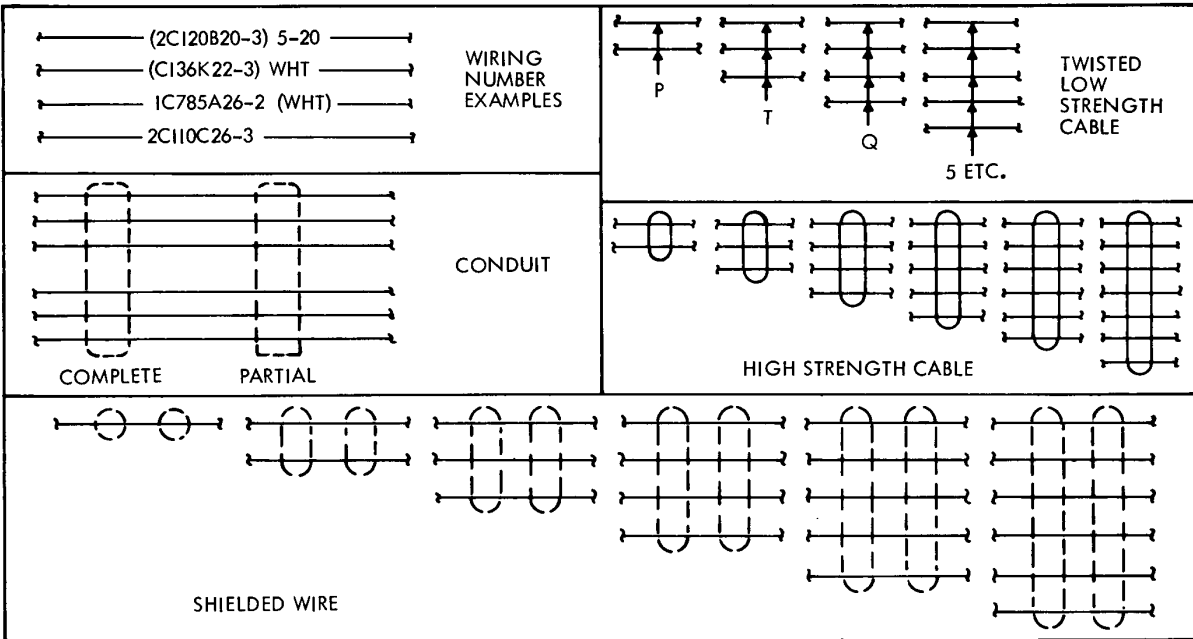
LAMPS (*INDICATES COLOR)

 <p>JEWELLED INDICATOR OR WARNING LIGHT</p> <p>COLORS</p> <table border="0"> <tr> <td>A</td><td>AMBER</td> <td>R</td><td>RED</td> </tr> <tr> <td>B</td><td>BLUE</td> <td>W</td><td>WHITE</td> </tr> <tr> <td>C</td><td>CLEAR</td> <td>Y</td><td>YELLOW</td> </tr> <tr> <td>G</td><td>GREEN</td> <td>O</td><td>ORANGE</td> </tr> <tr> <td>NE</td><td>NEON</td> <td>P</td><td>PURPLE</td> </tr> </table>	A	AMBER	R	RED	B	BLUE	W	WHITE	C	CLEAR	Y	YELLOW	G	GREEN	O	ORANGE	NE	NEON	P	PURPLE	 <p>NON-JEWELLED INDICATOR OR WARNING LIGHT OR ILLUMINATING LT</p>
A	AMBER	R	RED																		
B	BLUE	W	WHITE																		
C	CLEAR	Y	YELLOW																		
G	GREEN	O	ORANGE																		
NE	NEON	P	PURPLE																		
 <p>LIGHT BULB</p>	 <p>JEWELLED INDICATOR WITH PUSH TO TEST CIRCUIT</p>																				
 <p>LIGHT WITH CASE GROUND</p>	 <p>INPUT (+) TO TEST (+) TO DIM</p> <p>OVERHEAT</p>																				

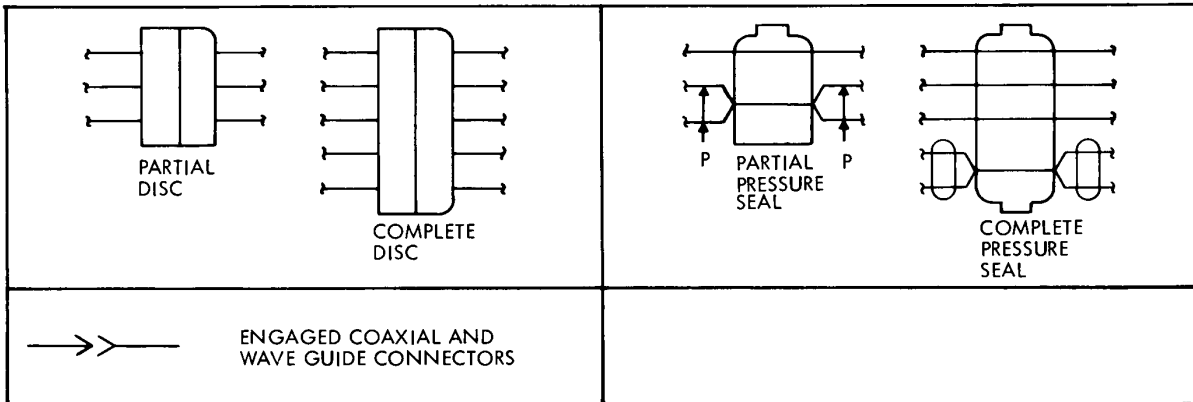
MISCELLANEOUS

 <p>END CAP</p>	 <p>PLUG, ADAPTER, PLUG</p>
 <p>OR QUICK-DISCONNECT OR DRAW-OUT CONNECTOR</p>	 <p>TRANSISTOR, TRIODE PNP TYPE</p>
 <p>WIRE CROSSING</p>	 <p>TRANSISTOR, TRIODE NPN TYPE</p>
 <p>WIRE JUNCTION (SPLICE)</p>	 <p>TERMINAL BLOCK</p>
 <p>GROUND</p>	 <p>COAXIAL CABLE WITH SHIELD GROUND</p>
 <p>HORN</p>	 <p>SERVICE OUTLETS RECEPTACLE</p>
 <p>LOOP ANTENNA</p>	 <p>OR BUS</p>
 <p>SPEED REGULATOR GOVERNOR</p>	 <p>BATTERY</p>
 <p>INDUCTANCE OR COIL</p>	 <p>PHOTOTUBE</p>
 <p>MECHANICAL LINKAGE</p>	 <p>AMPLIFIER</p>
 <p>ANTENNA, GENERAL</p>	 <p>OHM</p>
 <p>GROUND, CHASSIS OR FRAME CONNECTION - MAY BE AT SUBSTANTIAL POTENTIAL WITH RESPECT TO AIRCRAFT STRUCTURE</p>	 <p>HERTZ</p> <p>\emptyset PHASE</p> <p>$>$ GREATER THAN</p> <p>$<$ LESS THAN</p>

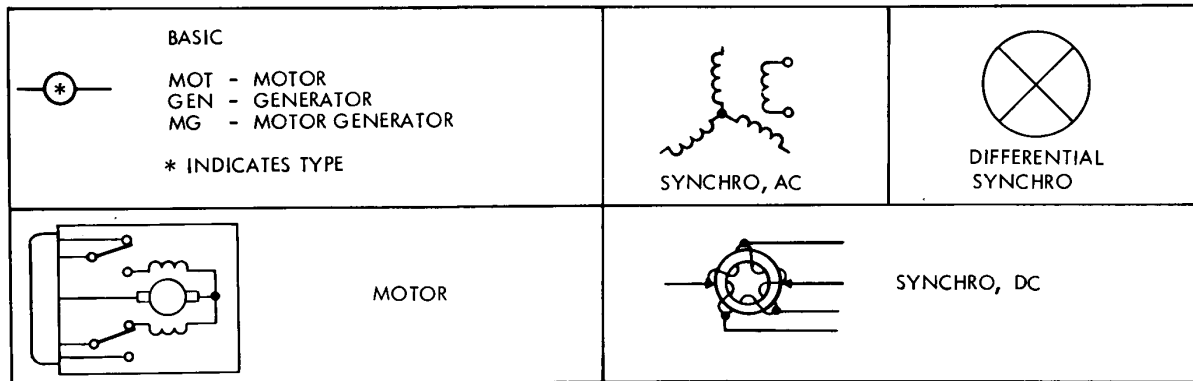
MISCELLANEOUS







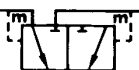
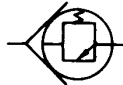
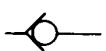
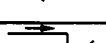
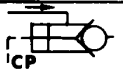
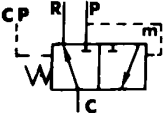
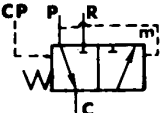
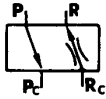
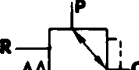
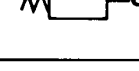

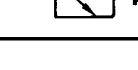
CONNECTION, MECHANICAL



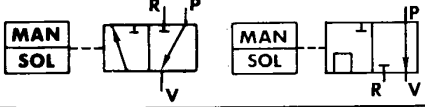
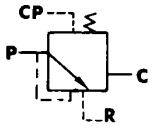
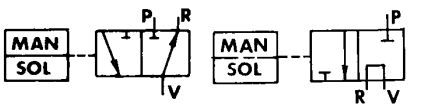
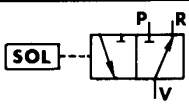
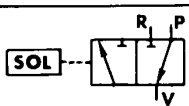
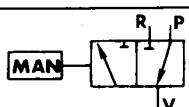
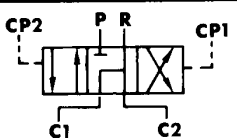
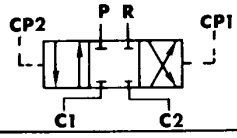
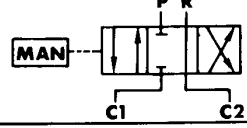
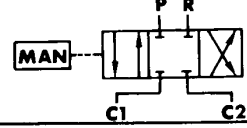
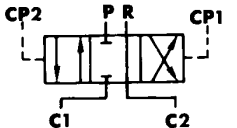
ROTARY EQUIPMENT



HYDRAULIC CARTRIDGES

	FRT TWO-WAY FLOW REGULATING HYDRAULIC VALVE CARTRIDGE	L - LIMITED FLOW
	FRF ONE-WAY FLOW REGULATING HYDRAULIC VALVE CARTRIDGE	
	RVF ONE-WAY RESTRICTOR HYDRAULIC VALVE CARTRIDGE	O - ORIFICE FLOW
	RVT TWO-WAY RESTRICTOR HYDRAULIC VALVE CARTRIDGE	
	SVA SHUTTLE VALVE HYDRAULIC CARTRIDGE	m - INTERNAL PASSAGE
	CVL RELIEF CHECK HYDRAULIC VALVE CARTRIDGE (LOW PRESSURE CRACKING)	
	CVA CHECK HYDRAULIC VALVE CARTRIDGE (2-8 PSIG CRACKING PRESSURE)	
	CVH CHECK HYDRAULIC VALVE CARTRIDGE (HIGH PRESSURE CRACKING)	
	CVP PRESSURE OPERATED CHECK HYDRAULIC VALVE CARTRIDGE	
	TWC THREE-WAY NORMALLY CLOSED DIRECTIONAL CONTROL HYDRAULIC VALVE CARTRIDGE, PILOT OPERATED	CP - CONTROL PRESSURE P - SUPPLY PRESSURE C - CYLINDER PORT R - RETURN PRESSURE
	TWO THREE-WAY NORMALLY OPEN DIRECTIONAL CONTROL HYDRAULIC VALVE CARTRIDGE, PILOT OPERATED	
	FRA ONE-WAY LIMITING DUAL PATH FLOW REGULATING HYDRAULIC VALVE CARTRIDGE	P_c - CONTROL SUPPLY PRESSURE R_c - CONTROL RETURN PRESSURE
	PDA PRESSURE REDUCER HYDRAULIC VALVE CARTRIDGE (100 - 850 PSI)	
	PDC PRESSURE REDUCER HYDRAULIC VALVE CARTRIDGE (850 - 2,600 PSI)	
	PRA PRESSURE RELIEF HYDRAULIC VALVE CARTRIDGE (HIGH PRESSURE)	
	PRL PRESSURE RELIEF HYDRAULIC VALVE CARTRIDGE (LOW PRESSURE)	

HYDRAULIC CARTRIDGES

	<p>PVA NORMALLY OPEN SOLENOID AND MANUALLY OPERATED TRAIL CENTER PILOT HYDRAULIC VALVE CARTRIDGE</p>
	<p>SOP NORMALLY CLOSED PRESSURE OPERATED SHUTOFF HYDRAULIC VALVE CARTRIDGE</p>
	<p>PVC THREE-WAY NORMALLY CLOSED SOLENOID AND MANUALLY OPERATED PILOT HYDRAULIC VALVE CARTRIDGE</p>
	<p>PVD THREE-WAY NORMALLY CLOSED SOLENOID OPERATED PILOT HYDRAULIC VALVE CARTRIDGE</p>
	<p>PVE THREE-WAY NORMALLY OPEN SOLENOID OPERATED PILOT HYDRAULIC VALVE CARTRIDGE</p>
	<p>PVH THREE-WAY NORMALLY OPEN MANUALLY OPERATED PILOT HYDRAULIC VALVE CARTRIDGE</p>
	<p>DCO FOUR-WAY THREE-POSITION TRAIL CENTER DIRECTIONAL CONTROL HYDRAULIC VALVE CARTRIDGE, PILOT OPERATED</p>
	<p>DCC FOUR-WAY THREE-POSITION DIRECTIONAL CONTROL HYDRAULIC VALVE CARTRIDGE, PILOT OPERATED</p>
	<p>DCD FOUR-WAY THREE-POSITION MANUALLY OPERATED DIRECTIONAL CONTROL HYDRAULIC VALVE CARTRIDGE</p>
	<p>DCA FOUR-WAY THREE-POSITION MANUALLY OPERATED DIRECTIONAL CONTROL HYDRAULIC VALVE CARTRIDGE</p>
	<p>DCB FOUR-WAY DIRECTIONAL CONTROL HYDRAULIC VALVE CARTRIDGE, PILOT OPERATED</p>

HYDRAULIC CARTRIDGES

	<p>DCM FOUR-WAY TRAIL CENTER MANUALLY OPERATED DIRECTIONAL CONTROL HYDRAULIC VALVE CARTRIDGE</p>
	<p>DCF FOUR-WAY THREE-POSITION ONE-HALF NORMALLY OPEN HYDRAULIC VALVE CARTRIDGE, PILOT OPERATED</p>
	<p>DCE FOUR-WAY THREE-POSITION TRAIL CENTER DIRECTIONAL CONTROL HYDRAULIC VALVE CARTRIDGE, PILOT OPERATED (DETENTED)</p>

VALVES

<p>PRIORITY VALVE</p>	<p>SHUT OFF MANUAL VALVE</p>	<p>LINE MOUNTED CHECK VALVE</p>
<p>ACCUMULATOR AIR VALVE</p>	<p>SNUBBER VALVE</p>	<p>RELIEF VALVE</p>
<p>MOTORIZED VALVE</p>	<p>TWO POSITION FOUR-WAY LINE MOUNTED PILOT OPERATED SELECTION VALVE</p>	
<p>BY-PASS VALVE</p>	<p>SNUBBER MECHANICALLY OPERATED</p>	<p>BALANCED RELIEF VALVE</p>
<p>TWO POSITION LINE MOUNTED MANUALLY OPERATED SHUT-OFF VALVE</p>		

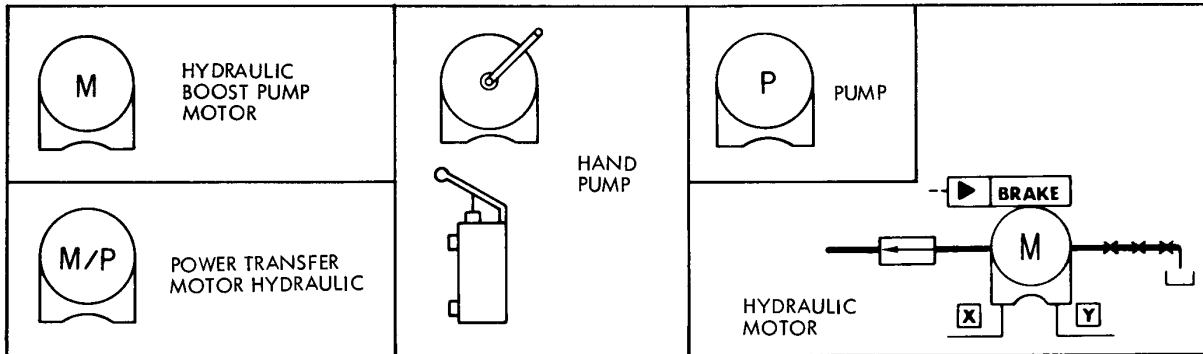
SWITCHES

<p>PRESSURE TRANSMITTER</p>	<p>PRESSURE SWITCH</p>	<p>MECHANICALLY OPERATED SWITCH</p>
<p>TEMPERATURE TRANSMITTER</p>	<p>PRESSURE SWITCH</p>	<p>LIQUID LEVEL TRANSMITTER</p>

CYLINDERS

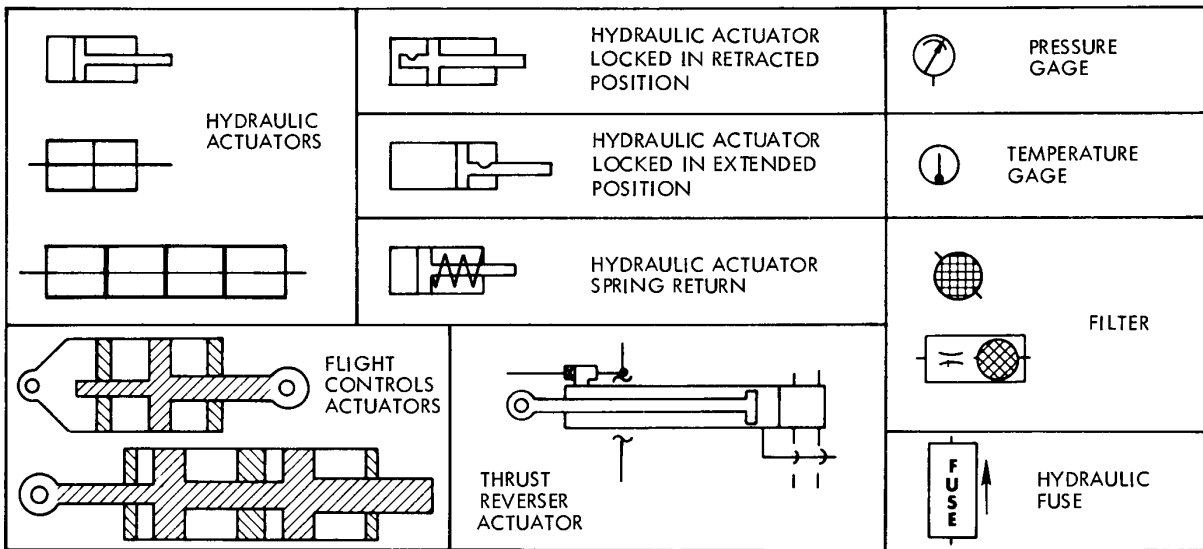
<p>ACCUMULATOR</p>	<p>AIR BOTTLE</p>
	<p>RESERVOIR</p>

MOTORS AND PUMPS

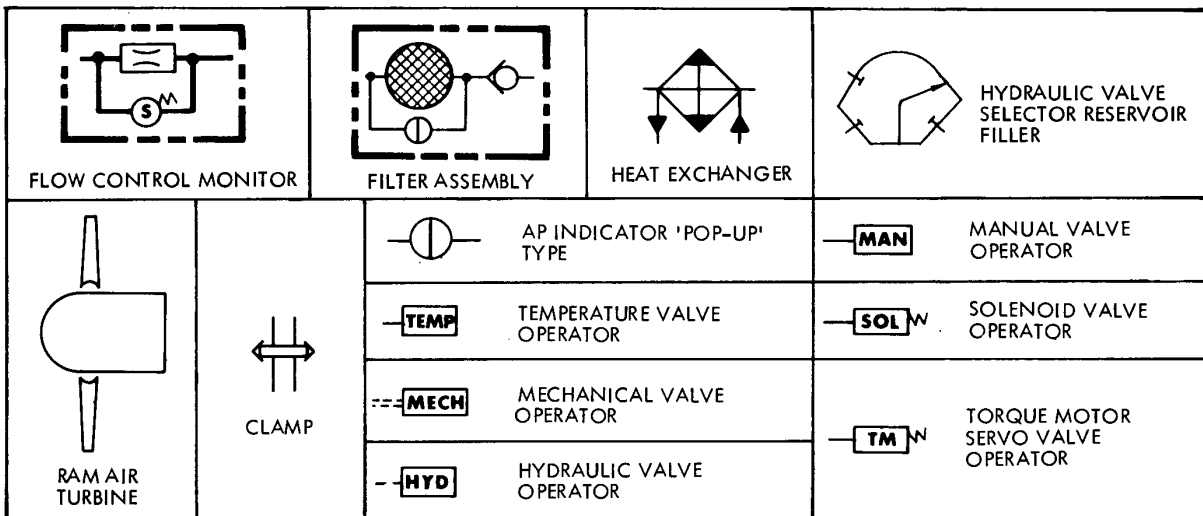


ACTUATORS

MISCELLANEOUS



MISCELLANEOUS



GENERAL INFORMATION

The C-5 aircraft is equipped with a tricycle-type, fully retractable landing gear. The main landing gear (MLG) consists of four separate shock struts and bogie assemblies, each with six wheel-and-brake assemblies. The four MLG assemblies are mounted in a dual tandem arrangement on each side of the fuselage. The NLG consists of a single, steerable shock strut and integral axle beam assembly with four wheel-and-tire assemblies, mounted on the centerline of the aircraft. The MLG and NLG door systems completely enclose their respective wheel wells after gear retraction.

Gear retraction, extension, and door operations, are accomplished by a hydraulically powered mechanical actuation system. Emergency gear and door extension is accomplished by electric motors that connect with the mechanical actuation system.

The caster/powerback system permits free castering of the aft main landing gears for ground maneuvering, towing, and taxiing operations. The system also provides a power-back (drive-back) mode of bringing the gears back to a straight ahead centered position.

Each MLG is fitted with six hydraulically actuated, multi-disc brake assemblies. The brakes are manually controlled by metering hydraulic pressure from the pilot brake control valves. An electrically controlled anti-skid system senses and monitors braking action for maximum efficiency.

The landing gear system includes three kneeling modes that will accommodate various types of cargo loading operations. The three kneeling modes are:

- Level kneeling
- Forward kneeling (nose down)
- Aft kneeling (tail down)

An electrically powered indicating and warning system provides the flight crew with all necessary gear and door position indications.

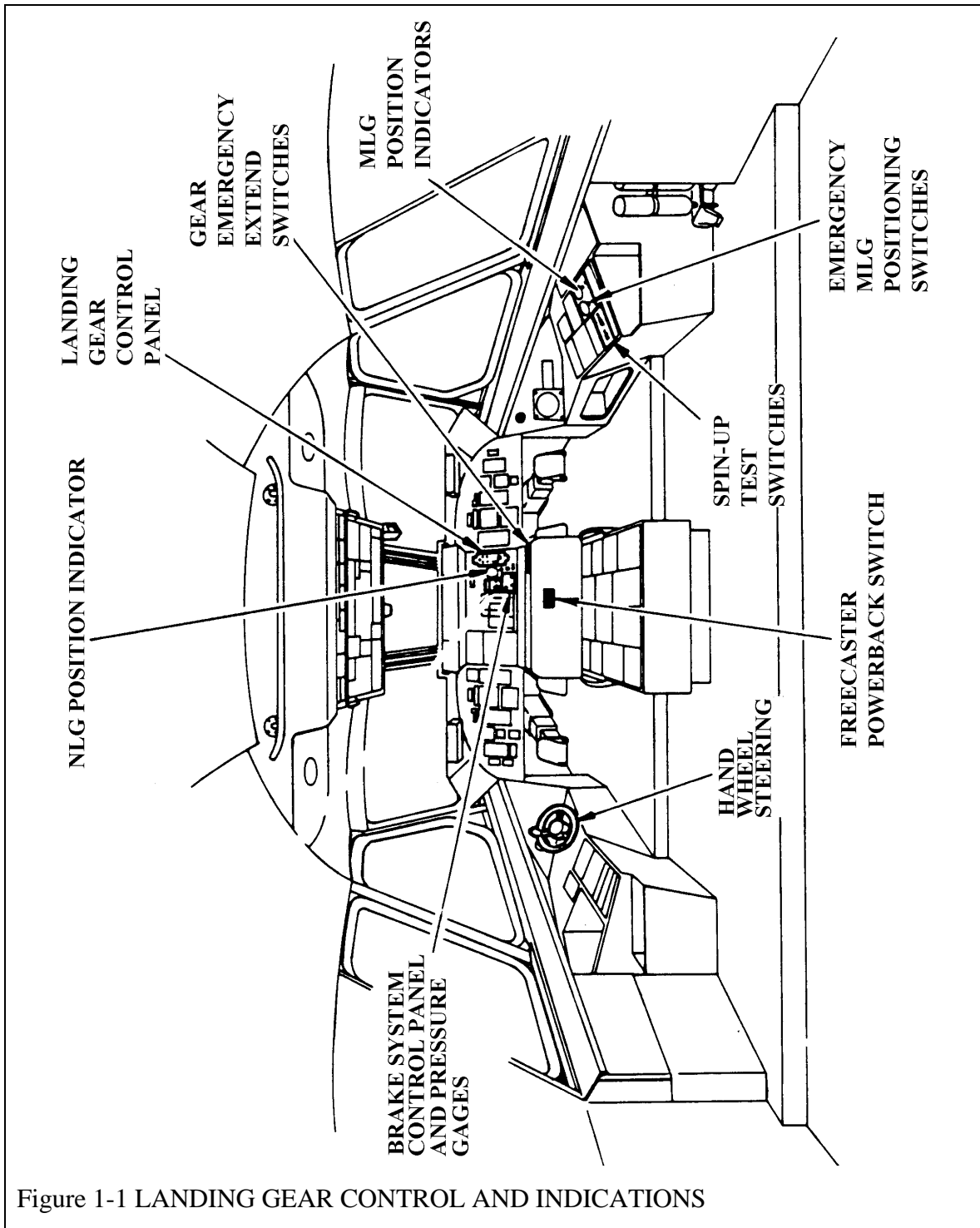
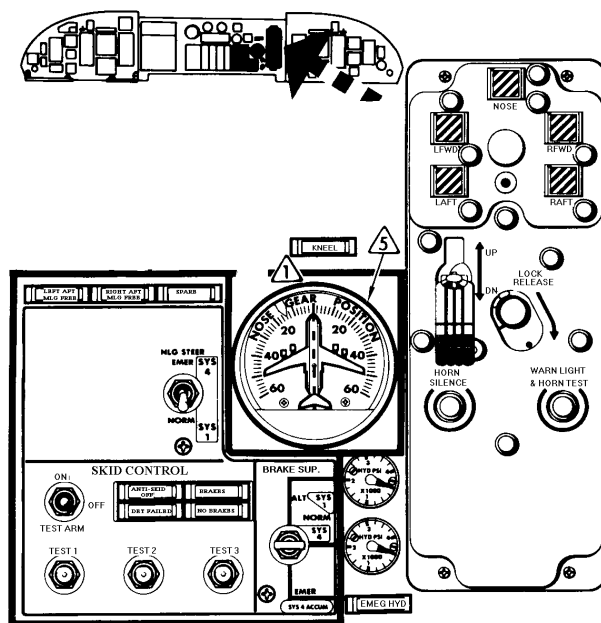


Figure 1-1 LANDING GEAR CONTROL AND INDICATIONS



TYPICAL FOR NOSE GEAR	TYPICAL FOR MAIN GEAR
DOWN AND LOCKED	BOGIE ALIGNED AND LOCKED
DOORS FULLY OPEN AND GEAR NOT DOWN AND LOCKED	DOWN AND LOCKED
DOORS IN TRANSIT	IN TRANSIT
UP AND LOCKED	UP AND LOCKED

NOTE

- NOT MODIFIED BY T.O. 1C-5A-1978.
- MODIFIED BY T.O. 1C-5A-1978.
- EITHER TYPE OF INDICATOR MAY BE INSTALLED ON AIRPLANES MODIFIED BY T.O. 1C-5A-1978.

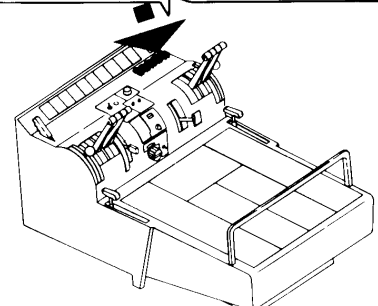
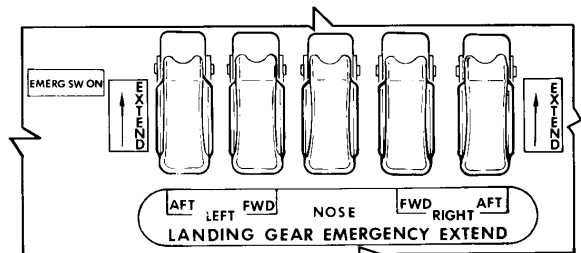
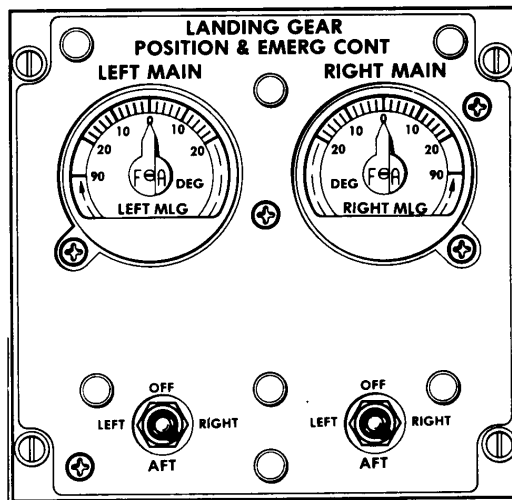
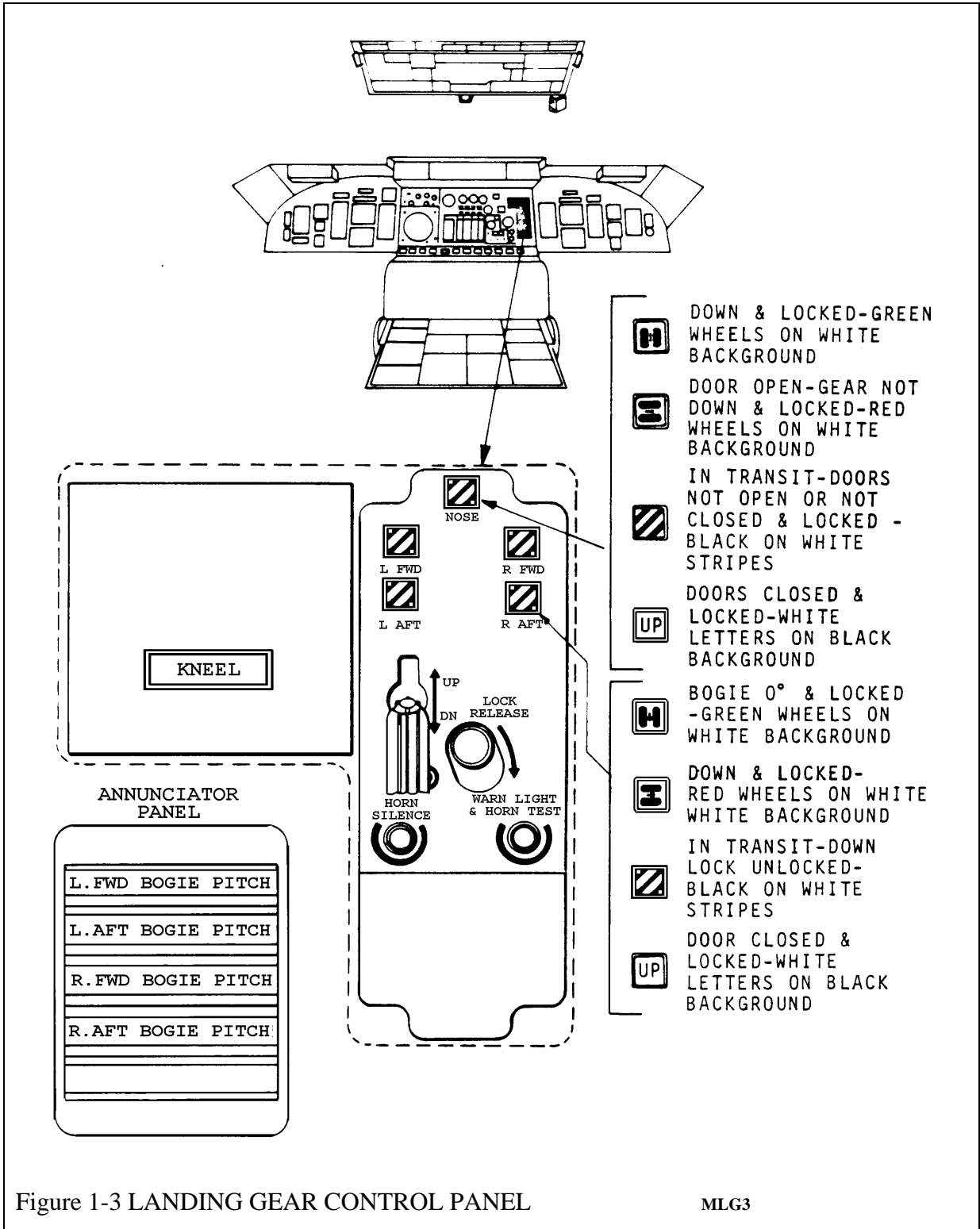


Figure 1-2 LANDING GEAR CONTROL AND INDICATORS



LANDING GEAR CONTROL LEVER—The landing gear control lever, located on the right side of the center instrument panel, initiates gear retraction and extension operations. The control lever has two positions, UP and DOWN, which mechanically operate the landing gear control switches. The control switches, in turn, provide the necessary input signals to five landing gear control manifolds which electrically control gear operations. See figure 1-3.

The control lever includes an anti-retraction lock that prevents inadvertent operation of the control lever to the UP position while the aircraft is on the ground. The lock mechanism is electrically disengaged when the touchdown relay is de-energized. The lock mechanism can be overridden manually by a release knob located adjacent to the control lever.

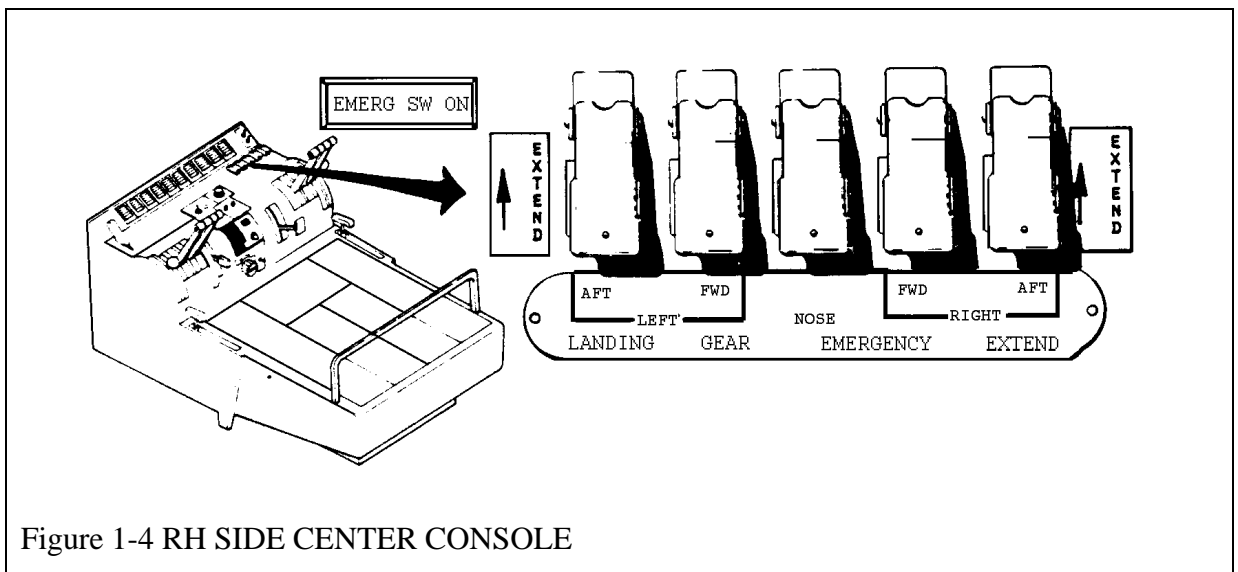


Figure 1-4 RH SIDE CENTER CONSOLE

WARNING HORN AND SILENCE SWITCHES—A warning horn on the overhead panel sounds for a variety of unsafe conditions. With the respect to the landing gear, the horn sounds during extension if the landing gear is not in the down-and-locked position and one or more of the throttles are in a minimum cruise setting with airplane speed below 200 knots. The horn also sounds any time the landing gear is not down-and-locked and the flaps are in a greater than the approach position. See figure 1-3.

Two switches are provided on the landing gear control panel for manual operation of the warning horn. A **WARN LIGHT AND HORN TEST** button test the horn and the warning lights on the landing gear control handle. A **HORN SILENCE** button silences the horn if it is sounding because a throttle(s) is at the minimum cruise setting before the landing gear is in a safe condition. However, the **HORN SILENCE** will not turn off the horn if it is sounding because the flap control is in the greater than the approach position while the landing gear is not in a safe landing attitude. After the horn has been silenced for one condition, it re-

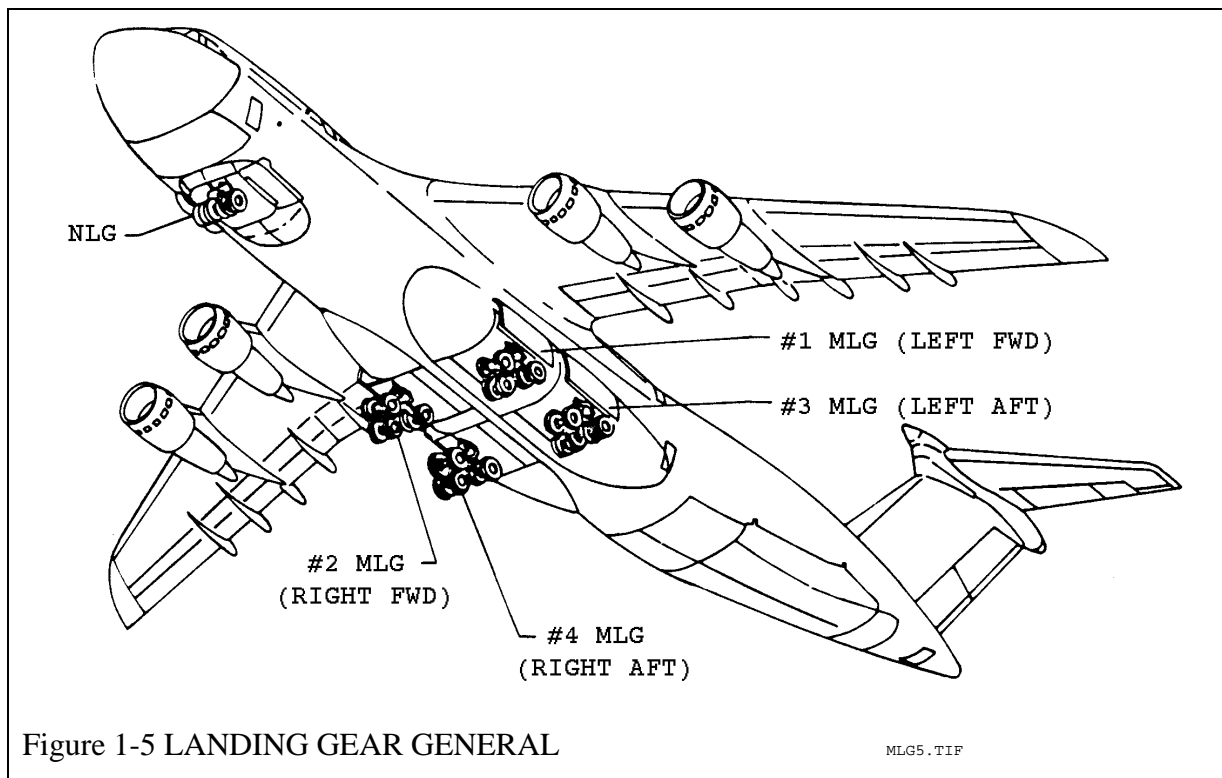
tains its warning capability for other conditions, and will sound again if needed by other systems.

GEAR EMERGENCY EXTEND SWITCHES—Five landing gear emergency extend switches, located on the forward right side of the center console, control the NLG and MLG emergency extend systems. The switches have two positions, EXTEND and NORMAL and are cover-guarded to avoid inadvertent operation. A red light to the left of the switches illuminates when either NLG door is open or when the affected MLG assembly has rotated to the zero-degree position and the switch is in the extend position. See figure 1-4.

MAIN LANDING GEAR (MLG) AND DOORS—The four MLG assemblies are designated as #1 (left fwd), #2 (right fwd), #3 (left aft), #4 (right aft). Each MLG consists of six wheel-and-brake assemblies attached to a bogie that, in turn, attaches to a shock strut. See figure 1-5.

STRUT AND BOGIE ASSEMBLIES

The shock strut is mounted to the aircraft by two trunnion pins that insert into two fuselage support fittings and bearings. See figure 1-6.



LANDING GEAR GENERAL

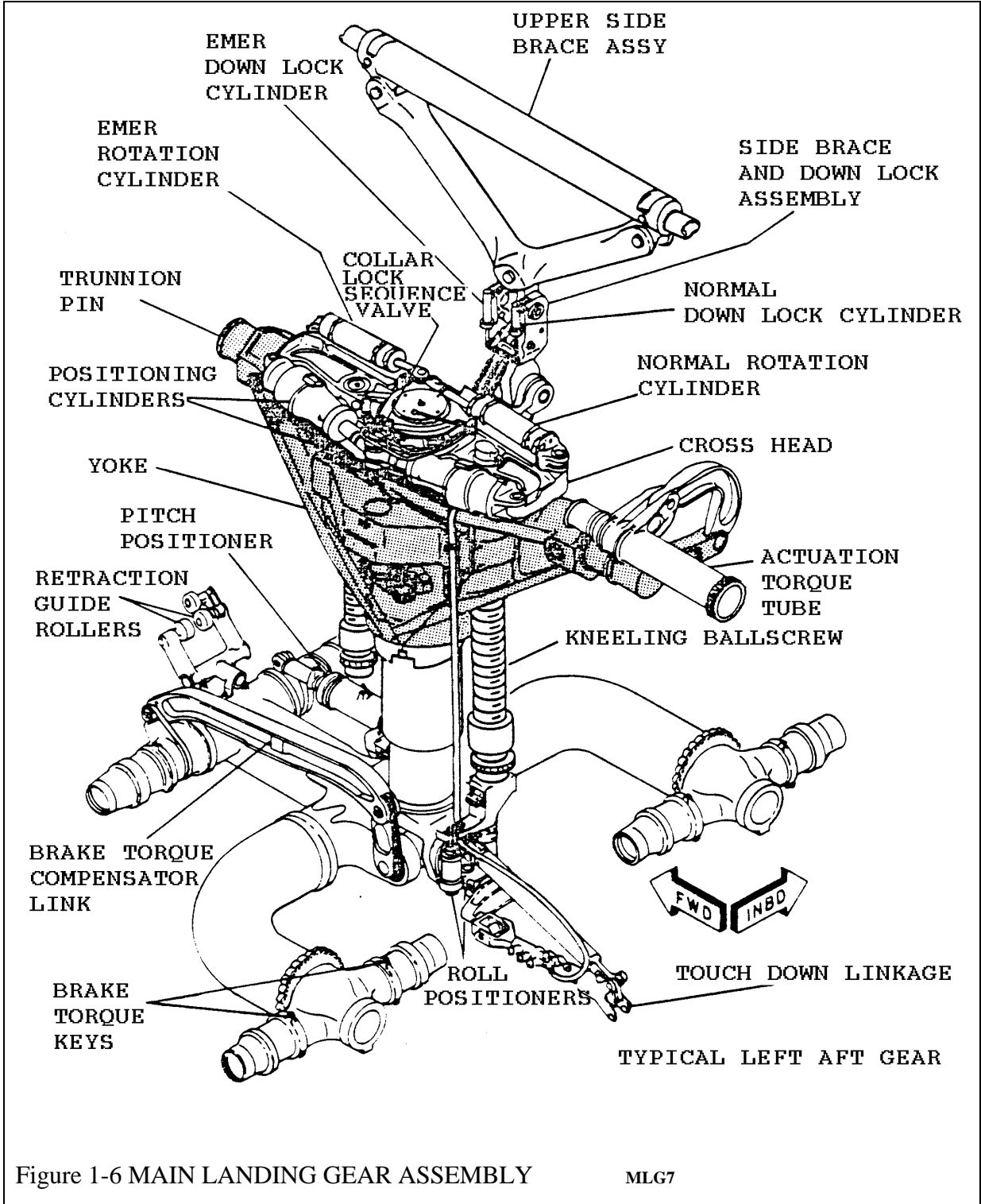
Gear retraction consists of two separate movements. The first movement rotates each shock strut and bogie assembly 90-degrees inboard around the strut vertical axis. The second movement retracts the gear inboard and up into the wheel well. During the inboard and up cycle, the 90-degree relationship of the strut and bogie increases to ap-

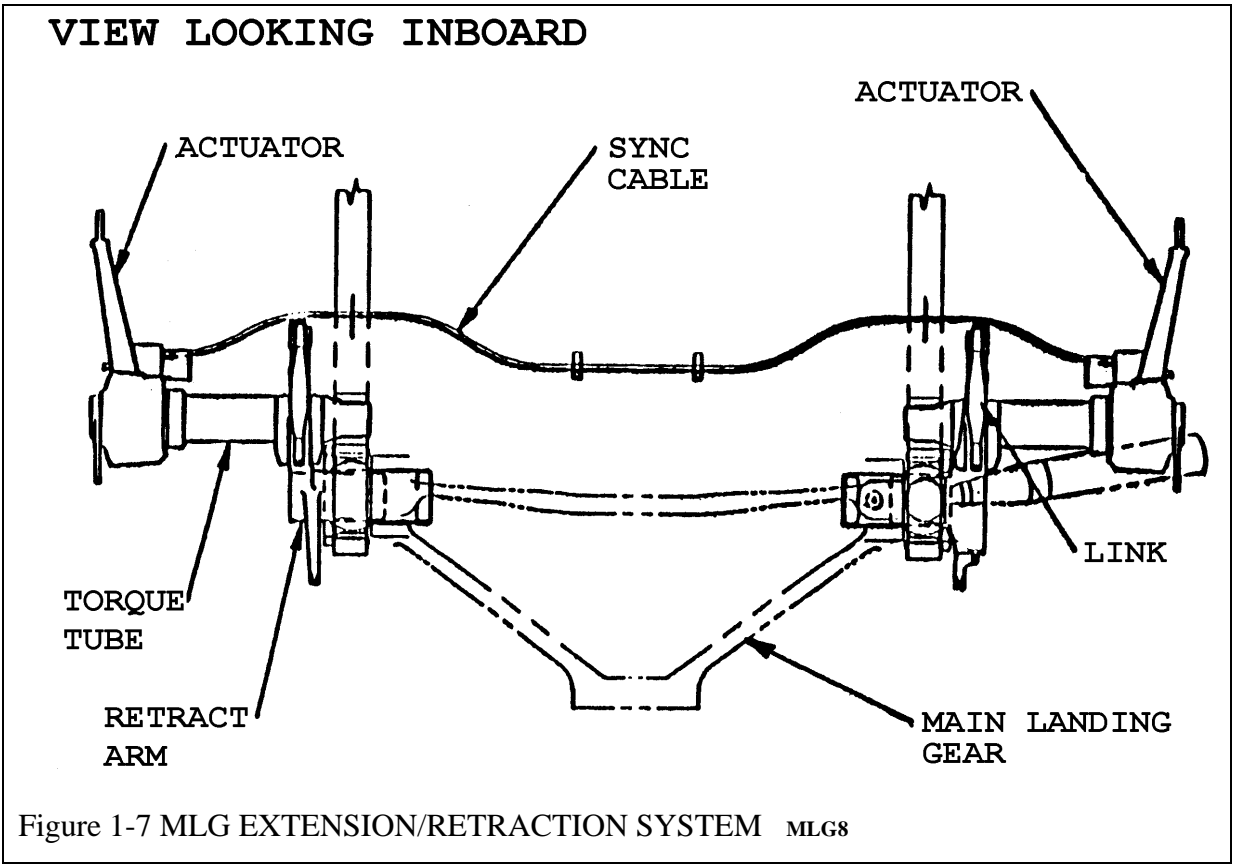
proximately 175 degrees as the bogie pitches down. This pitching motion of the bogie allows the gear assembly to assume an almost flat configuration. As the outboard door reaches the closed position, four door locks mounted on the outboard door lock to maintain the gear and doors in the up and locked position. The gear extension sequence is the reverse of the retraction sequence.

Each MLG door assembly is made up of an inboard door, outboard door, and two slot doors. The inboard and outboard doors open during gear extension. The inboard door closes after gear extension while the outboard door remains open after gear extension. Two slot doors open to allow outboard door actuating linkage to extend beyond fuselage structure.

The bogie assembly, attached to the bottom of the strut, consists of a three-arm tubular structure. The bogie forms a triangular pattern for the mounting of the wheel and brake assemblies. See figure 1-6.

One arm of the bogie extends forward with reference to the strut and includes a socket at its forward end that accepts the forward axle beam upon which is mounted two wheel-and-brake assemblies. The two remaining arms extend aft with reference to the strut, one on the inboard side, the other on the outboard side. Each aft arm includes an integral axle beam that contains machined bearing lands at each end for mounting two wheel and brake assemblies.





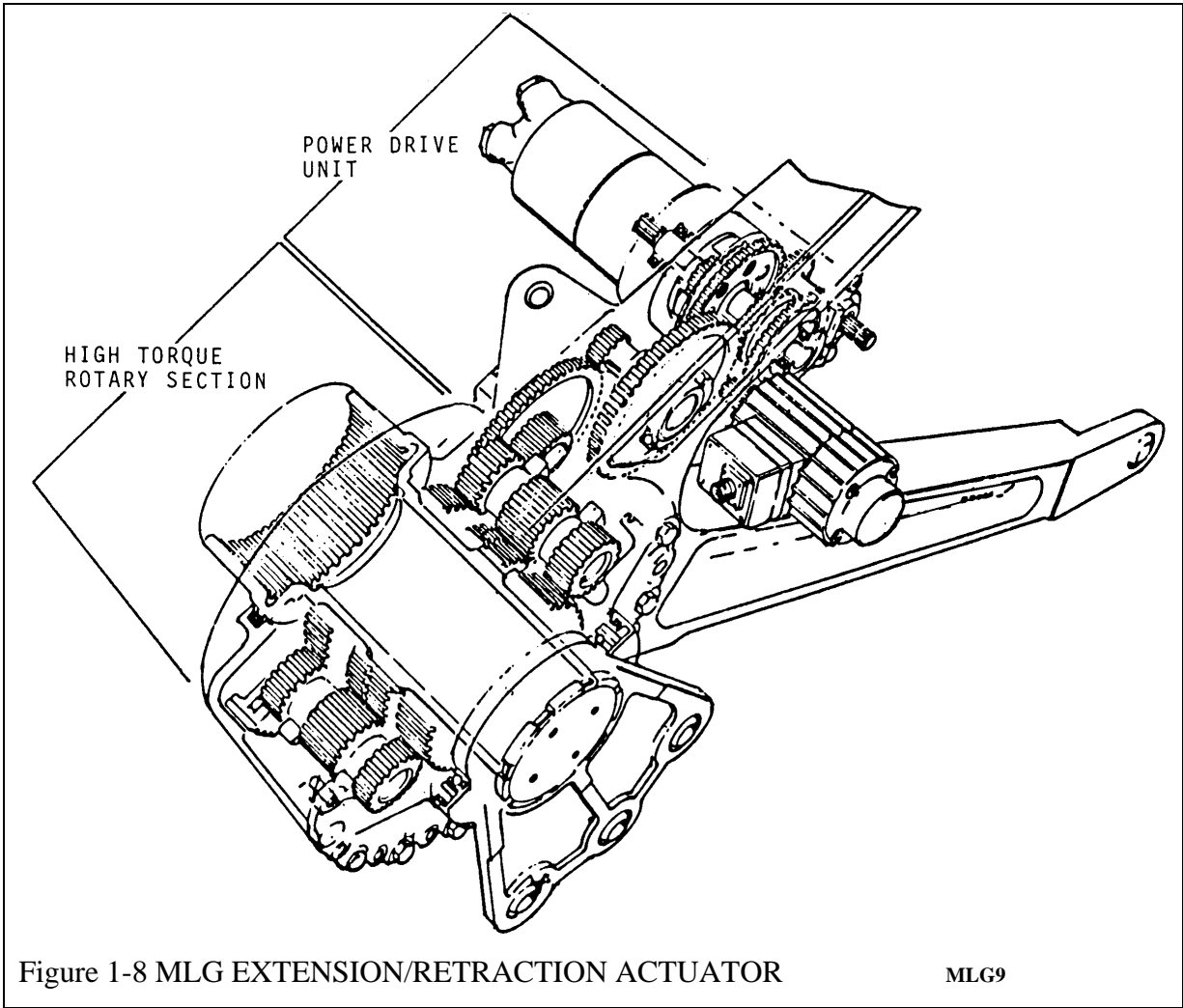
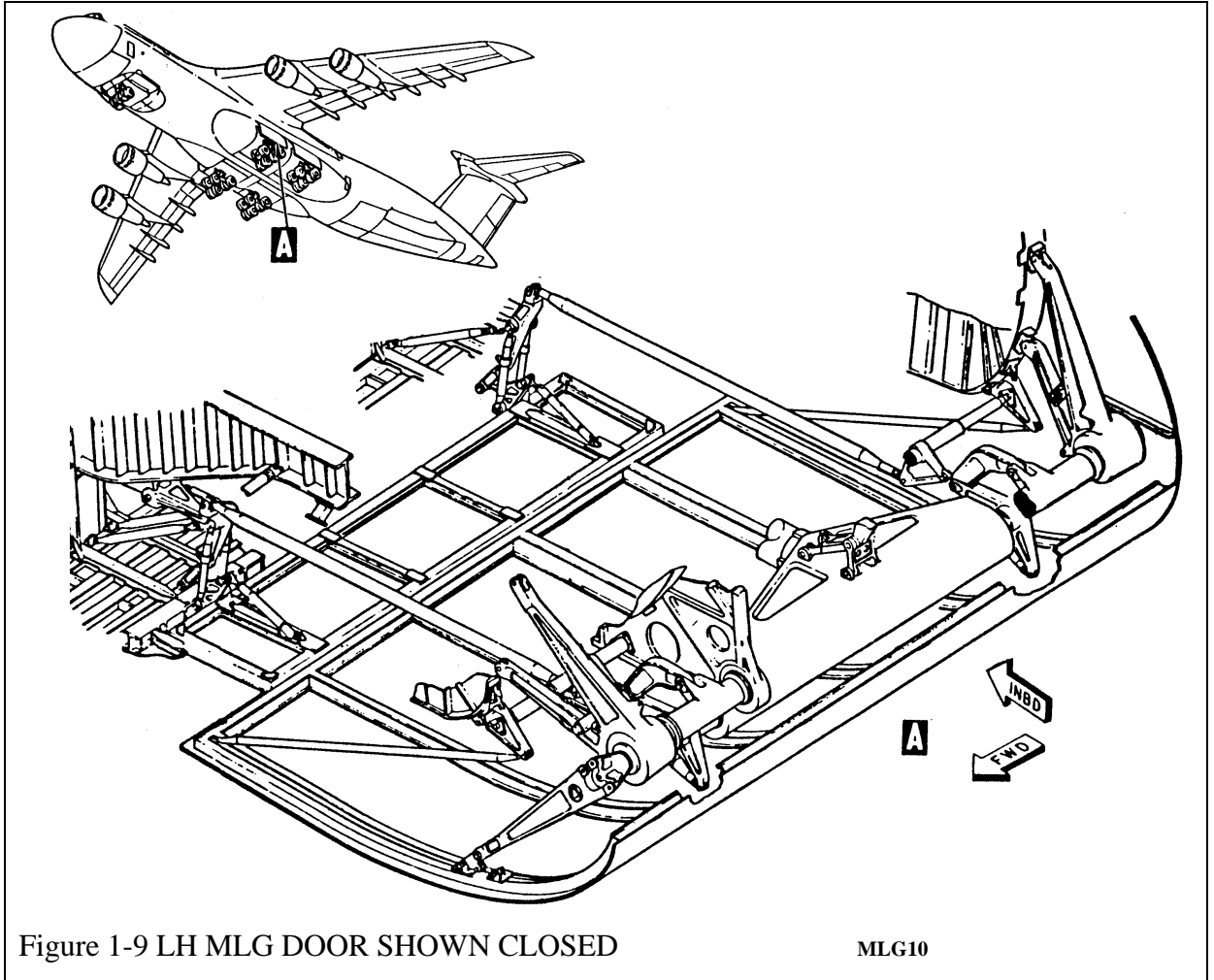
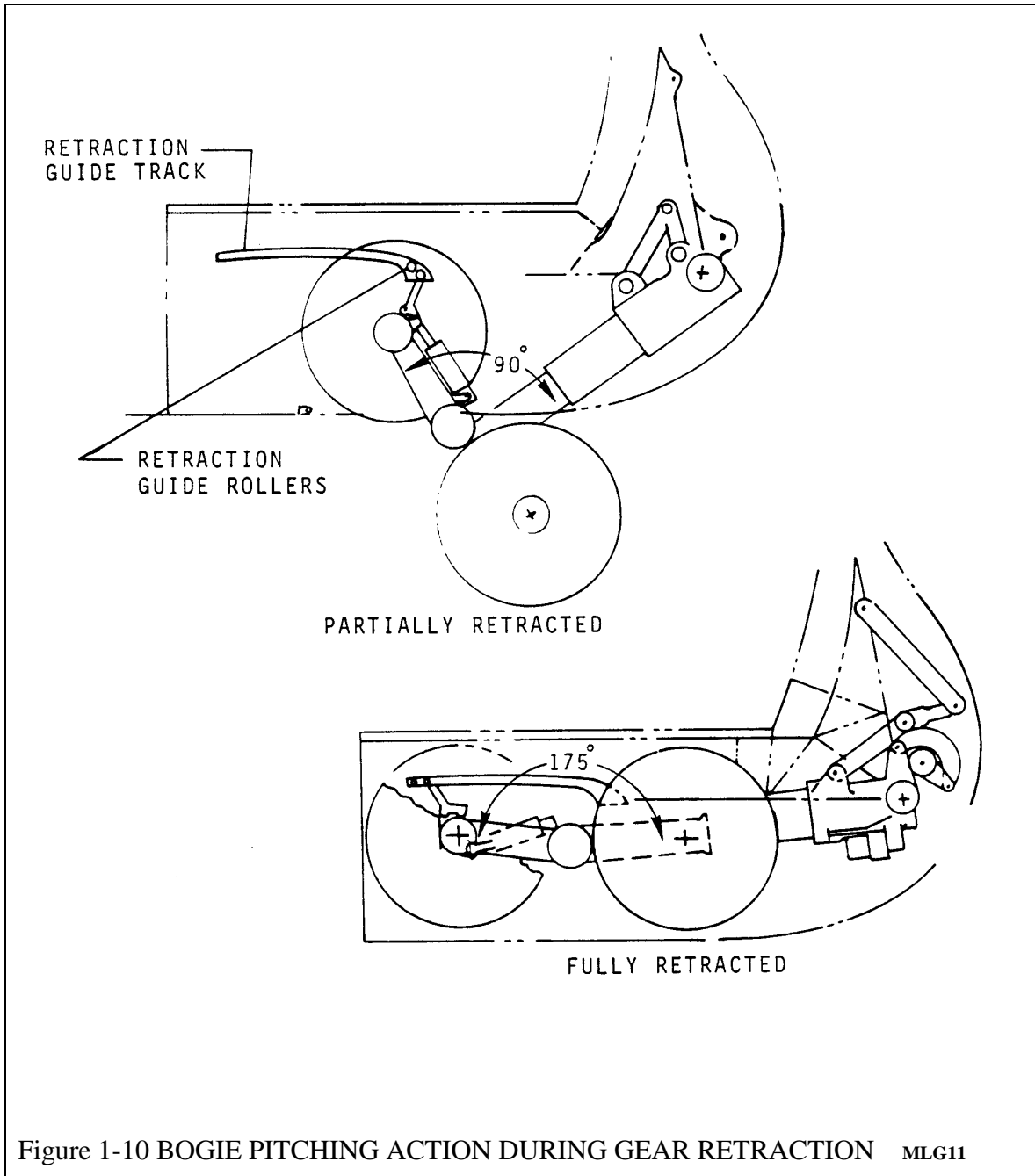


Figure 1-8 MLG EXTENSION/RETRACTION ACTUATOR

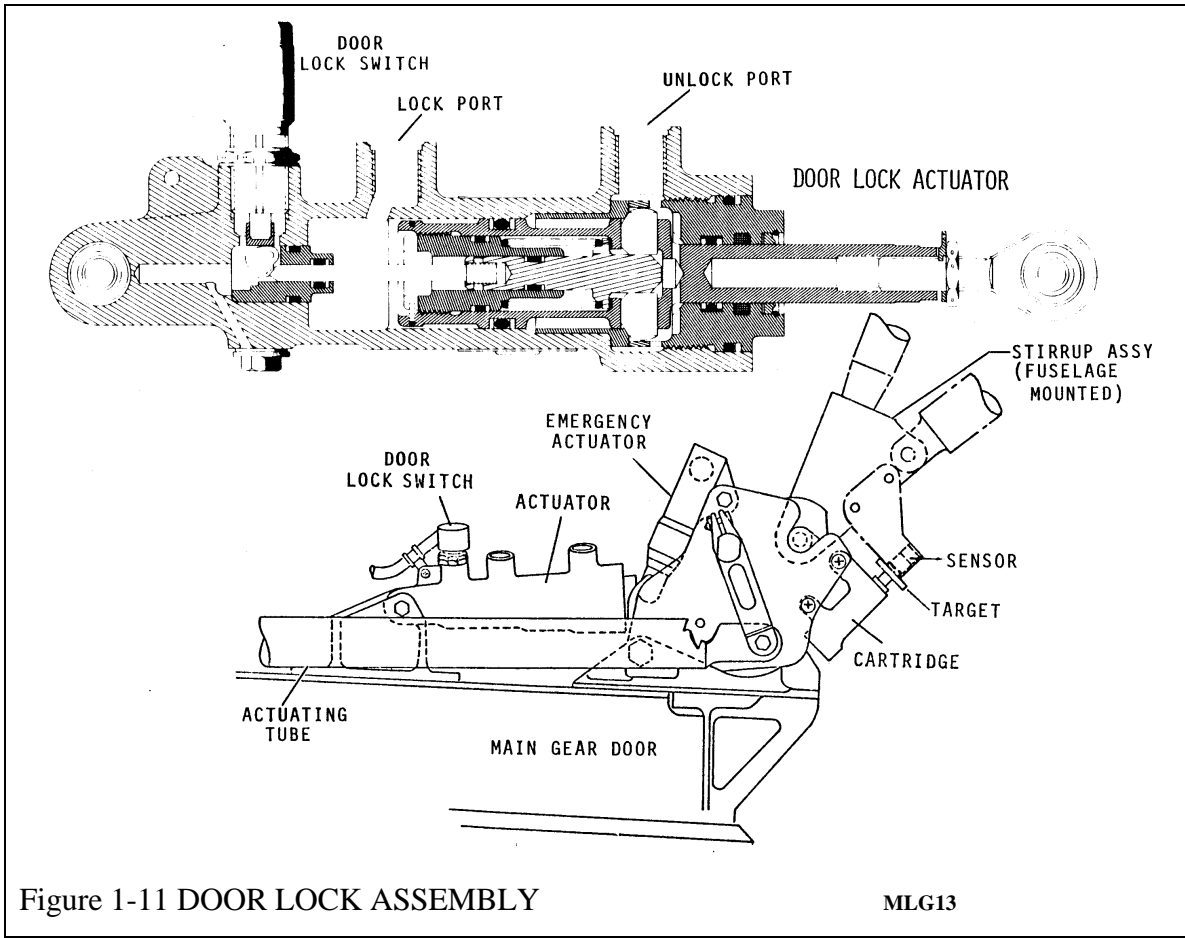
MLG9





MAIN GEAR DOORS—The main gear doors enclose the MLG wheel wells to produce an aerodynamically smooth surface once the gear is retracted. There are two main doors for each gear: an inboard door and outboard door. Both doors are mechanically linked to a common gear and door actuation system by a series of drive arms, link arms, torque tubes, and gearboxes. Two slot doors are also provided in the pod structure to permit the outboard door actuating linkage to extend beyond the fuselage.

Sixteen door lock assemblies are used to hold the MLG outboard doors in a closed position. Four lock assemblies are used per outboard door with two located on the fwd edge and two on the aft edge. Hydraulic lock actuators, two per outboard door, are used for normal operation. Each actuator operates two lock assemblies through a push-pull rod and lever arm connection. Each lock assembly consists of a hook and hook toggle linkage, overcenter detenting linkage, a cartridge-type target assembly, and an emergency unlock hydraulic actuator. The emergency unlock actuator will unlock the doors if the normal system fails. Each lock assembly engages a stirrup attached to the aircraft structure at which time the cartridge-type target on each inboard door lock is compressed by a sensor bracket attached to the stirrup. As the cartridge-type target comes in close proximity to the sensor, the door closed circuit is completed which signals the door locks to lock.



MLG AND DOOR ACTUATION SYSTEM

The mechanical actuation system operates the MLG and doors during the retraction and extension cycles. The four mechanical actuation systems are located within their respective wheel wells. Each system consists of two actuator assemblies interconnected by means of a flex shaft. This provides each MLG with a dual drive system. See figure 1-7.

A dual power source for each system is provided at each actuator for each system. A hydraulic motor system provides power input to the actuator during normal operation and an electric motor provides the input for emergency gear extension. Should one of the motors fail during operation, either hydraulic or electric, the interconnecting flex shaft allows driving through both actuators to extend the gear, rather than driving through one actuator and having to back drive the other actuator through its gearing. This provides a more efficient and reliable system.

The system components are interchangeable fore and aft and left to right with respect to each wheel well location.

The actuator consists of a high torque rotary section of the cageless balanced differential planetary (free planet) type with an integral power drive unit containing both the primary drive hydraulic motor and an emergency drive electric motor. See figure 1-8.

The gears and bearings of the high torque, low speed, section are lubricated with 1 part MIL-L-7808 and 3 parts MIL-G-23827 grease. (To service, remove a bolt in the cover plate at 3 or 9 o'clock, pull another bolt near the top, fill through top hole until it flows out of bottom hole.) The power drive unit, low torque high speed, section is splash lubricated with MIL-L-7808 oil.

All shafts are sealed with dual seals wherever exposed to the outside environment.

The hydraulic motor drives through a brake assembly and operates at 3400 RPM with a primary drive ratio of 1181:1. This results in a normal extension or retraction time of 13 seconds.

During normal gear extension with no hydraulic pressure applied to the brake, springs prevent the hydraulic piston from contacting the brake plates, thus allowing free rotation of the shaft. During emergency gear extension, the brake is energized by pressure from the emergency door unlock hydraulic system which moves the brake piston and applies a clamping force to the brake plates to lock the shaft. The brake is fully released at all hydraulic pressure up to 500 PSI and fully engaged (locked) at pressures from 1500 to 3000 PSI.

The electric motor is a 110/220-Volt AC three phase unit with an integral spring engaged brake with dual 28 VDC release coils. The electric motor operates at 7600 RPM through an emergency drive ratio of 19,360:1. This results in an emergency extension time of less than 170 seconds.

The power drive unit gearbox mounts directly on the hub of the high torque (low speed) section of the main housing between the two reaction arms. This gearbox contains reduction gearing and a simple planetary gear input arrangement that is used as a differ-

ential to allow driving with either the primary hydraulic system or the emergency electric drive system.

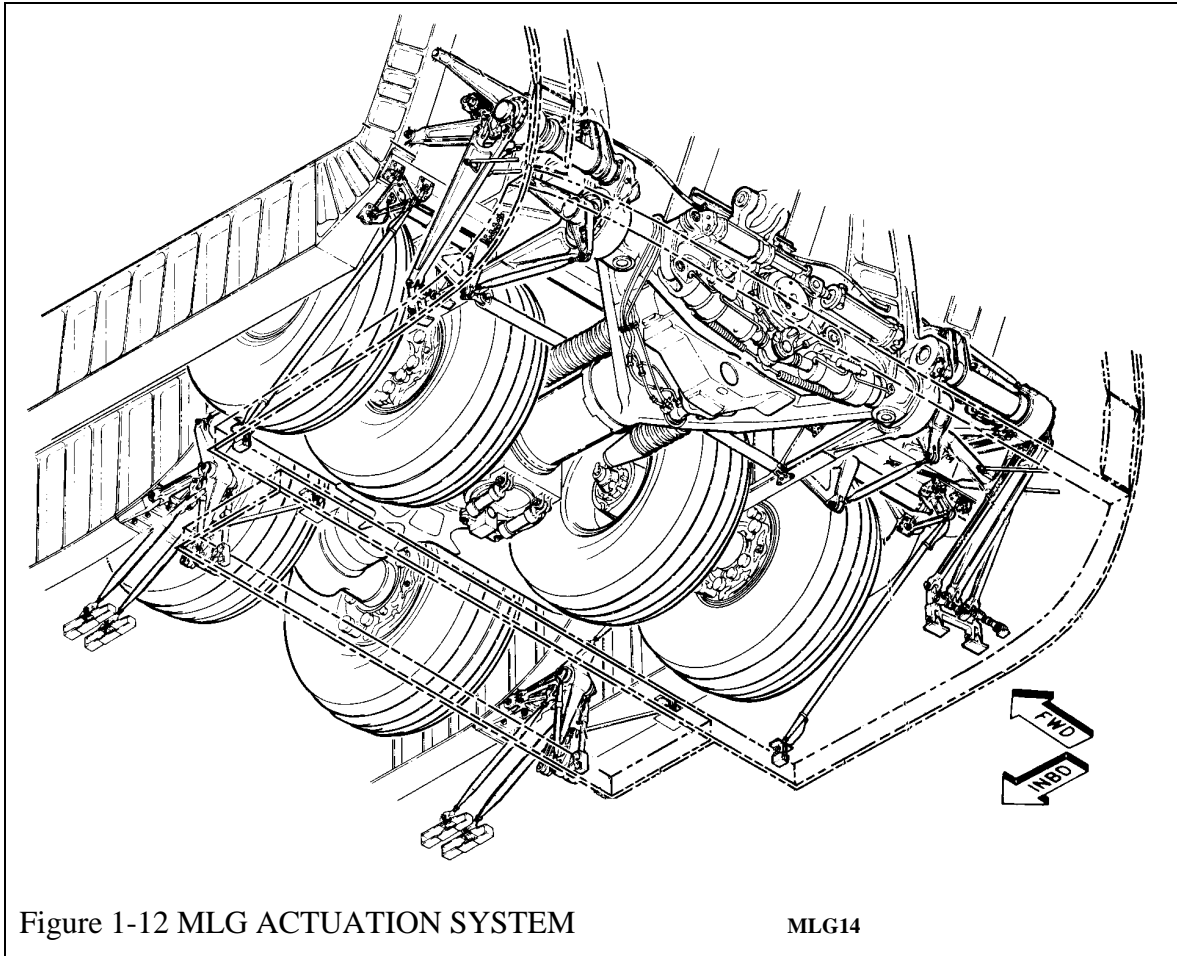


Figure 1-12 MLG ACTUATION SYSTEM

MLG14

The high torque rotary section of the actuator is the final torque-amplifying device and does the work of raising and lowering the landing gear, as well as opening and closing the outboard door.

During normal operation electrical power is not supplied to the emergency extend motor. The result is the electric motor brake, which holds the sun gear of the simple planetary arrangement stationary, is engaged allowing the primary system to drive the gear.

The actuator interconnecting flex shaft connects the forward and aft gearboxes together and provides additional protection against gearbox or motor failures. See figure 1-7.

COMPONENT DESCRIPTIONS

The following component descriptions pertain to any one of the four identical systems; therefore, component locations are identical with respect to the individual system installations.

MLG CONTROL MANIFOLD—The MLG control manifold is a six-port module located on the cargo compartment sidewall adjacent to its respective wheel well and controls all normal extension and retractions.

MLG DOOR UPLOCK VALVE—A MLG door uplock valve is located on the cargo compartment sidewall and controls the door lock/unlock operations. The valve contains two pilot valves and a double-detented control valve. The pilot valves are controlled electrically and have manual overrides.

ROTATION MANIFOLD—The rotation manifold is a seven-port module located on the inboard side of the crosshead assembly and controls normal rotation operation.

ROTATION SEQUENCE INTERLOCK VALVE—The detented, two-position, 3-port, rotation-sequence interlock valve, located on the inboard side of the crosshead near the collar lock, is mechanically actuated to either of its two positions and provides rotation sequencing operations in relation to collar lock and unlock positions. The sequence valve prevents bogie rotation during landing gear retraction until the collar lock is unlocked. When collar locking is complete, the collar lock sequence valve is mechanically tripped, venting pilot pressure from the rotation control valve to the return line.

HYDRAULIC MOTORS—A 3000-PSI, fixed displacement, piston-type hydraulic motor is mounted to each system main drive gearbox. It provides power for normal gear and door extension and retraction operations. The direction or rotation is controlled by the MLG manifold. Motor speed is regulated by the flow regulator in the hydraulic system.

GEAR-DOWN LOCK/UNLOCK CYLINDER—A hydraulically actuated, gear-down lock/unlock cylinder is located on the knee joint of the side brace assembly and locks or unlocks the main landing gear downlock overcenter linkage. Extension of the piston locks the overcenter linkage, while retraction of the piston unlocks the overcenter linkage. See figure 1-19.

COLLAR LOCK SEQUENCE VALVE—The collar lock sequence valve prevents pressure application to the crosshead lock cylinder during rotation thus reducing the internal friction of the related components. The valve is located on the outboard side of the crosshead and is positioned by mechanical linkage to apply pressure when the gear rotates to zero position during the extension cycle. In addition, an internal relief valve allows the pressure to bypass when the valve is closed. See figure 1-16.

NORMAL INTERCOLLAR LOCK CYLINDER—A hydraulically operated normal intercollar lock cylinder located on the top, center, outboard side of the crosshead provides normal locking and unlocking of the MLG shock strut collar lock assembly. The body is bolted to the crosshead, while the adjustable end of the piston rod is bolted to the lock assembly. See figure 1-16.

Extension of the piston rotates the collar lock assembly, mechanically locking the MLG strut to the positioning collar. Retraction of the piston reverses the previous operation and locks the MLG strut to the rotation collar.

EMERGENCY INTERCOLLAR LOCK CYLINDER—A hydraulically operated emergency intercollar lock cylinder located on the top, center, outboard side of the

crosshead provides locking of the strut collar lock assembly during emergency extension and is powered by the APU accumulator. See figure 1-16.

ROTATION CYLINDER—A hydraulically actuated rotation cylinder, mounted to the top inboard side of the crosshead, rotates the strut and bogie assembly during retraction and extension cycles. The body is mounted to the crosshead, while the piston rod is bolted to the stop plate assembly. The normal rotation cylinder includes the 90-degree rotation switch and its actuating push rod. See figure 1-13.

EMERGENCY ROTATION CYLINDER—A hydraulically actuated rotation cylinder mounted to the top inboard side of the crosshead is provided for emergency strut and bogie rotation if the normal rotation cylinder becomes inoperative. On the aft MLGs, the emergency rotation cylinders also function as positioning cylinders if the normal positioning system becomes inoperative. This is accomplished by using the BEEPER switches located on the copilot's side instrument panel. See figure 1-13.

EMERGENCY CONTROL MANIFOLD—The emergency control manifold is a six-port module located on the cargo compartment sidewall adjacent to the wheel well. The manifold controls emergency outboard rotation and emergency outboard and inboard positioning operations. The manifold contains three manually or electrically actuated pilot valves; a two-position, pilot-actuated, emergency system isolation control valve; and a three-position, pilot-actuated, emergency positioning and rotation control valve.

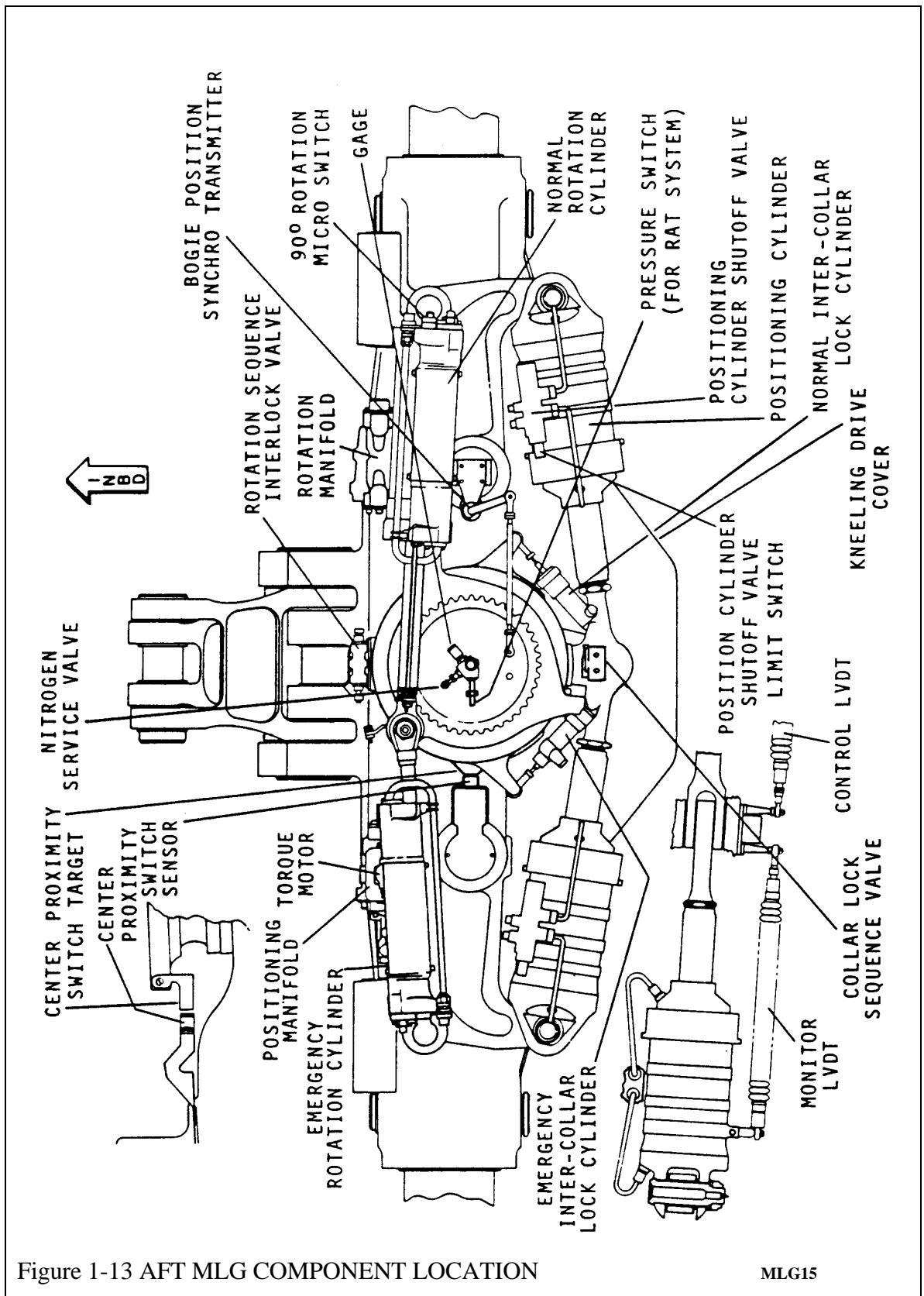


Figure 1-13 AFT MLG COMPONENT LOCATION

MLG15

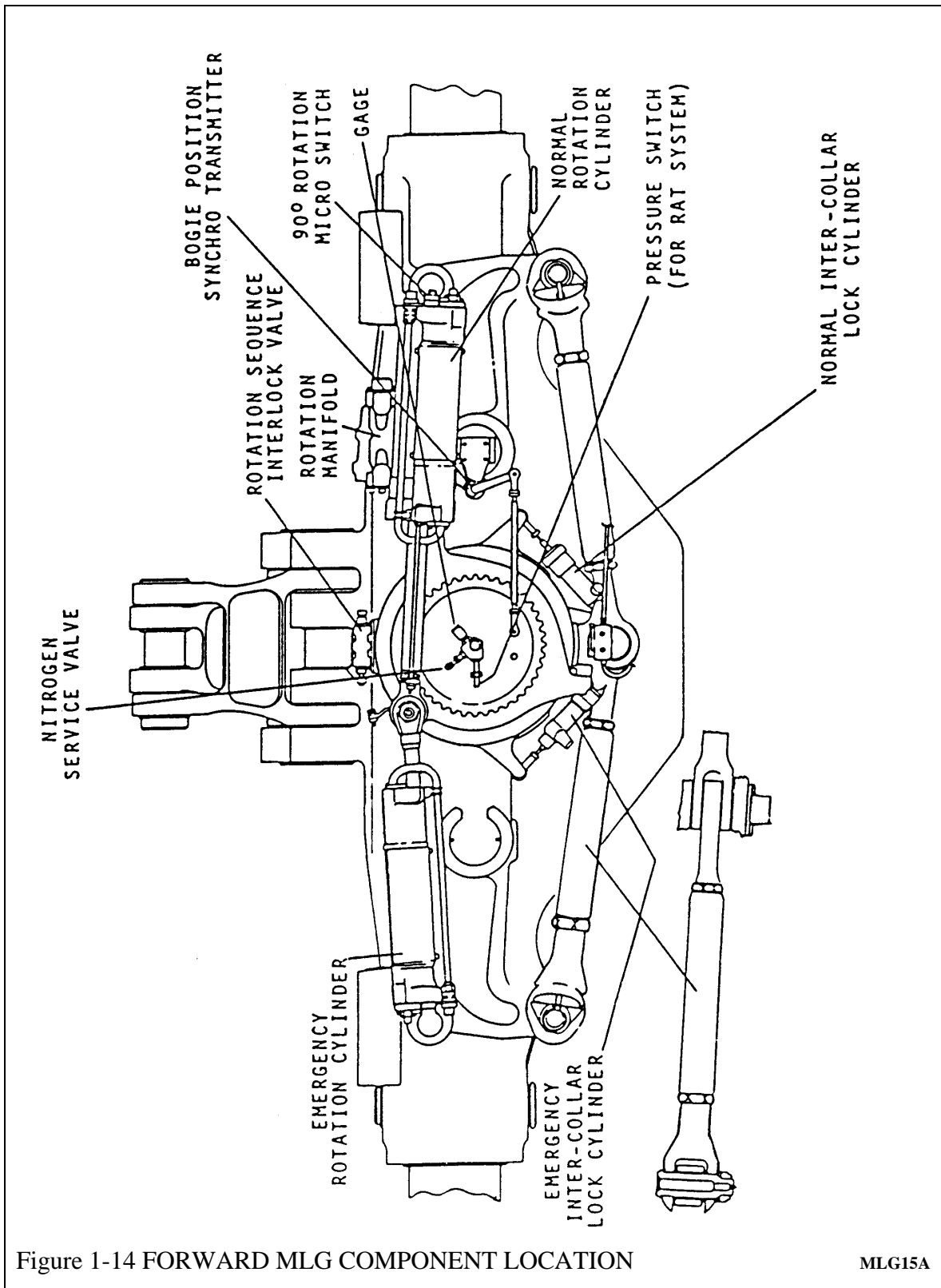


Figure 1-14 FORWARD MLG COMPONENT LOCATION

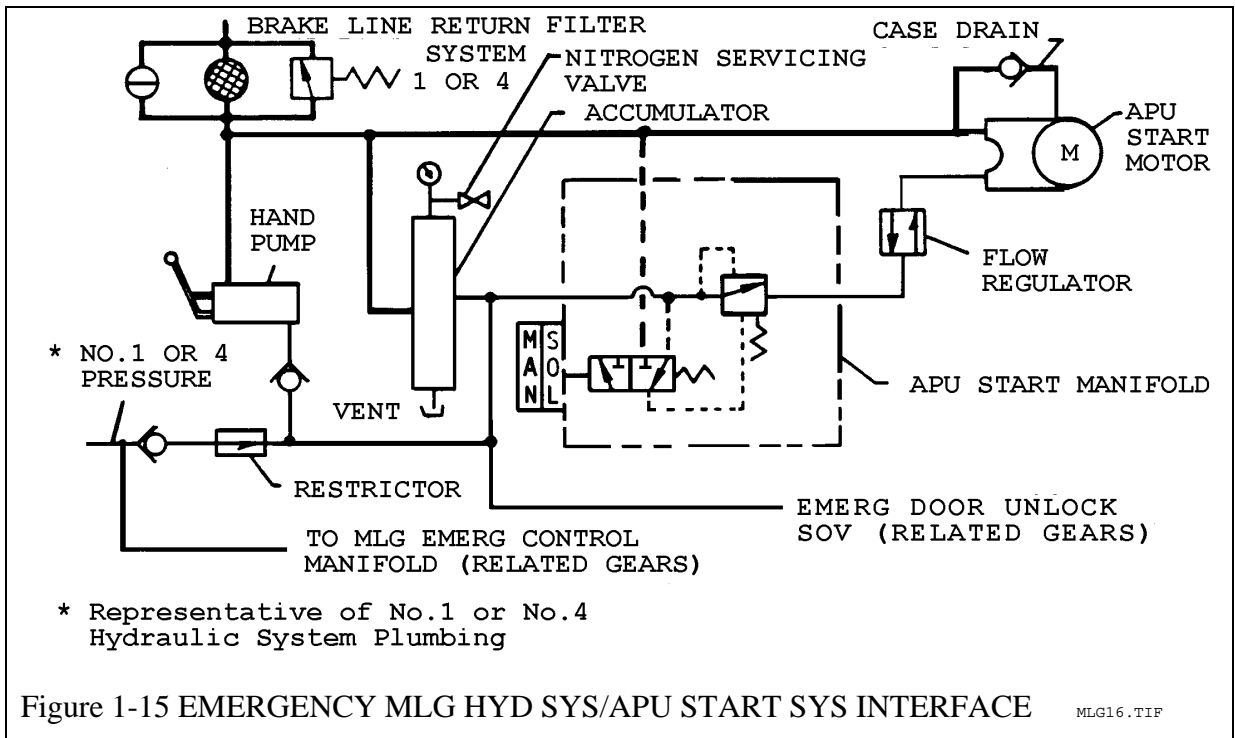
MLG15A

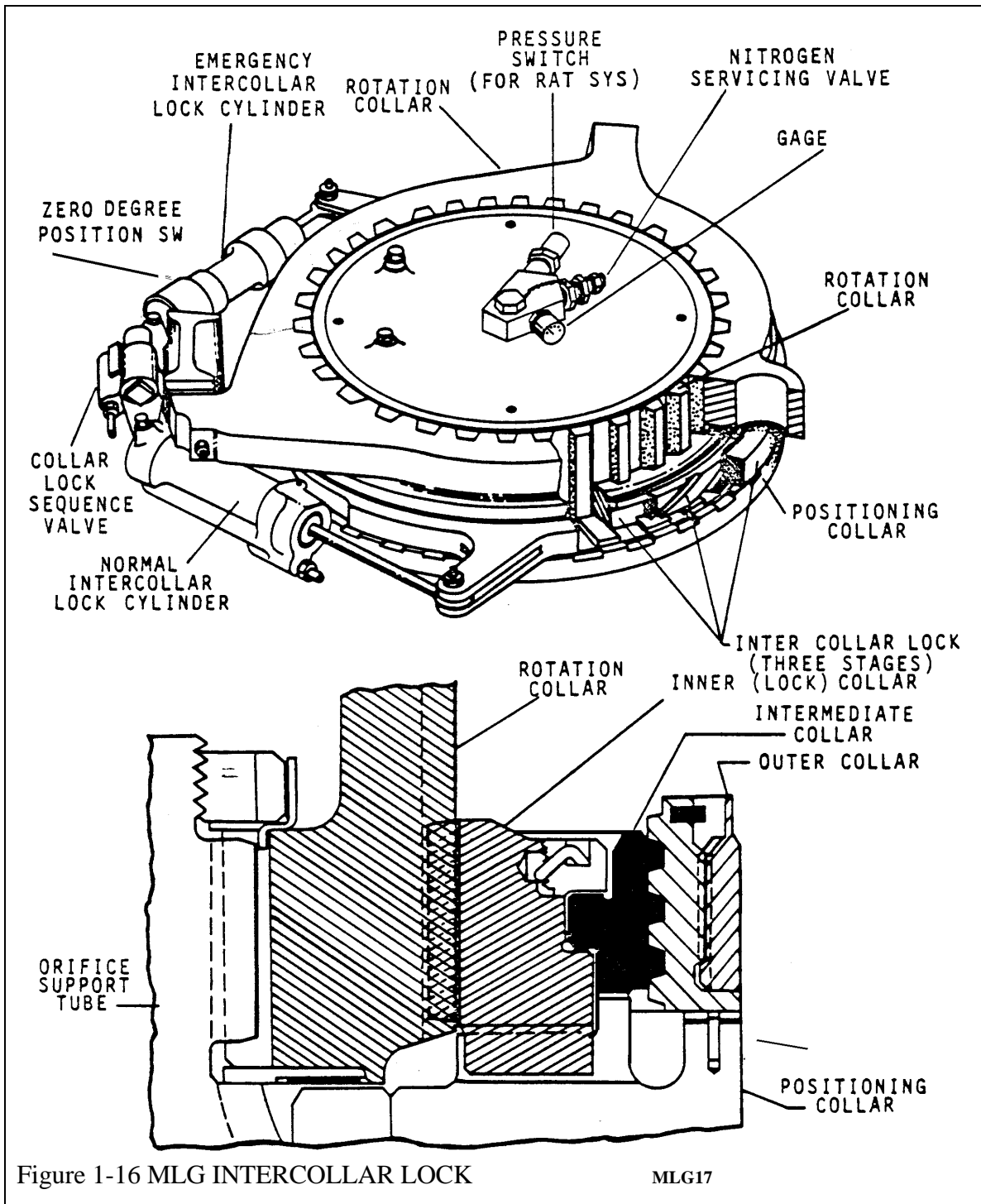
POSITIONING CYLINDERS—Two hydraulically operated positioning cylinders provide caster and positioning of the AFT MLG bogies. The cylinders are attached to the positioning collar and the crosshead. A hydraulic, pilot-operated shutoff valve is mounted on each positioning cylinder. On the FWD MLGs, the positioning cylinders are replaced with fixed links. See figure 1-13.

DOOR LOCK CYLINDERS—Two door lock cylinders are mounted on each MLG outboard door. A lock cylinder is mounted adjacent to each door lock mechanism. Using push-pull rods and lever arms, two lock mechanisms are actuated by each door lock cylinder. The door lock/unlock switches are located in the door lock cylinders. See figure 1-11.

EMERGENCY DOOR UNLOCK CYLINDERS—Four emergency door unlock cylinders are located on each MLG outboard door. One cylinder is mounted to each door lock mechanism and serves to unlock the door locks under emergency extend conditions. See figure 1-11.

EMERGENCY DOOR UNLOCK VALVE—The electrically/manually operated, two-position, three-port, emergency door unlock valve is located on the cargo compartment sidewall adjacent to its respective wheel well. The unlock valve pressurizes the MLG door locks during emergency conditions, energizes the brake in the MLG gearboxes, and pressurizes the emergency downlock cylinder.





MLG SHOCK STRUT

The double-acting shock strut is an oleo-pneumatic strut with the following functions:

- ◆ Arrests vertical motion of the aircraft when landing.
- ◆ Absorbs peak impact loads, which are transmitted to the structure.
- ◆ Minimizes rebound tendency during landing.
- ◆ Provides air spring suspension to support the aircraft during ground operation.
- ◆ Provides directional control for aircraft ground maneuvering.

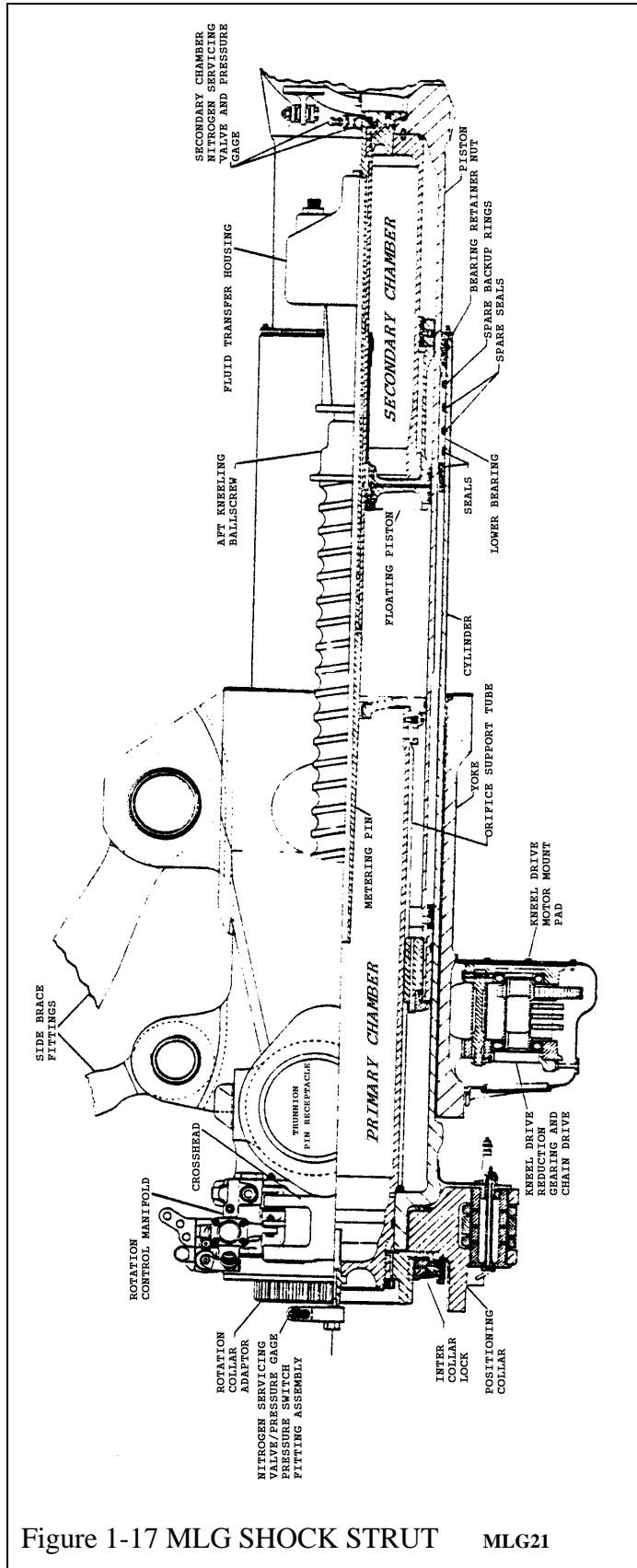


Figure 1-17 MLG SHOCK STRUT MLG21

CYLINDER AND PISTON ASSEMBLY—The piston includes a metering pin, which travels through an orifice plate located in the cylinder chamber. The orifice plate is held stationary (relative to vertical movement) within the chamber by an orifice support tube. The support tube is connected to the rotation collar located at the top of the strut assembly. The outer circumference of the support tube located within the cylinder is vertically splined in order to mate with a splined collar attached to the top of the piston. This arrangement allows vertical movement of the piston while also providing a rotational constraint between the piston and cylinder when rotation or positioning operations are not in effect. See figure 1-17.

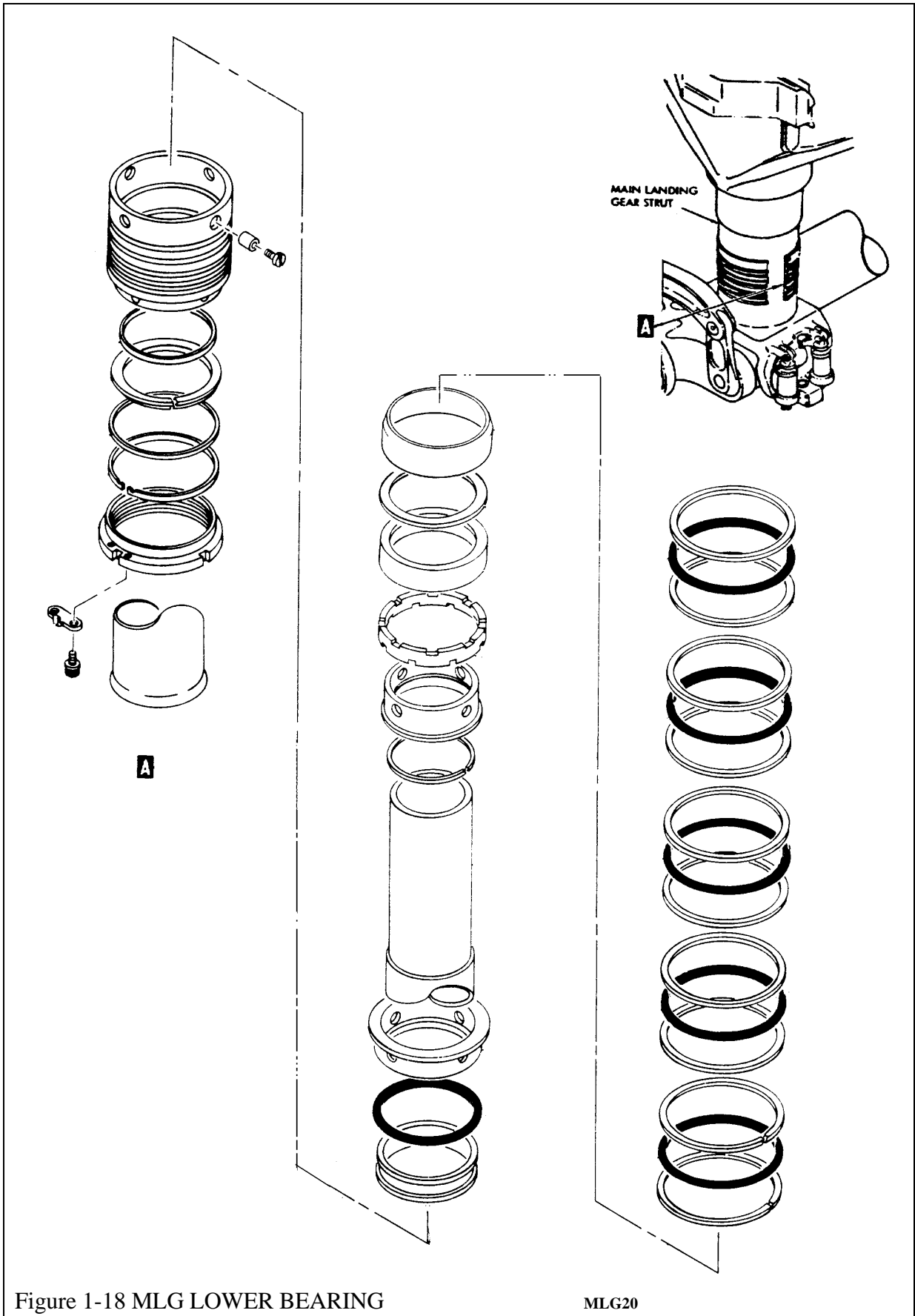


Figure 1-18 MLG LOWER BEARING

MLG20

The piston chamber is divided into two sections by a floating piston. The upper section, called the primary air chamber, contains hydraulic fluid and a low-pressure air charge. The lower section, called the secondary air chamber, contains a high-pressure air charge. During strut compression, hydraulic fluid is forced through the orifice of the orifice plate and compresses the air within the primary chamber. The compressed air now serves as an air spring and attempts to return the piston to an extended position. Due to the compressed state of the piston, return flow of hydraulic fluid is restricted by the metering pin. Under normal operating conditions, only the primary chamber is used. Should a vertical load on the strut exceed 1.25 Gs, the floating piston compresses the nitrogen in the secondary chamber. This creates additional stroke but at a lower spring rate than a conventional oleo-pneumatic strut would experience. Located at the bottom rear side of each strut is the nitrogen servicing valve and pressure gage, which is used to service the chamber. Located on the top of the strut is another nitrogen servicing valve and gage used to service the primary chamber with nitrogen. The servicing valve/gage fitting must be removed to service the strut with hydraulic fluid. Total stroke of the shock strut is 25 inches.

The cylinder outer surface is polished to a bearing finish to allow for vertical yoke travel during kneeling operations. The top end of the cylinder includes horizontal forward and rearward extending arms, referred to as the crosshead. The crosshead provides necessary mount points and support for numerous components used during gear extension, retraction, and positioning operations. The crosshead also includes mount points for two non-rotating, hollow core ballscrews used for MLG kneeling. One ballscrew is located forward of the strut while the second is located aft. The top and bottom ends of the aft ballscrew are equipped with manifolds to provide connection points for wheel brake hydraulic lines. These lines run from the aircraft, through the aft ballscrew, and on to the brake assemblies. Also running through the aft ballscrew is the wiring for skid detectors, tire deflation, and the touchdown sensors. See figure 1-18.

The cylinder and piston assembly includes necessary seals and backup rings to retain the oil and air pressure inside the cylinder. Spare seals and backup rings for the lower strut bearing are located on the lower bearing.

POSITIONING COLLAR AND ROTATION COLLAR—This assembly located on top of the crosshead transmits linear motion of positioning cylinders or rotation cylinders into a rotating motion of the piston and bogie. A hydraulically operated inter-collar lock unit locks or unlocks the positioning collar to the rotation adapter. The positioning collar must be locked to the rotation collar to achieve MLG caster operations and unlocked to allow rotation operations. See figure 1-16.

SIDE BRACE ASSEMBLY—The side brace assembly provides lateral support of the gear in the gear down position. The assembly is made up of an upper link, lower link, and a knee joint. See figure 1-19.

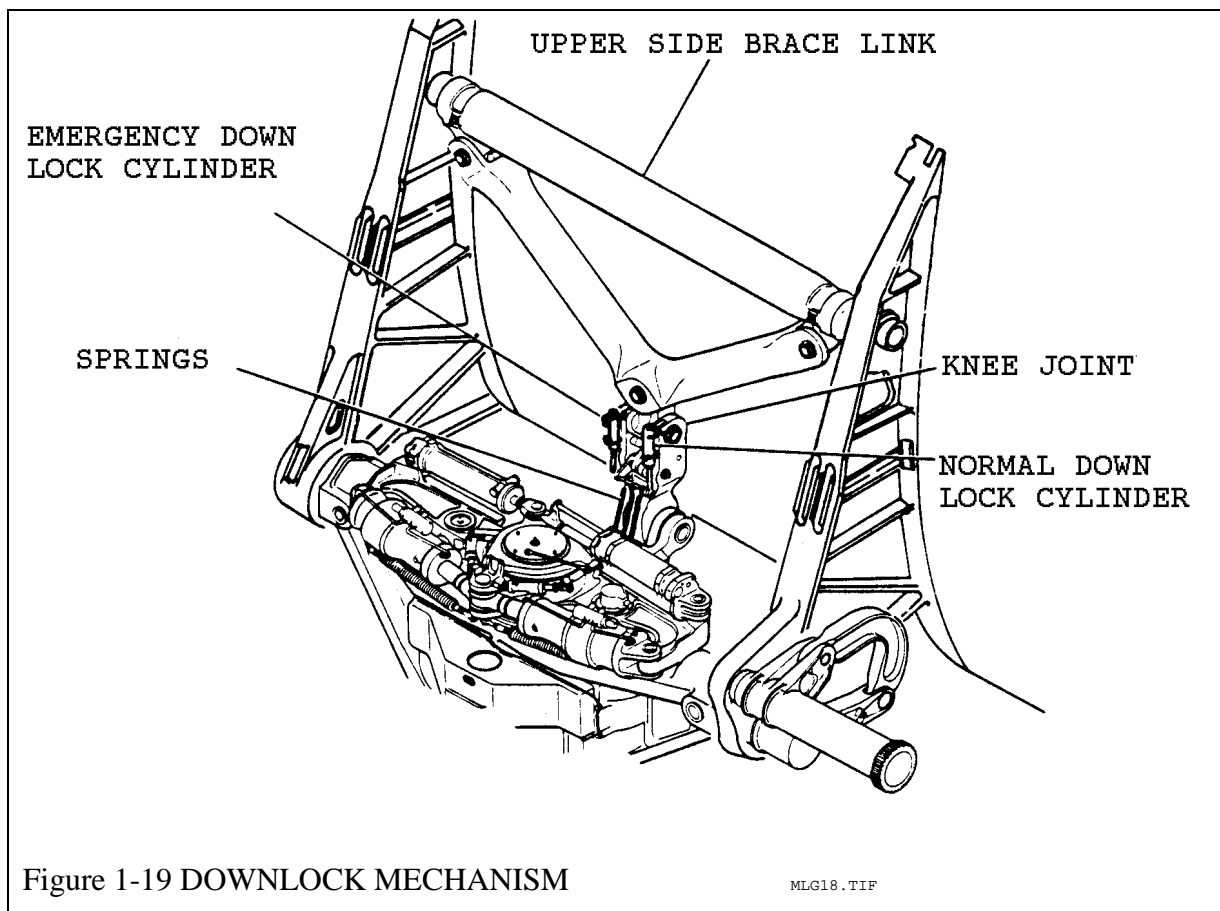


Figure 1-19 DOWNLOCK MECHANISM

MLG18.TIF

The triangle-shaped upper link is trunnion-mounted to the structure. The lower link is mechanically attached to the inboard side of the yoke. The upper and lower link are attached by a knee joint which includes an overcenter locking linkage and hydraulic actuating cylinders and three coiled springs. One actuator is used to lock or unlock the overcenter linkage during normal operations. The second actuator provides gear down lock operations during emergency gear extension. The three coil springs hold the downlock mechanism in a locked configuration whenever hydraulic pressure is unavailable.

YOKE ASSEMBLY—The yoke assembly attached to each strut includes the following: Two trunnion pins, two retract arms, two retract links, a mount pad for a hydraulic kneeling drive unit, kneeling reduction gearing, kneeling sprocket and chain drive, and two ball nuts. See figure 1-6.

The trunnion pins serve as pivot and mounting points for the gear assembly to the aircraft. The actuation arms are connected to the gear actuation system, and transfers retraction and extension inputs to the yoke assembly. The actuation arms are connected to the trunnion pins.

The yoke is attached to each strut by the two ball nuts, which connect to the two ballscrews. This type of attachment allows the yoke to move up or down the strut vertically whenever the ball nuts are rotated by the sprocket and chain drive assembly. The sprocket and chain drive assembly is controlled by the hydraulic kneeling drive unit, which is discussed in the kneeling section of this manual. Since the MLG is attached to the aircraft through the yoke assembly, any vertical movement of the yoke increases or decreases the distance between the aircraft and the bottom of the strut.

BOGIE ASSEMBLY

The bogie assembly, attached to the bottom of the strut, consists of a three-arm tubular structure. The bogie forms a triangular pattern for the mounting of the wheel and brake assemblies. One arm of the bogie extends forward with reference to the strut and includes a socket at its forward end, which accepts the forward axle beam. The beam, in turn, mounts two wheel-and-brake assemblies. The two remaining arms extend aft with reference to the strut, one on the inboard side, the other on the outboard side. Each aft arm includes an axle beam, which contains machined bearing lands at each end for mounting two wheel assemblies. See figure 1-6.

An integrally forged flange with three keys is located near each end of the aft axles for the attachment of the brake assemblies. The axles are internally threaded at each end for installation of the wheel retainer nuts.

A built-up bogie assembly is interchangeable between forward and aft positions on the left or right sides.

The bogie is attached to the shock strut by a universal joint consisting of a gudgeon pin and a roll pin. The following components are included in the buildup of each bogie assembly:

- ◆ Universal joint
- ◆ Forward floating axle beam
- ◆ Bogie pitch positioner
- ◆ Emergency pitch-stop
- ◆ Brake torque compensator link
- ◆ Roll positioner cylinders
- ◆ Bogie positioning rollers

UNIVERSAL JOINT—The universal joint, consisting of the gudgeon and roll pin, provides the necessary pivot points for pitch and roll axis movement of the bogie in relation to the strut. The gudgeon pin is splined into the roll pin to form a tee-shaped assembly, which allows rotation of the strut about the rollpin and pitch of the bogie about the gudgeon pin. The gudgeon pin is equipped with an arm, which is the anchor point for the aft end of the brake torque compensator link. See figure 1-20.

FORWARD FLOATING AXLE BEAM—The floating axle beam is supported by, and allowed to rotate within, the bogie forward arm socket. Bearing lands are machined at each end of the axle for mounting the two forward wheel assemblies, and the axle is internally threaded at each end for installation of the wheel retaining nuts. An integral flange with three keys is forged on the outboard half of the axle to mate with three key-

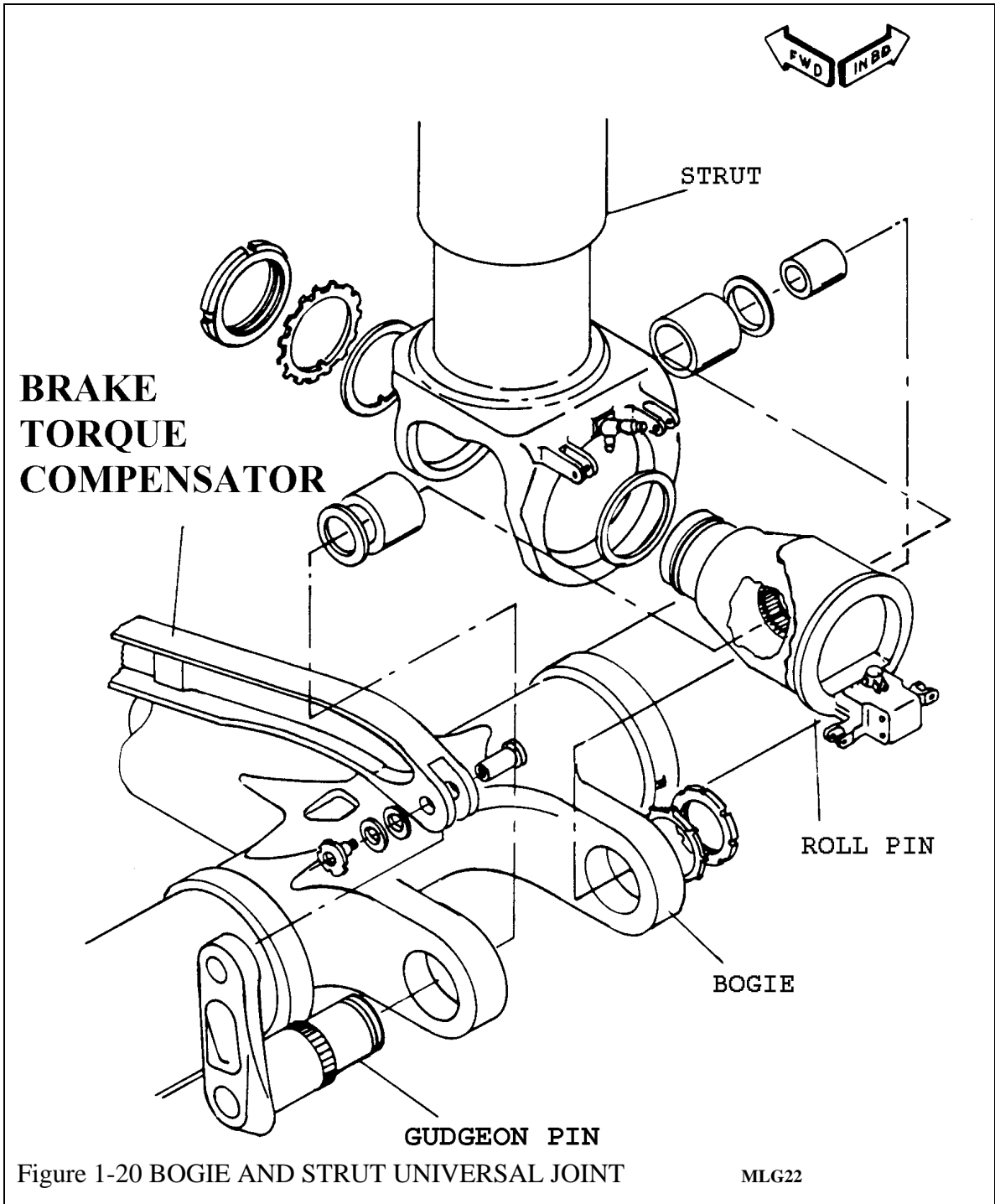
ways in the brake housing to prevent rotation between the brake stators and axle. See figure 1-21.

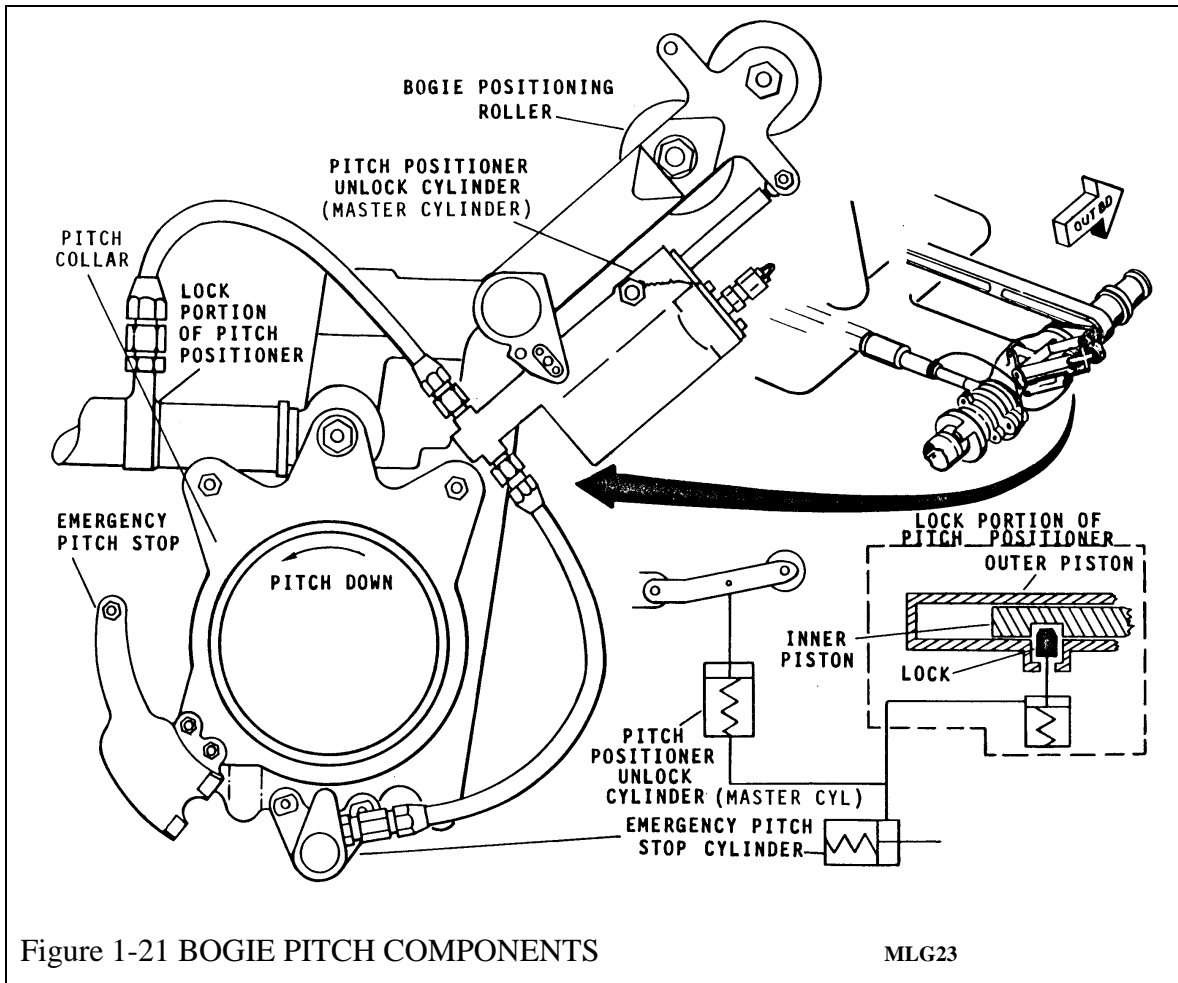
A lug is provided on the integral flange of the axle for attachment of the brake torque compensator link. Two mechanically linked collars are splined onto the inboard half of the axle. One collar includes three keys for inboard brake installation, while the second collar provides a mounting point for the pitch positioner rod end. The axle beam is interchangeable between the four possible bogie positions.

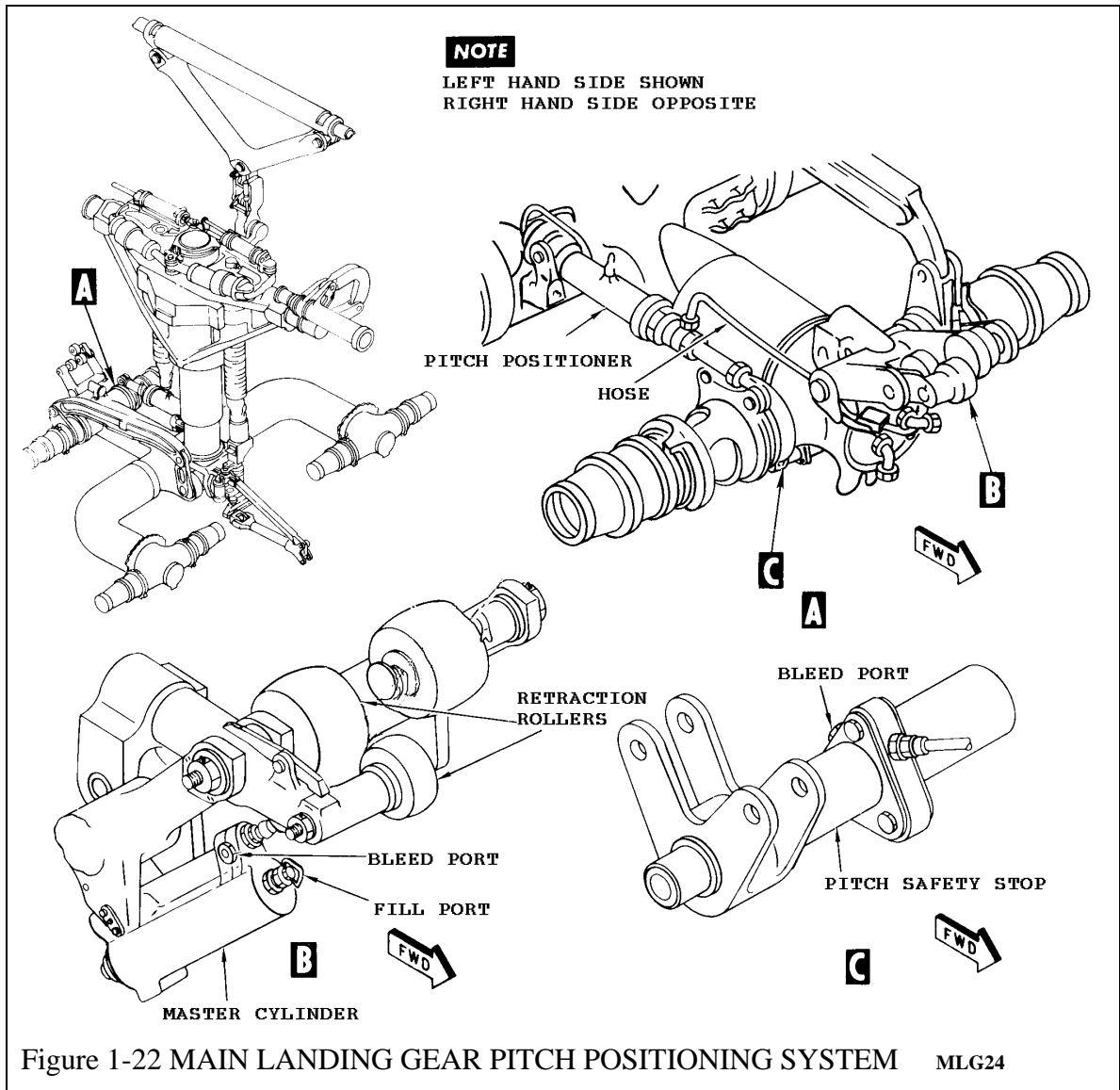
BOGIE PITCH POSITIONER—The pitch positioner is used to maintain a perpendicular relationship between the vertical line of the strut and the horizontal plane of the bogie when the gear is extended. The pitch positioner is located on the inboard side of each bogie forward-extending arm and consists of a pneumatically charged cylinder and a self-centering piston. The cylinder is attached to the bogie while the rod end of the piston is attached to the forward floating axle. During bogie pitch changes due to terrain conditions, the piston stroke allows approximately 11 degrees pitch up and 15 degrees pitch down. See figure 1-24.

The pitch positioner includes a valve for servicing and a pressure gage to check internal pressure. The positioner is precharged with dry air or nitrogen to a value that corresponds with a *Pressure vs. Temperature* Chart located on the positioner.

During retraction of the MLG assembly, the pitch positioner piston must be inserted into the cylinder beyond its normal travel to allow the perpendicular relationship between the bogie and the strut to form a greater angle for gear retraction. This is accomplished by directing hydraulic pressure into the cylinder, which repositions the internal stop keys. This allows pitch down of the bogie in order to assume an increased angle of approximately 175 degrees in relation to the strut centerline. Hydraulic pressure is directed into the cylinder lock chamber by a mechanically actuated hydraulic master cylinder mounted to the top forward side of the bogie forward extending arm. A roller and lever arm connected to the master cylinder is used to mechanically force hydraulic fluid from the master cylinder into the positioner lock chamber and also retracts the pin in the emergency pitch stop cylinder. The above action takes place during gear retraction as the roller and lever arm contacts the retraction guide track located on the top side of the wheel well. The reverse action takes place during MLG extension. Hydraulic fluid is allowed to reenter the master cylinder, allowing the positioner stop keys to assume their original position, thus relocking the rod to the piston.







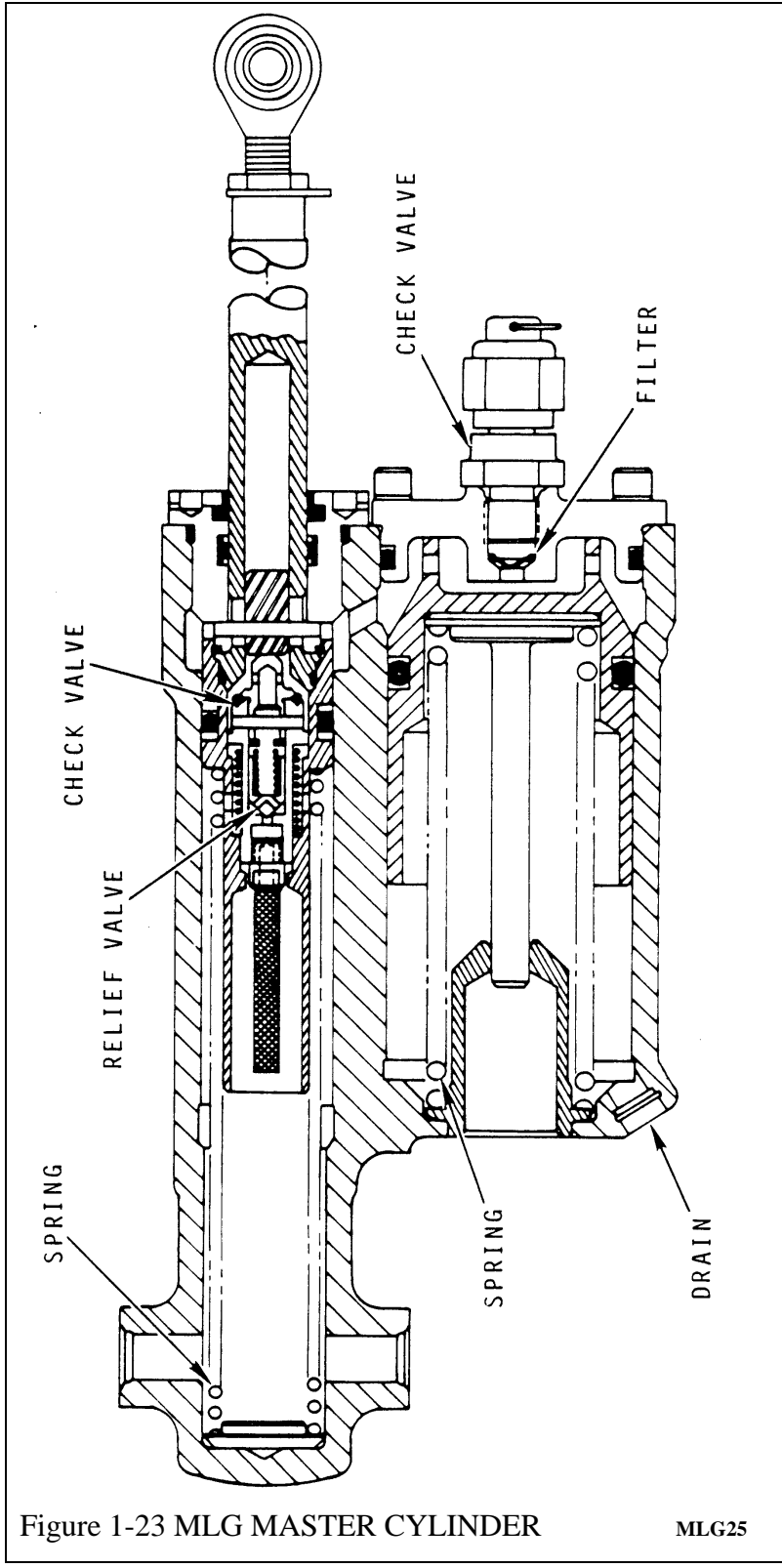
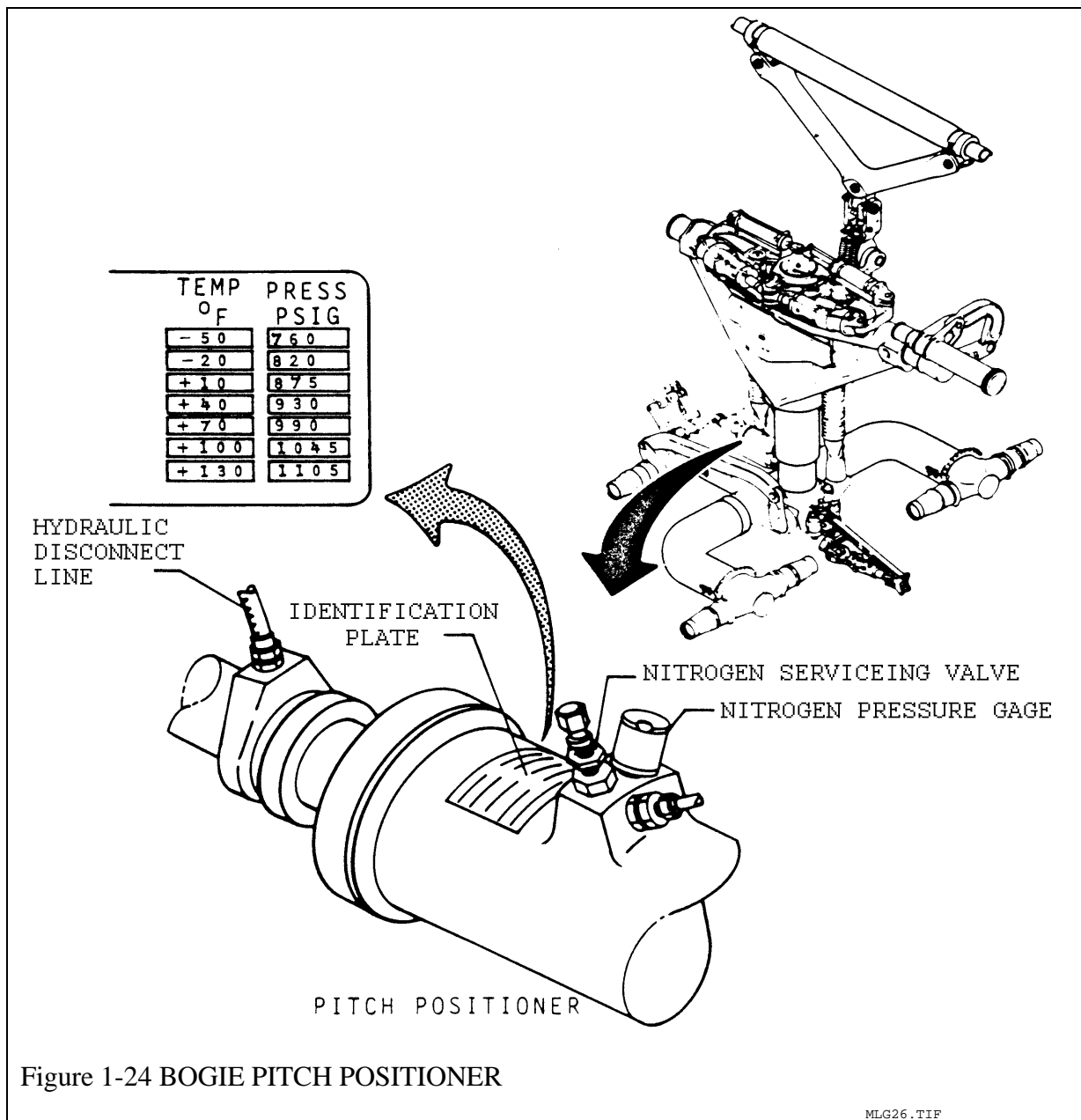


Figure 1-23 MLG MASTER CYLINDER

MLG25



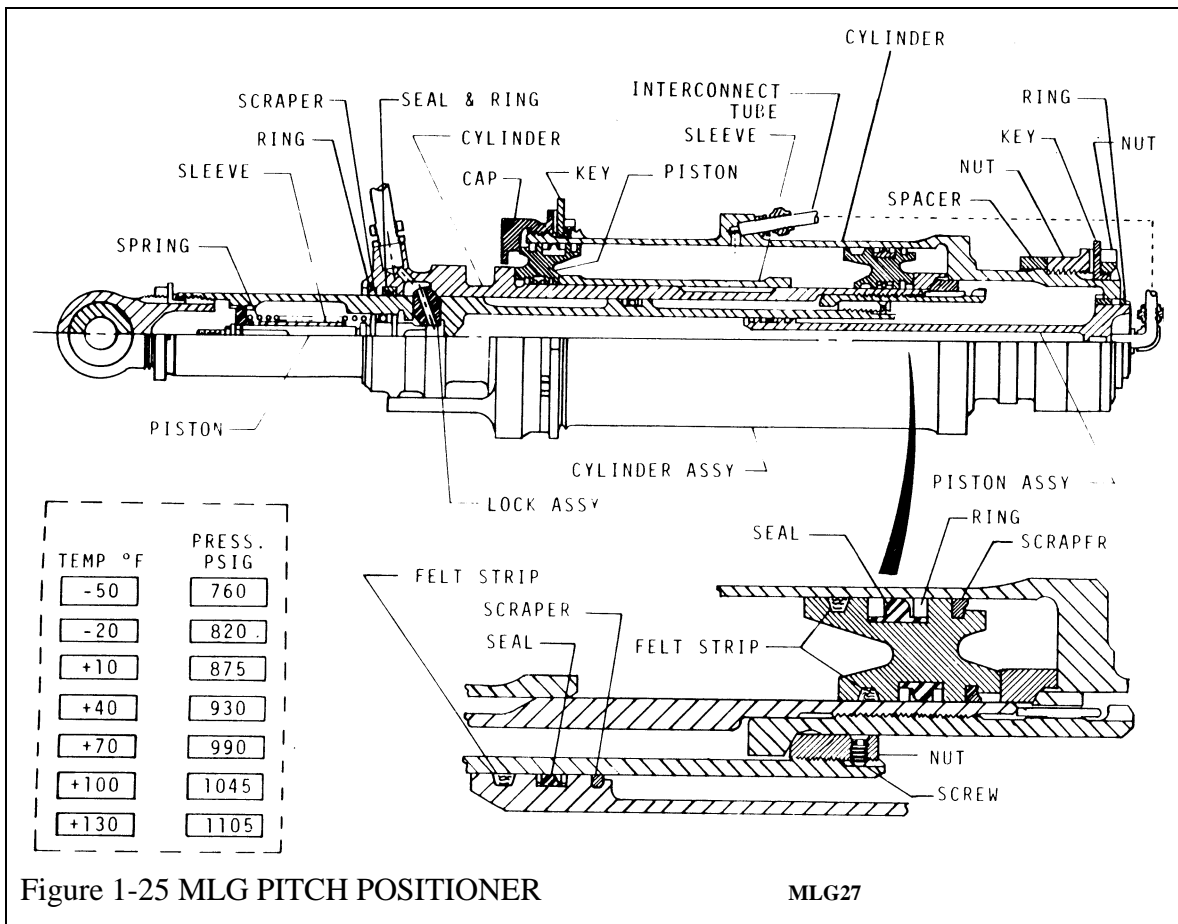
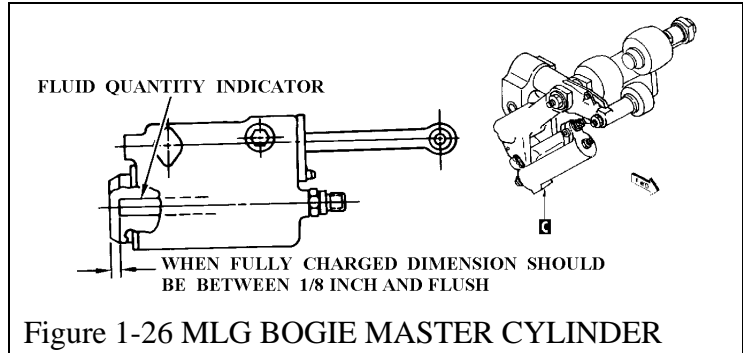


Figure 1-25 MLG PITCH POSITIONER

MLG27

Bleeding and refill of the bogie pitch positioning master cylinder is required when the fluid quantity indicator is recessed 0.500 inch or more and considered fully charged when the quantity indicator is between flush and 0.125 inch.



EMERGENCY PITCH-STOP—The emergency pitch-stop is a mechanical safety device mounted on the lower aft side of the MLG forward axle pitch collar. This device prevents the bogie from pitching down past a certain point in case of a pitch positioner malfunction when the gear is down and locked, and the wheels are off the ground. See figure 1-21.

BRAKE TORQUE COMPENSATOR LINK—The brake torque compensator link is a structural member installed adjacent to the longitudinal arm of the bogie center axle beam. The forward end of the compensator link attaches to a lug on the outboard side of the forward axle while the aft end attaches to the gudgeon pin. The compensator link counteracts the torquing action, which cause the forward wheels to dip and the rear wheels to rise when the brakes are applied. See figure 1-20.

ROLL POSITIONER CYLINDERS—Two roll positioner cylinders are mounted aft of the connecting point between the shock strut and bogie assembly. The two cylinders connect to lugs on the shock strut and roll pin. The roll positioner cylinders maintain the bogie perpendicular to the shock strut when the wheels are off the ground.

BOGIE POSITIONING ROLLERS—The bogie positioning rollers mount between lugs on the forward top side of the bogie assembly and engage the retraction guide track as the gear retracts into the wheel well. The positioning rollers guide the bogie along the retraction guide track as the bogie pitches from the perpendicular, in relation to the strut, to an angle of 175°. See figure 1-22.

PROXIMITY SWITCH SYSTEM

The proximity switch system consists of a variable reactance sensor and a solid state switch. The switch is actuated by bringing a steel plate (target) into proximity with the sensor. The system has no moving parts, will operate for unlimited switching cycles, will not interfere with other systems, and is fail-safe. The system will not operate if the sensor or wiring to the sensor opens or shorts.

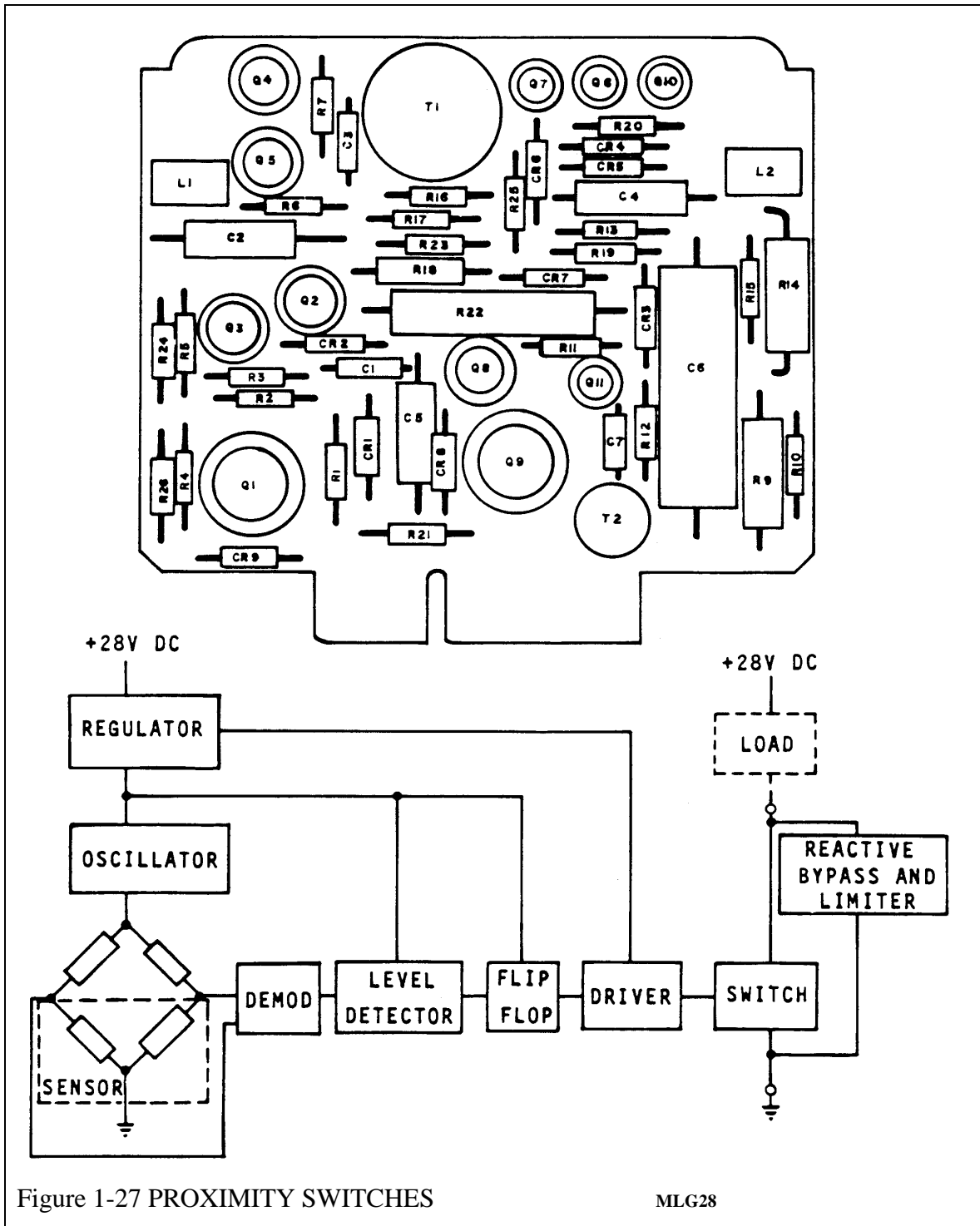


Figure 1-27 PROXIMITY SWITCHES

MLG28

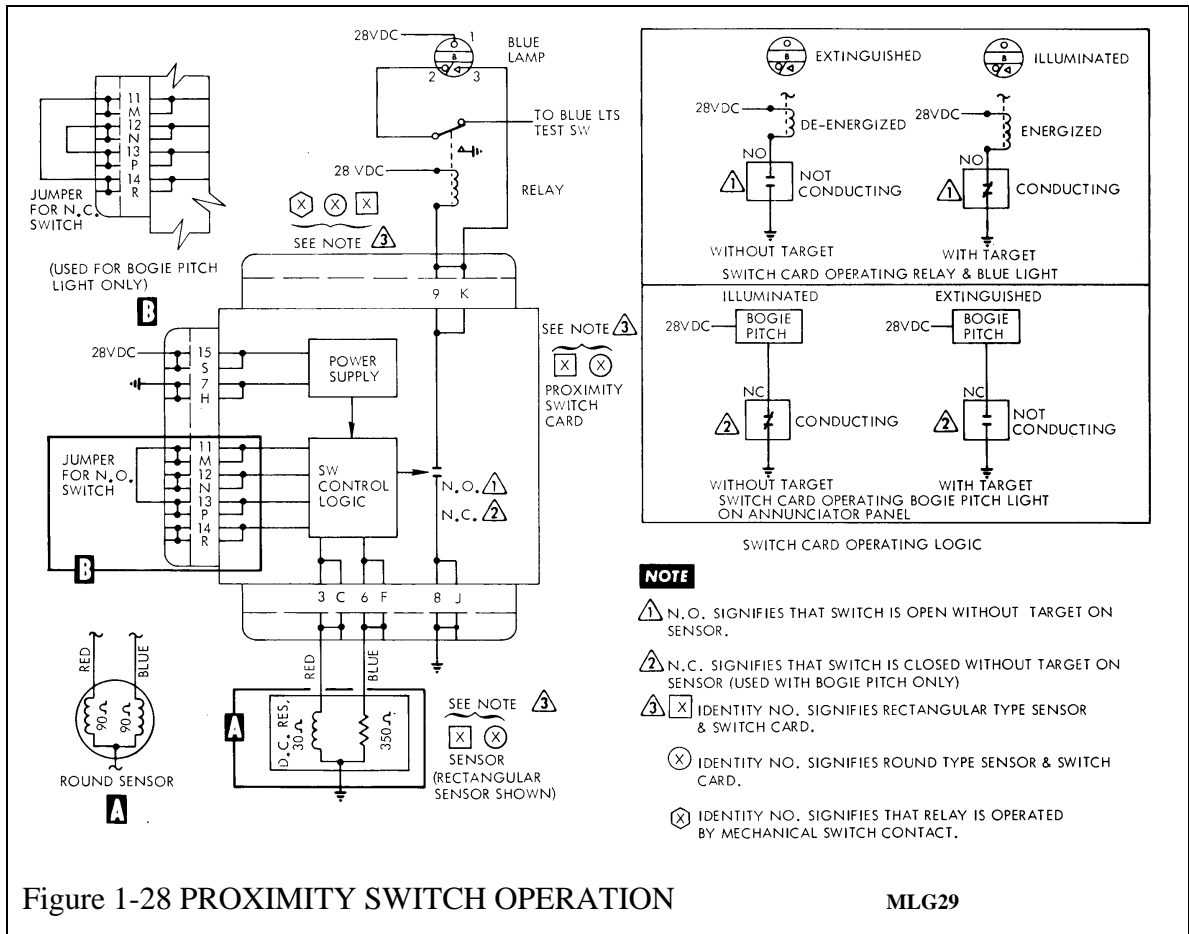


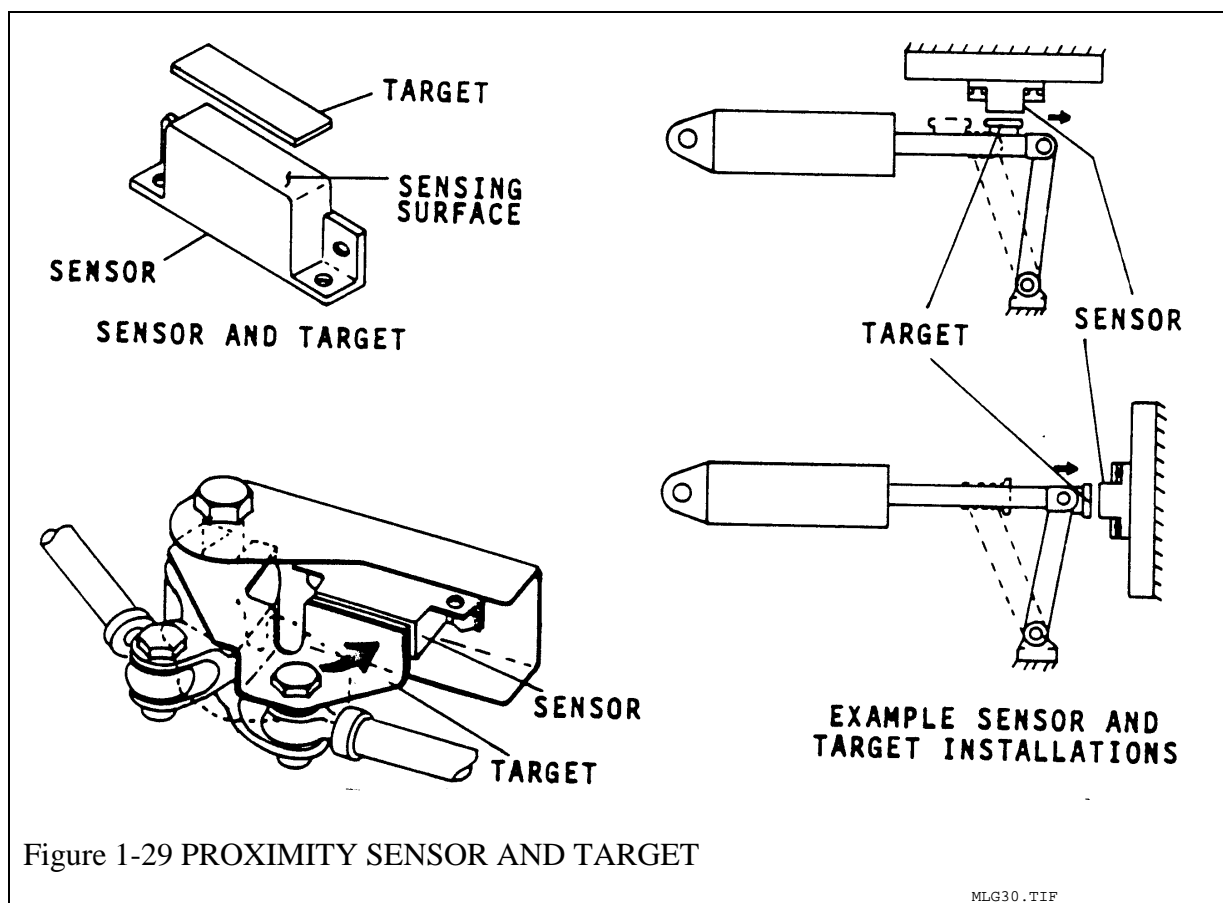
Figure 1-28 PROXIMITY SWITCH OPERATION

MLG29

The sensor is a magnetic, field-producing, coil-core combination imbedded in epoxy or ceramic depending on temperature operation. Electrical connections are permanently affixed Teflon-covered wire or threaded stainless steel studs.

The switch is a solid-state circuit, mounted on a printed-circuit board, and normally installed remote from the sensor in a controlled environment.

The sensor can be installed anywhere and exposed to almost any environment. It is normally installed in a fixed position, with the target affixed to the movable object to be sensed. The target may be brought into proximity with the sensing surface by any of three means: It may move across the sensing surface, move toward the sensing surface, or decrease the angle to the sensing surface.



The system operates as follows: As the target is brought into proximity with the sensor face, the reactance of the sensor varies. This variation creates a voltage change across the sensor coil, which is used to control a transistor switch. The transistor switch is rated for the high inrush current associated with lamp circuit operation. As the target is moved out of proximity, the transistor switch returns to its original condition.

MLG SEQUENCE CONTROL PANELS—DESCRIPTION

The MLG sequence control panels are installed in the cargo compartment for control of the landing gear hydraulic and electrical functions during retraction and extension. The RH and LH MLG sequence control panels are located on the side walls of the center

cargo compartment between the two related gear areas. The left panel controls the left FWD and left AFT gear. The right panel controls the right FWD and the right AFT gear.

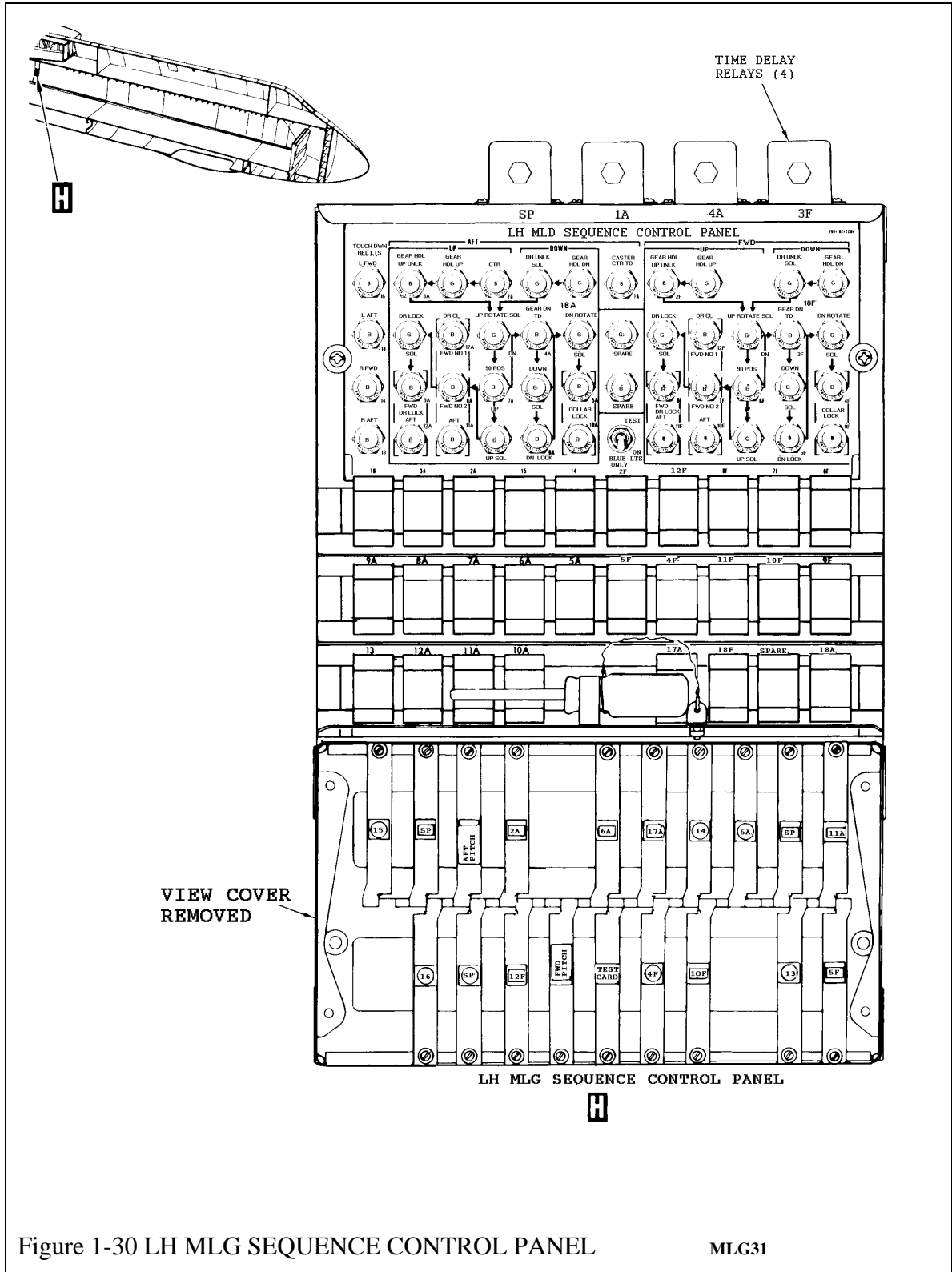


Figure 1-30 LH MLG SEQUENCE CONTROL PANEL

MLG31

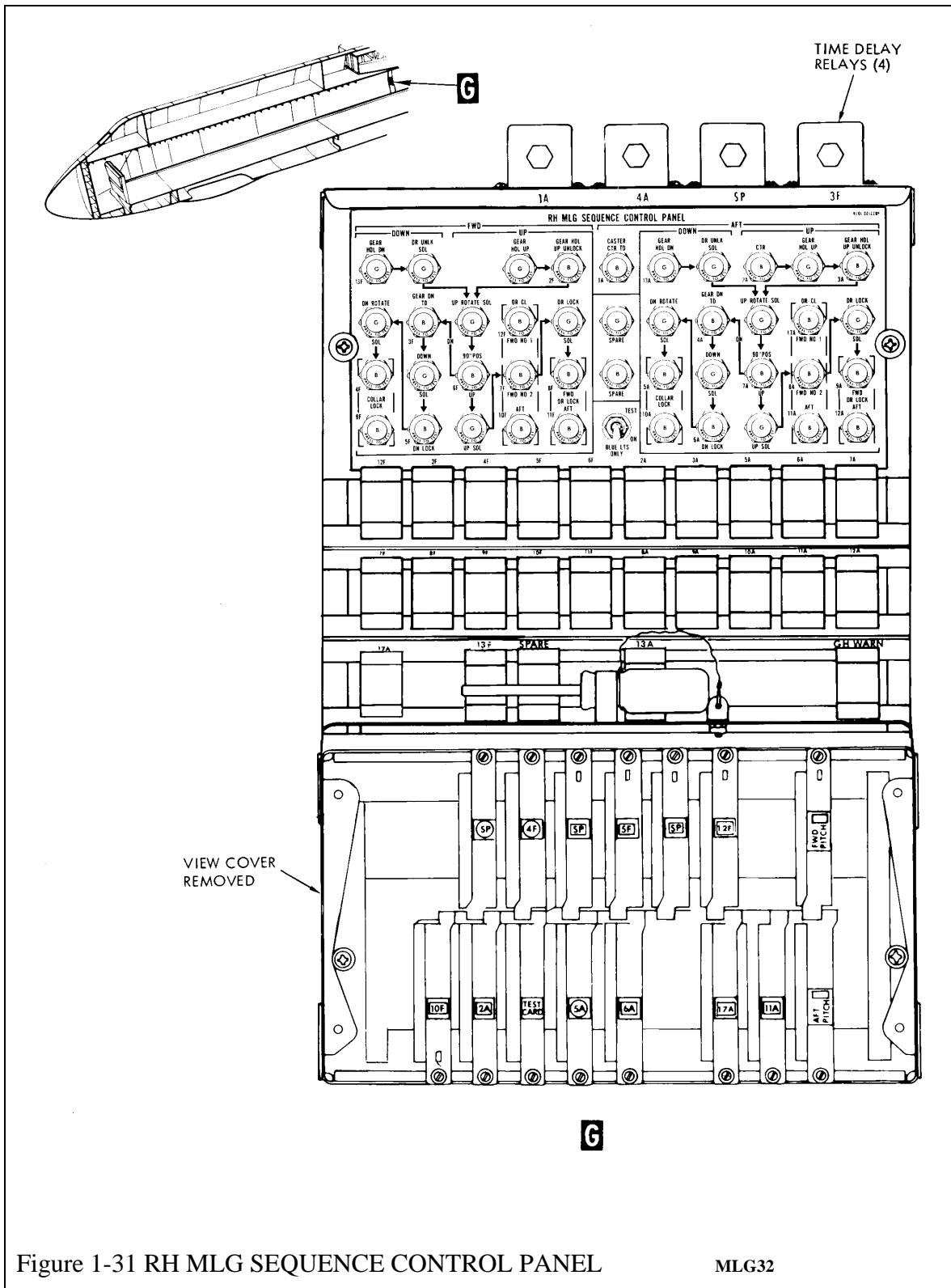


Figure 1-31 RH MLG SEQUENCE CONTROL PANEL

MLG32

COMPONENTS—Components used in each panel are similar and they consist of the following items:

- ◆ Relays
- ◆ Proximity switch cards
- ◆ Functional checkout lights
- ◆ Spare components
- ◆ Light panel decal
- ◆ Test card

RELAYS—Relays are used for relay logic in controlling external relays, hydraulic solenoid valves, and electrical motors. The relays located on the face of the panel are the plug-in type and are decal numbered or named. Four non-plug-in type, time-delay relays are located on top of each of the left and right panels. The numbered decals, which identify relays, also correspond to numbers identifying functional checkout lights. Spare relays provided on both the RH and LH control panels serve as replacement for relays located in the center section of the panels. Spares for the time delay relays are located on the RH MLG sequence control panel. The relay identified as SP is a spare for the 4A or 3F time delay relays on either the RH or LH panel. On the LH sequence control panel, the relay identified as SP is a spare for the 1A time delay relay¹ on either the RH or LH sequence control panel.

PROXIMITY SWITCH CARDS—Proximity switch cards are used to control relay operation. Identification decals are found on the card hold-down bar. Two types of switch cards are used. A circle or square on the decal designates card type. The card number or name found on the decal corresponds to related relays or system function. As an example of function, the FWD PITCH and AFT PITCH switch cards control warning lights at the flight station and are not related to relay control. The NLG CENTERED switch function is an example of a relay operation. If the gear is centered, the normally open CENTERED proximity switch will be closed and the CENTERED relay will be energized. Contacts of the CENTERED relay are located in the gear retraction sequence circuit. With the test switch in the ON position and the CENTERED relay energized, the CTR (centered) functional checkout light will illuminate. Switch cards coded with a square containing letters SP means that card is a spare card for switch cards coded with squares only. Switch cards coded with a circle containing letters SP means that card is a spare for cards coded with a circle.

FUNCTIONAL CHECKOUT LIGHTS—The functional checkout lights are the press-to-test type and have either green or blue lenses.

Green lights are used to monitor input and output control signals: gear handle up, up rotate solenoids, etc. The press-to-test feature checks the lamp of the green lights.

Blue lights are used to monitor relay operation. A blue light will illuminate when a corresponding relay is energized. The sequence control panel has a test switch, which is spring-loaded to the ON position that tests lamp integrity of only the blue lights when the

¹ Caster time delay relay.

switch is positioned to TEST. When the test switch is in the ON position an observer can monitor relay operation during gear operation.

The press-to-test feature of the blue lights is used to check for a faulty relay, switch card, or microswitch. A malfunction is indicated if the blue light fails to illuminate when operating the gear. If during this time of the operation sequence the light is pressed and the lamp illuminates, a failed relay is indicated. If the lamp remains extinguished, a failed switch card, microswitch, or wiring may be the problem.

MLG RETRACTION AND EXTENSION

GENERAL

There are four identical MLG hydraulic control systems, which provide power for operation of the four gear and door systems during retraction and extension. Normal power for the left and right forward MLG retraction and extension operations is furnished by the No.4 hydraulic system. Normal power for the left and right AFT MLG retraction and extension operations is furnished by the No.1 hydraulic system. Each of the four MLG hydraulic power systems is electrically controlled to initiate a simultaneous, automatic, and in-proper-sequence operation of each gear.

In case of a normal hydraulic system power loss, the affected gear can be pressurized by another hydraulic system using the hydraulic power transfer units. In case of a total hydraulic power loss, electric motors are used to provide emergency power for gear and door extension. During emergency operation, the door locks are unlocked by an alternate pressure source or an APU accumulator plumbed to individual emergency door lock-unlock cylinders. The No.1 hydraulic system, as an alternate, provides power for emergency rotation to the two forward gear assemblies, while the No.4 hydraulic system provides power for emergency rotation of the two aft gear assemblies. APU accumulators provide further reliability for the rotation cycle.

Gear and door cycles are initiated electrically from the flight station by operating the gear control handle and using two MLG sequence control panels; one for both left MLG installations and the other for both right installations. The sequence control panels are located on the cargo compartment inside wall between the respective wheel well areas. The electrical control system incorporates microswitches and proximity switches that provide validation of prerequisite gear and door lock positions so that hydraulic gear and door operations may begin once gear commands are given.

The following is a list of microswitches and proximity switches along with their locations and functions, which are used during retraction and extension operations. This list is typical of a MLG installation.

- ◆ Two door-lock microswitches, one located on the forward door lock cylinder, and the other located on the aft door lock cylinder. The two microswitches verify either locked or unlocked conditions of the MLG door locks.
- ◆ Two door-closed proximity switch sensors are located on the forward and aft inboard door lock stirrups. Targets are located on the inboard door locks.
- ◆ A MLG centered proximity switch, on No.3 and No.4 MLG only, verifies that a centered condition of the bogie and strut exists. The proximity switch target is mounted on the MLG positioning collar and its sensor is mounted on the crosshead assembly.
- ◆ A MLG downlock proximity switch verifies the down and locked or not locked conditions of the MLG. The target and sensor are mounted on the overcenter linkage of the MLG side brace assembly.
- ◆ The intercollar lock proximity switch verifies that the MLG intercollar lock assembly is either locked or unlocked. The sensor is located in the emergency intercollar lock cylinder.

- ◆ A 90-degree rotation microswitch verifies whether a rotated condition of the bogie and strut exists. The switch is located on the normal rotation cylinder.
- ◆ Pitch position sensor is located inside the cover at the end of the center axle beam. It indicates whether the bogie is level for landing. If the bogie is pitched up more than 11 degrees or down more than 15 degrees, a signal is sent to light the appropriate BOGIE PITCH light on the pilot's annunciator panel. There is a separate light for each bogie.
- ◆ Touchdown position sensor. Each MLG has a touchdown sensor. This sensor is actuated by a cam at the knee joint of the touchdown scissors linkage when the shock strut starts to compress. Either the two forward or the two aft MLG touchdown switches must be actuated to initiate a touchdown signal. This signal is used to make various airplane systems inoperative either in the air or on the ground. Elements within the avionics, guidance, and instrumentation systems are affected.

The following list identifies the solenoids and relays along with their locations that are used during normal and emergency MLG operations:

- ◆ Gear-up solenoid located on the MLG control manifold.
- ◆ Gear-down solenoid located on the MLG control manifold.
- ◆ Gear-down rotate solenoid located on the MLG control manifold.
- ◆ Gear-up rotate solenoid located on the MLG control manifold.
- ◆ Door lock solenoid located on the door uplock selector valve.
- ◆ Door unlock solenoid located on the door uplock selector valve.
- ◆ Emergency isolation solenoid located on the MLG control manifold.
- ◆ Emergency door unlock solenoid located on the emergency door unlock valve.
- ◆ Emergency inboard positioning solenoid located on the MLG emergency control manifold.
- ◆ Emergency outboard positioning and emergency outboard rotation solenoid located on the MLG emergency control manifold.
- ◆ Emergency system isolation solenoid located on the MLG emergency control manifold.
- ◆ Emergency MLG motor control relays located in the flight engineer's relay panel
- ◆ Emergency caster/powerback positioning SOV control valve located on the cargo compartment sidewall adjacent to the respective wheel well.
- ◆ Emergency inboard rotation relay located at the aft electrical equipment rack.

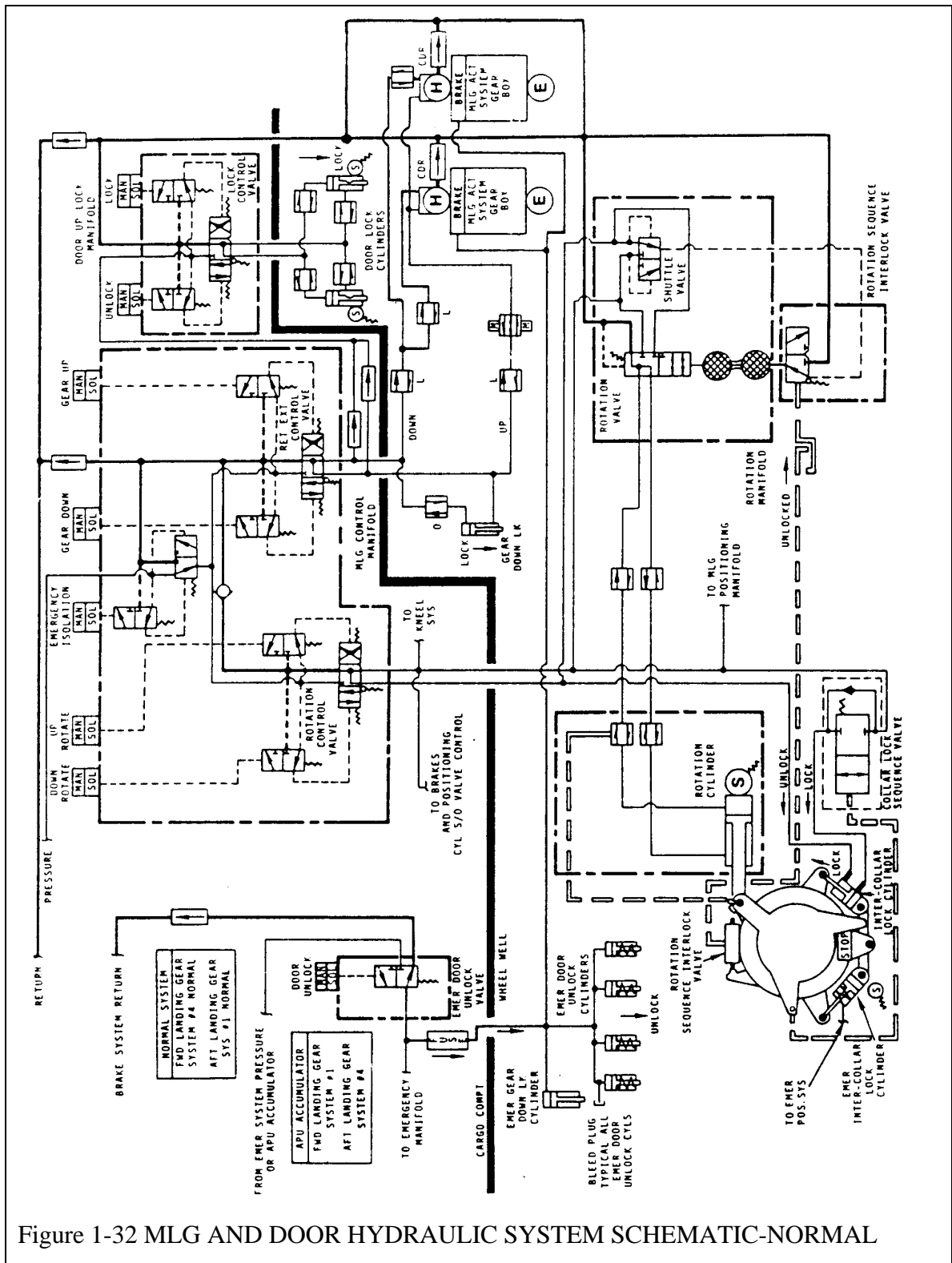


Figure 1-32 MLG AND DOOR HYDRAULIC SYSTEM SCHEMATIC-NORMAL

OPERATIONAL DESCRIPTION OF MLG RETRACTION AND EXTENSION

The following description outlines the normal retraction and extension of the right AFT MLG. The other three main gears are similar. The total operating time is 17 seconds maximum for retraction and 18 seconds maximum for extension.

GEAR-UP OPERATION—Prior to selection of gear-up, the gear handle is in the down position. The door unlock, gear-down, and down rotate solenoids are energized, and all three valves are detented in these positions. The landing gear position indicator shows green wheels.

Selection of gear-up initiates the following sequence: The gear handle light comes on and the gear-down, door unlock, and down rotate solenoids are de-energized, but will remain in their detented position. The anti-rotation spin up relay applies power to the GEAR HANDLE UP AND DOOR NOT LOCKED position relay when all wheels on the MLG stop rotating after takeoff. On the aft gears only, the GEAR HANDLE UP AND DOOR NOT LOCKED position relay will not energize until the center relay is energized by the center position sensor on the centered aft gears. Energizing the GEAR HANDLE UP AND DOOR NOT LOCKED position relay will energize the up rotate solenoid which positions the rotate pilot valve. The up rotate solenoid remains energized during gear retraction, keeping the normal rotation cylinder pressurized for the bogie to combat air loads and maintain alignment with the guide track. Pilot pressure shifts the rotation control valve from the detented down rotate position to the up rotate position and hydraulic pressure is applied to the following components:

1. Intercollar lock/unlock cylinder—The cylinder unlocks and mechanically opens the rotation sequence interlock valve.
2. Rotation manifold—Ports pilot pressure from the shuttle valve within the rotation manifold through the mechanically opened rotation sequence interlock valve which positions the rotation valve in the rotation manifold.
3. Normal rotation cylinder—Receives pressure from the hydraulically piloted rotation valve within the rotation manifold to rotate the bogie from 0-degree to 90-degree.

The position indicator shows red wheels.

Upon completion of bogie 90-degree rotation, the 90-degree microswitch energizes the 90-degree position relay, which completes the circuit to the gear-up solenoid. Pressure is then applied to the retract/extend control valve in the MLG control manifold. Pilot pressure from the energized solenoid operated gear-up pilot valve shifts the retract/extend control valve to the gear-up position which ports pressure simultaneously to the following:

- ◆ MLG downlock/unlock cylinder—Unlocks the side brace overcenter linkage.
- ◆ MLG actuators motors—Drives the hydraulic motors to retract the gear and close the doors.

- ◆ Door uplock manifold—Pressurizing the door lock cylinders to hold the door locks unlocked due to the de-energized door lock control valve being in the detented unlock position.

The landing gear position indicator shows in transit.

Upon completion of gear-up and doors closed, as sensed by the door closed proximity sensors, the door closed relays are energized. This completes the circuit to energize the lock solenoid in the door uplock manifold, which ports pilot pressure to lock the door locks.

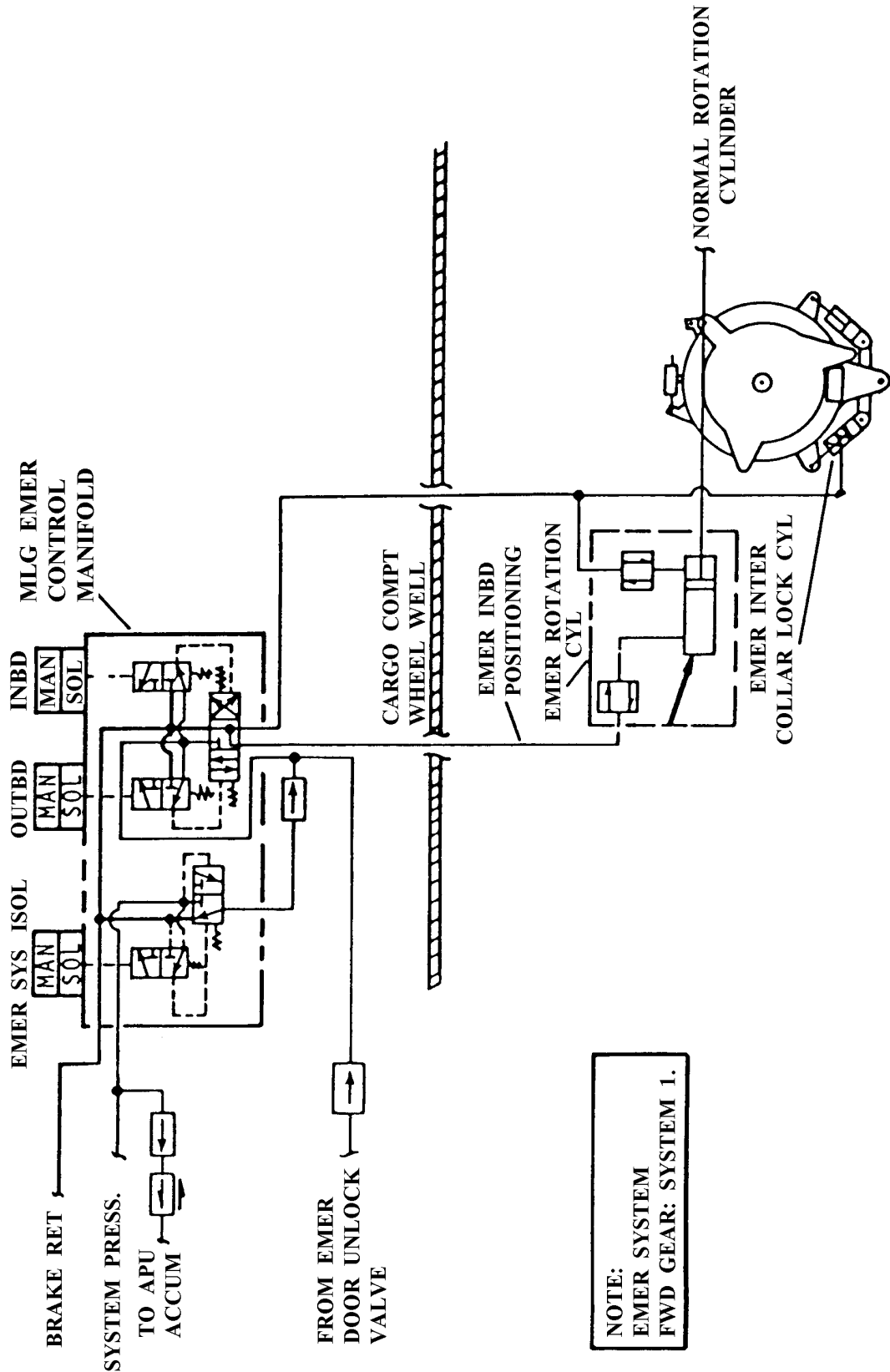


Figure 1-33 MLG EMERGENCY ROTATION HYDRAULIC SCHEMATIC

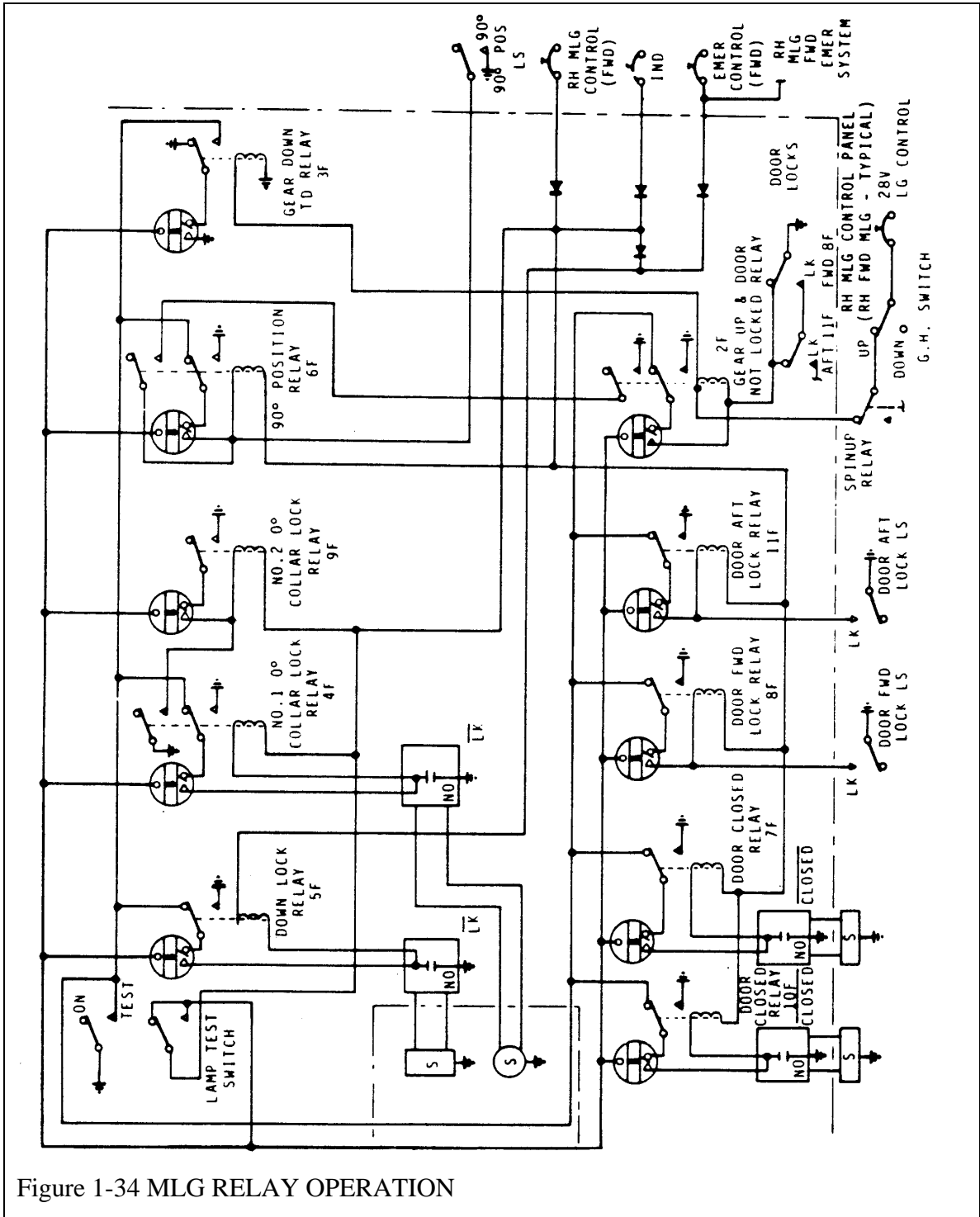
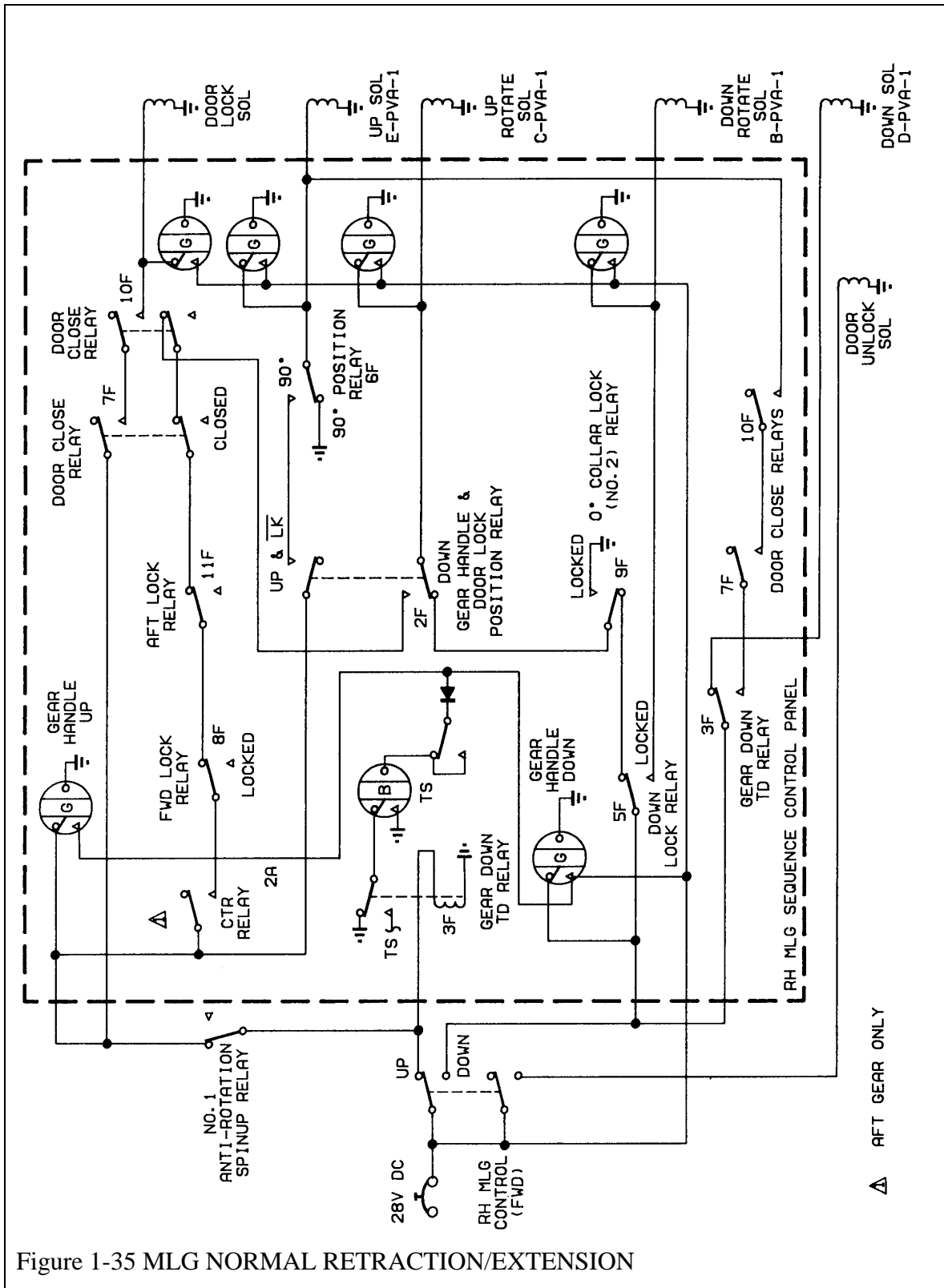


Figure 1-34 MLG RELAY OPERATION



Upon completion of door locking, the door lock limit switches close, energizing the door lock relays and repositioning the door lock relay switches. This de-energizes the GEAR HANDLE UP AND DOOR NOT LOCKED position relay, which de-energizes the gear-up solenoid and the up rotate solenoid. The rotation control valve in the MLG control manifold is centered. The door lock solenoid remains energized.

The landing gear position indicator shows UP and the light in the gear control handle goes out.

GEAR-DOWN OPERATION—Prior to selection of gear-down, the gear handle is in the UP position. The door closed relays are energized completing the circuit to energize the door lock solenoid. *The gear-down time delay is energized.* The landing gear position indicator shows UP. Selection of gear-down initiates the following sequence:

The gear handle light comes on. The door lock solenoid de-energizes and the unlock solenoid energizes to release the door locks when the retract/extend control valve shifts from its center position and ports pressure to the door lock manifold. The up rotate solenoid energizes, positioning the rotation control valve to port pressure to the rotation cylinder keeping the bogie at 90-degree to prevent the bogie from turning in the guide track as the gear comes out of the wheel well. The GEAR-DOWN TIME DELAY RELAY remains energized momentarily (approximately 1.75 seconds), and power is directed through the GEAR-DOWN TIME DELAY switch and the forward and aft door closed switches to energize the gear-up solenoid. This positions the gear-up pilot valve which pilots the retract/extend control valve to direct system pressure to the up side of the hydraulic motors. This pulls the gear-up, and unloads the door locks. The energized unlock solenoid will position its pilot valve to shift the lock control valve to direct system pressure to the door lock cylinders and unlock the door locks while the doors are unloaded.

Once the GEAR-DOWN TIME DELAY RELAY'S time has expired, power is switched from the GEAR-UP solenoid to the GEAR-DOWN solenoid, shifting the RETRACT/EXTEND control valve to drive the hydraulic motors, opening the doors and lowering the landing gear. Pressure is also directed to the lock side of the gear downlock cylinder to lock the gear in the downlock once it is fully extended. The landing gear position shows IN-TRANSIT.

Once the gear moves into the downlock, the following occurs: The downlock proximity sensor energizes the downlock relay, which closes the downlock switch. Then power is directed from the up rotate solenoid to the down rotate solenoid. The energized down rotate solenoid positions the down rotate pilot valve to port pilot pressure to the rotation control valve in the MLG control manifold. Pilot pressure shifts the rotation control valve to the down rotate position, and system pressure is directed to the rotation manifold, collar lock sequence valve, MLG brake manifold, kneel control manifold, and the caster/powerback positioning manifold (aft gears only).

Hydraulic pressure shifts the shuttle valve in the rotation manifold and flows through the shuttle valve to the mechanically positioned open rotation sequence interlock valve to the pilot section of the rotation valve. Pilot pressure positions the rotation valve in the rotation manifold, and system pressure is ported to the normal rotation cylinder to

rotate the bogie from the 90-degree to 0-degree position. The landing gear position indicator shows red wheels.

As the bogie reaches 0-degree, it mechanically opens the collar lock sequence valve which ports pressure to the lock side of the normal intercollar lock cylinder, locking the intercollar lock. Final movement of the collar lock mechanically positions the rotation sequence interlock valve, which now vents pilot pressure from the rotation valve in the rotation manifold and closes the rotation valve.

The 0-degree collar lock relay switch in the locked position prevents the MLG from going to an up rotate condition should the downlock relay switch fail in the NOT locked position. The landing gear position indicator shows green wheels.

NOTE: The gear-down solenoid, door unlock solenoid, and down rotate solenoid remain energized. This provides hydraulic pressure as follows:

- To the MLG actuators (to maintain the door open position which eliminates door vibration during landing and roll out).
- To the door lock actuators (to hold the door locks in an open condition).
- To the MLG caster/powerback system, the kneeling system, and the brakes.

The retract/extend control valve and the rotation control valve in the MLG manifold are detented in the gear-down and down rotation positions respectively to assure hydraulic pressure will be available to the brake system, the MLG caster/powerback system, the kneeling system, and the gear extension system if electrical failure occurs.

MLG EMERGENCY EXTENSION—If the MLG cannot be extended by the normal method, an emergency extend system using electric motors is provided. When the emergency extend system is selected, the main drive input shafts and hydraulic motors are prevented from rotating by hydraulically actuated brakes and the electric motors drive the gearboxes using the differential principle. When the gear is down, hydraulic system No.1 and No.4, as alternate systems, supply pressure for the emergency downlock actuator and for the emergency rotation cylinder. In the event that the hydraulic system used as an emergency backup pressure source is inoperable, the APU start accumulators plumbed into the systems function as backup hydraulic sources. System accumulator No.1 supplies pressure to the forward main gears and system accumulator No.4 supplies pressure to the aft main gears. A hand pump is provided at each APU accumulator installation and is plumbed into the respective pressure line to provide further backup as an emergency pressure source.

Four MLG EMERGENCY EXTEND switches located on the forward right side of the center console control emergency extension. Positioning an EMERGENCY EXTEND switch to EXTEND causes the red light in the landing gear control handle to illuminate and energizes the following relays and solenoids:

- ◆ Emergency isolation pilot valve in the MLG control manifold. The pilot valve operates the emergency isolation directional control valve, which cuts off normal system pressure and vents the normal system to return.
- ◆ The unlock solenoid in the door emergency unlock valve to allow the ALT hydraulic system, if available, or APU accumulator pressure to unlock the emergency door un-

lock actuators, to apply pressure to the emergency downlock actuator, and to lock the gearbox brakes between the hydraulic motors and the gearboxes. The position indicator now shows IN TRANSIT.

- ◆ The FWD and AFT emergency motor control relays allowing the emergency drive motors to open the doors and extend the gear. The AFT emergency motor control relay cuts power to the emergency outboard positioning pilot valve.
- ◆ Sends power to release the FWD and AFT emergency drive brake No.1 and No.2.
- ◆ The 90-degree rotation relay energizes the emergency inboard positioning pilot valve. The solenoid pilot valve positions the emergency positioning directional control valve. It directs pressure to the inboard positioning side of the emergency rotation cylinder to keep the gear rotated inboard while the gear extends.

Once the gear extends and locks in the downlock, the position indicator shows RED WHEELS. The DN switch (down lock relay) in the MLG sequence control panel opens to cut power to the FWD and AFT emergency motor control relays. They stop the two motors and de-energize the motor brakes. The DN lock switch cuts power to the 90-degree rotation relay. This de-energize the emergency inboard positioning pilot valve and energizes the emergency outboard positioning pilot valve. The emergency positioning directional control valve then directs pressure to the outboard positioning side of the emergency rotation cylinder to rotate the bogie 90-degree to the 0-degree position.

Once the bogie rotates to 0-degree and the collar locks, the collar lock switch closes to illuminate the EMERGENCY SW ON light. When the EMERGENCY EXTEND switch is returned to NORMAL, the EMERGENCY SW ON light extinguishes. All remaining emergency solenoids are de-energized.

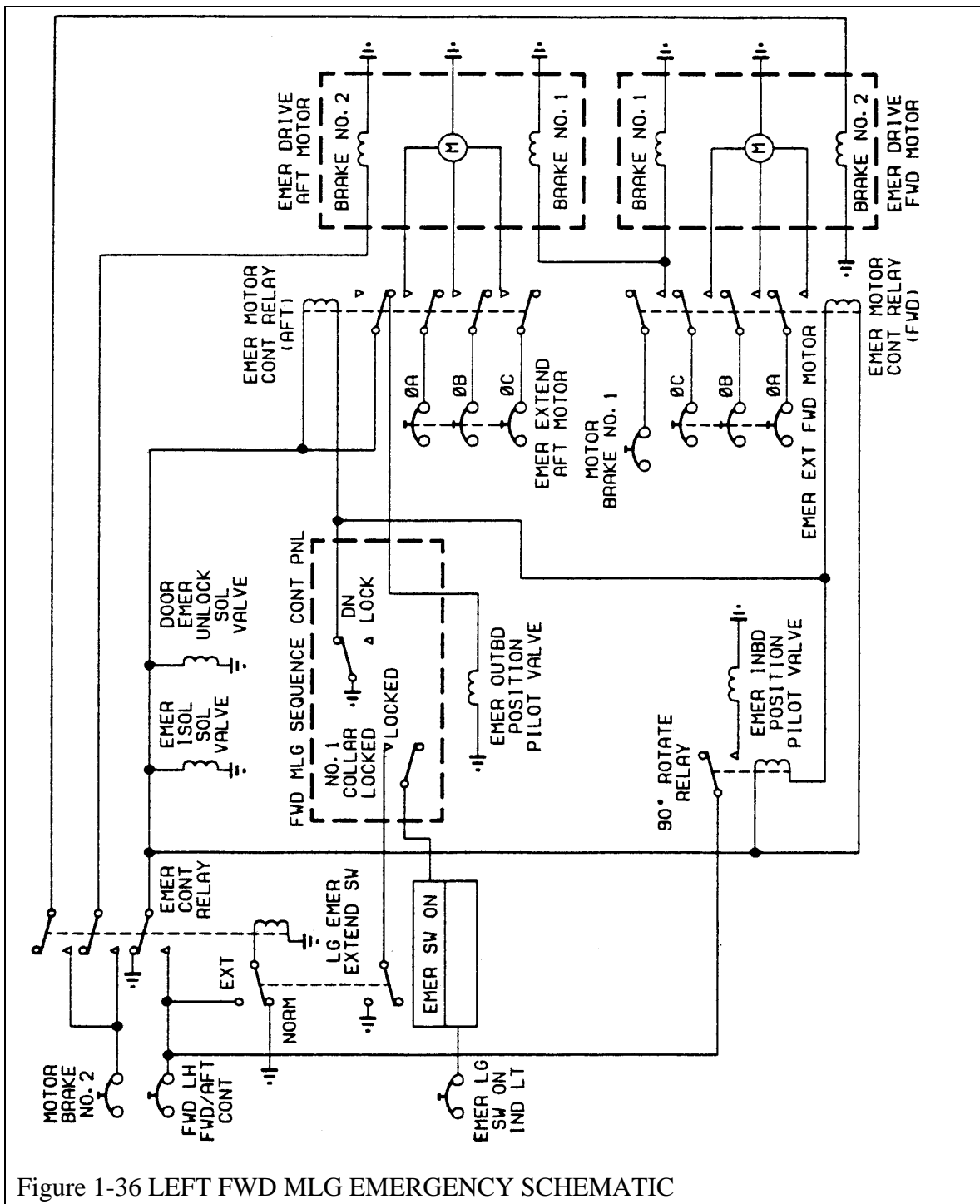


Figure 1-36 LEFT FWD MLG EMERGENCY SCHEMATIC

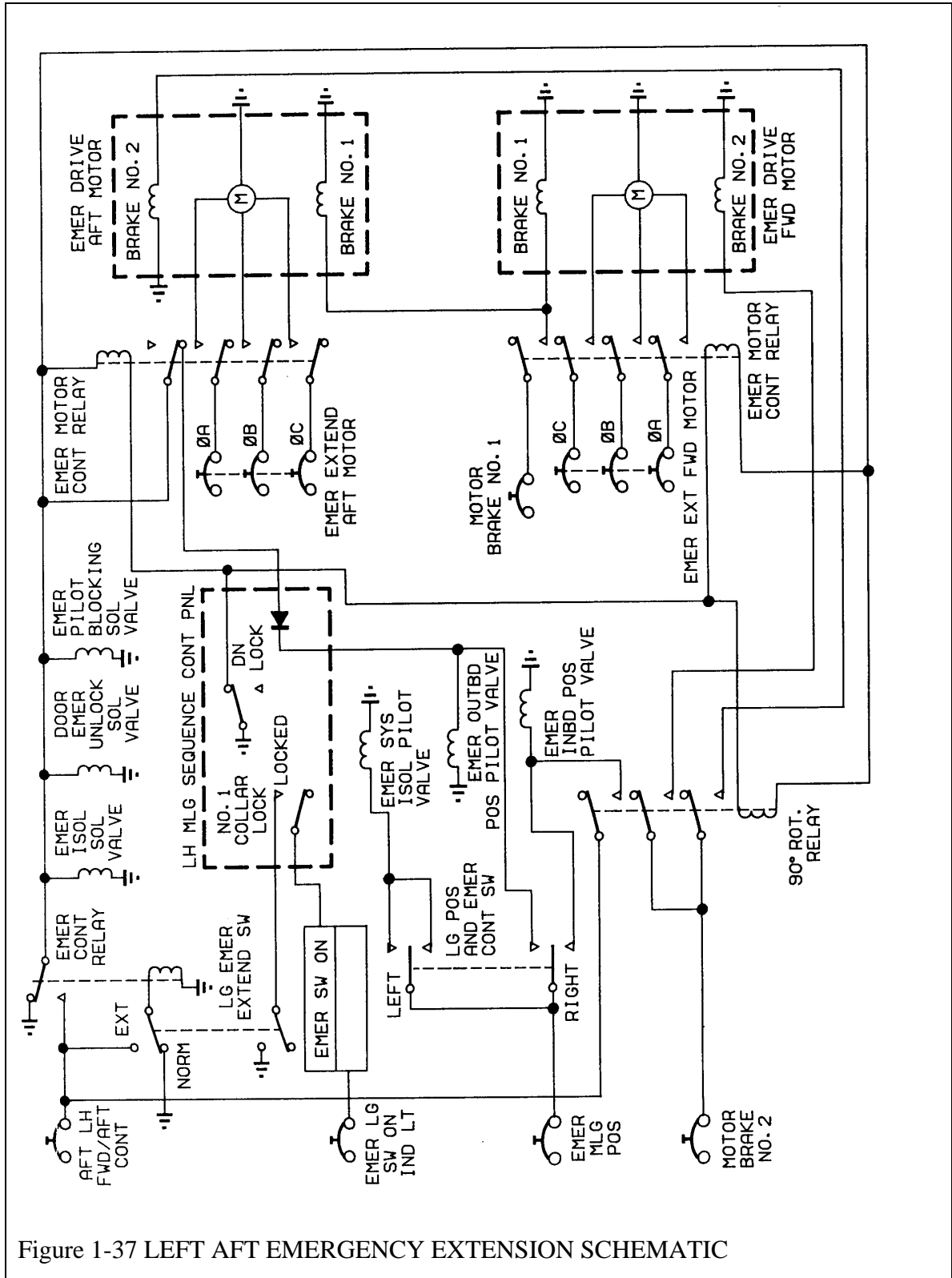


Figure 1-37 LEFT AFT EMERGENCY EXTENSION SCHEMATIC