

Shuttle Flight Operations Manual

U01 10C

Volume 10C
Payload Bay Doors/Radiators

Flight Operations Directorate
Crew Training and Procedures Division

Basic
January 22, 1979



National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
Houston, Texas

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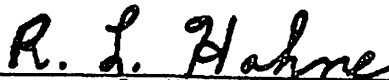
FLIGHT OPERATIONS DIRECTORATE

Basic

SHUTTLE FLIGHT OPERATIONS MANUAL
Volume 10C Payload Bay Doors/Radiators

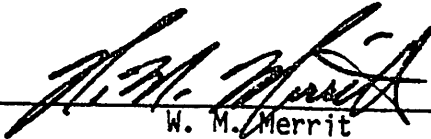
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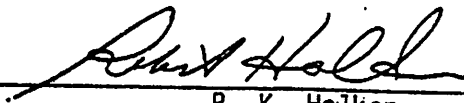


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SECTION 1
INTRODUCTION

The Payload Bay Doors (PBD's) provide an opening for payload deployment and retrieval, provide structural support for the Environmental Control and Life Support Subsystem (ECLSS) radiators, and react to mid-body torsional loads. Each door supports four radiator panels. The two forward radiator panels on each door are deployable, and the two aft radiator panels on each door are permanently attached to the doors. The four deployable panels are latched to the inner side of the PBD's. When the doors are opened, the deployable radiators can be unlatched and deployed to a fixed position, thus allowing heat radiation from both sides of the panels. The four aft radiator panels only radiate heat from the upper side. The purpose of the eight ECLSS radiators is to allow the radiation of excess heat from the Orbiter vehicle systems. Figure 1-1 shows the location of the PBD's, deployed and fixed radiator panels, latches, and drive mechanisms.

OV-102 & SUBS

- PLBD DRIVE SYSTEM
OPENS/CLOSES PAYLOAD BAY DOORS

- PBD LATCH SYSTEM
LOCKS PAYLOAD BAY DOORS

- RADIATOR DEPLOYMENT SYSTEM
DEPLOYS/RETRACTS RADIATORS PLB DOOR DRIVE (TYP.)

- RADIATOR LATCH SYSTEM
LOCKS/SUPPORTS RADIATORS

1-2

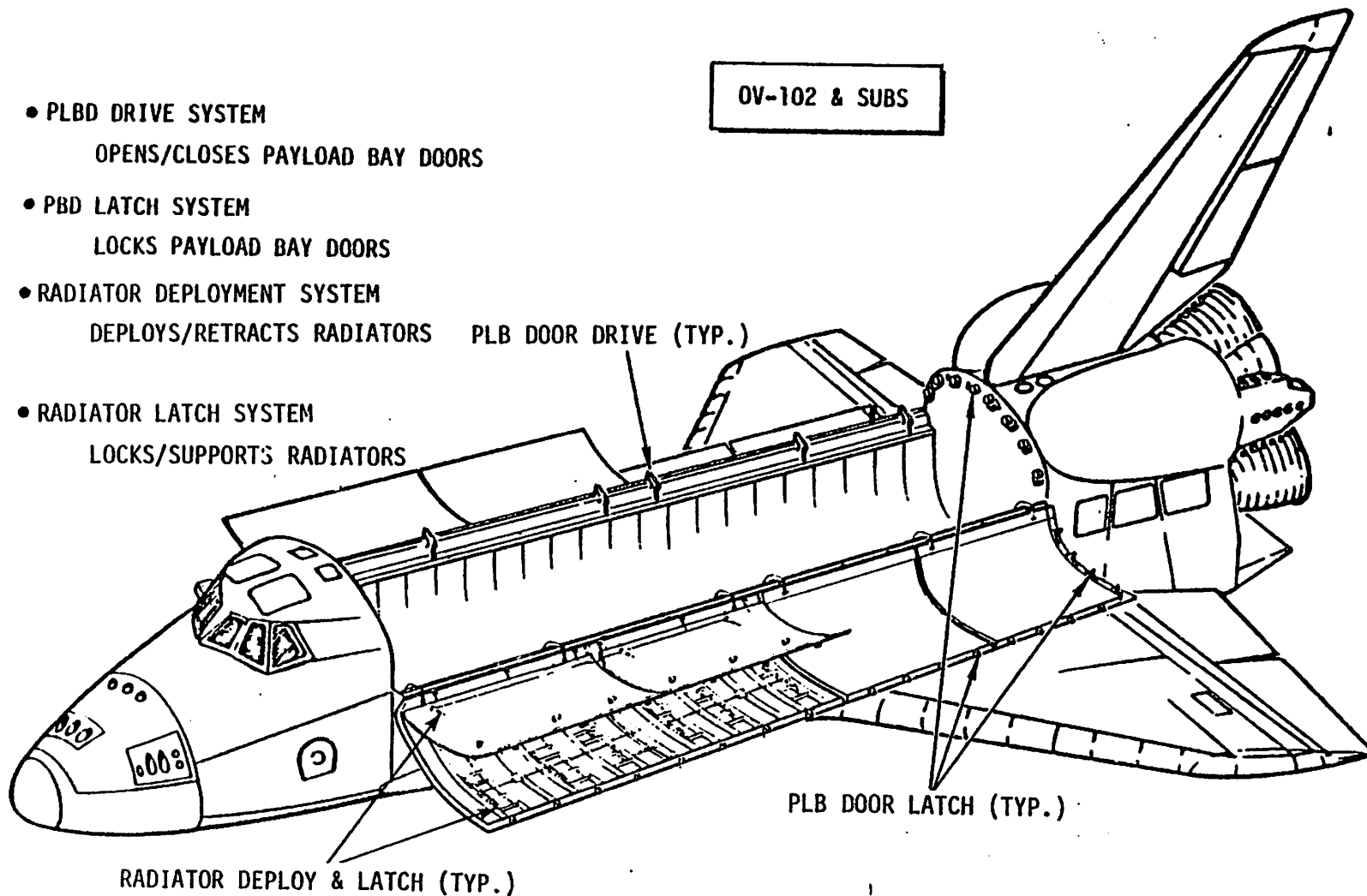


Figure 1-1.- PBD mechanisms.

10C-PBD/R

SECTION 2
SYSTEM INTERFACE

The PBD's/radiators interface with other vehicle systems as follows:

- A. Structure - provides structural support for PBD and radiator panels, hinges, latches, and deploy and stow mechanisms.
- B. ECLSS - Radiator panels interface with the ECLSS via the freon coolant loop plumbing.
- C. Electrical Power Distribution and Control System (EPDCS) - furnishes electrical power for the PBD/radiator latch motors, deploy/stow motors, telemetry transducers, limit switches, and status flags.
- D. Displays and Controls (D&C) - provides crew control and monitoring of systems operation and status via switches, circuit breakers, status flags, and Caution and Warning (C&W).
- E. Data Processing System (DPS) (GPC's) - receives system parameter inputs for Systems Management (SM) monitoring and control of PBD's; provides computer keyboard input capabilities for automatic or manual control of PBD operations.
- F. Instrumentation - receives PBD/radiator system parameters inputs for telemetry of system status to the ground and onboard.
- G. Thermal protection system - outer PBD surface insulation provides thermal protection when the PBD's are closed.

SECTION 3 SYSTEM DESCRIPTION

3.1 PAYLOAD BAY DOORS

The port and starboard doors are 60 feet long and have a combined area of approximately 1600 ft². Each door is made up of five segments interconnected by circumferential expansion joints. Each door is connected to the mid-fuselage by 13 hinges (Fig. 3-1). There are five shear hinges and eight floating hinges. The floating hinges allow fore and aft movement of the door panels (for thermal expansion).

The port door weighs 2375 pounds and the starboard door weighs 2535 pounds. The starboard door contains the centerline latch active mechanisms, which accounts for the weight difference. These weights do not include the weight of the radiator system - 833 pounds per door.

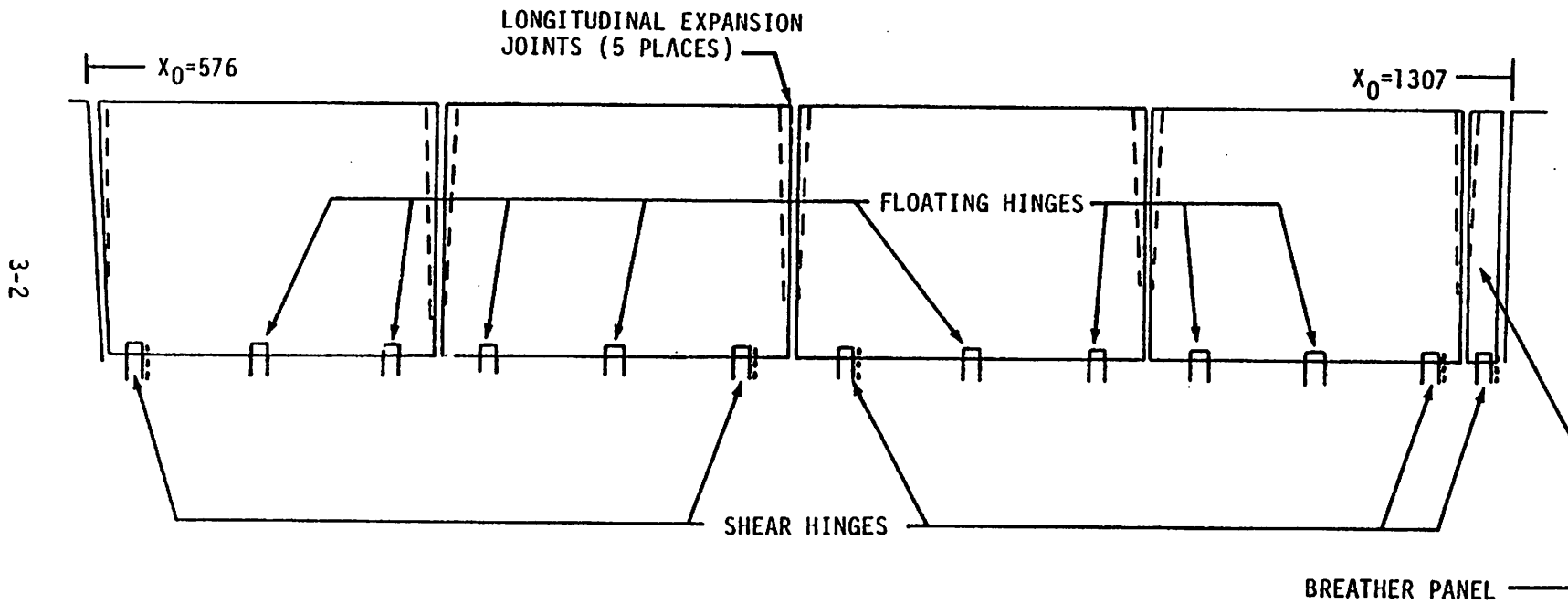


Figure 3-1.- Payload bay door.

Sixteen centerline latches (eight aft bulkhead latches, and eight forward bulkhead latches) secure the doors in the closed position.

Figure 3-2 shows the location of the door latches as well as the centerline latch numbering system. The PBD latches are in groups of four ganged latches each. Each group of latches is driven open or closed by two redundant 3-phase AC motors. The PBD latch groups can be opened/closed in a predetermined sequence automatically or by single individual latch groups (manual mode). All PBD AC motors are reversible by reversing two of the three phases by switch action. When opened in orbit, the doors rotate about their hinges by approximately 174°. Each door is driven open/closed by two redundant 3-phase AC motors (reversible). The starboard door must be opened first and closed last due to the centerline latch mechanisms' arrangement. Each motor in the PBD latch and door drive system is turned off at the end of its travel by limit switches. In the event of limit switch failure to turn off a motor, torque limiters within each motor actuator assembly are utilized to allow slippage, thus preventing damage to the motors or mechanisms.

3-4

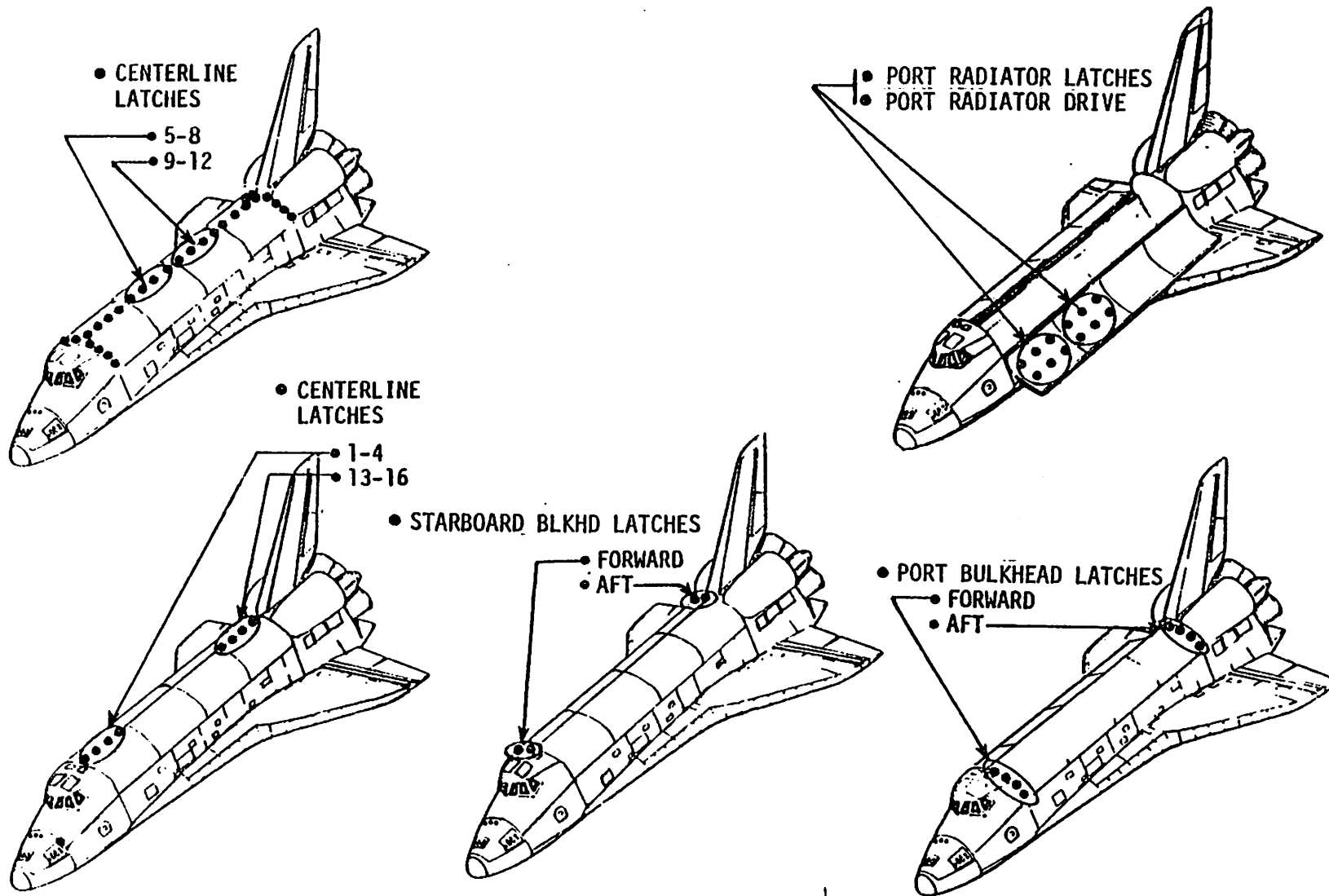


Figure 3-2.- PBD/radiator latches.

10C-PBD/R

3.1.1 Centerline Latches

Figure 3-3 is a block diagram of a centerline latch group which shows the various components and their relationship within each assembly.

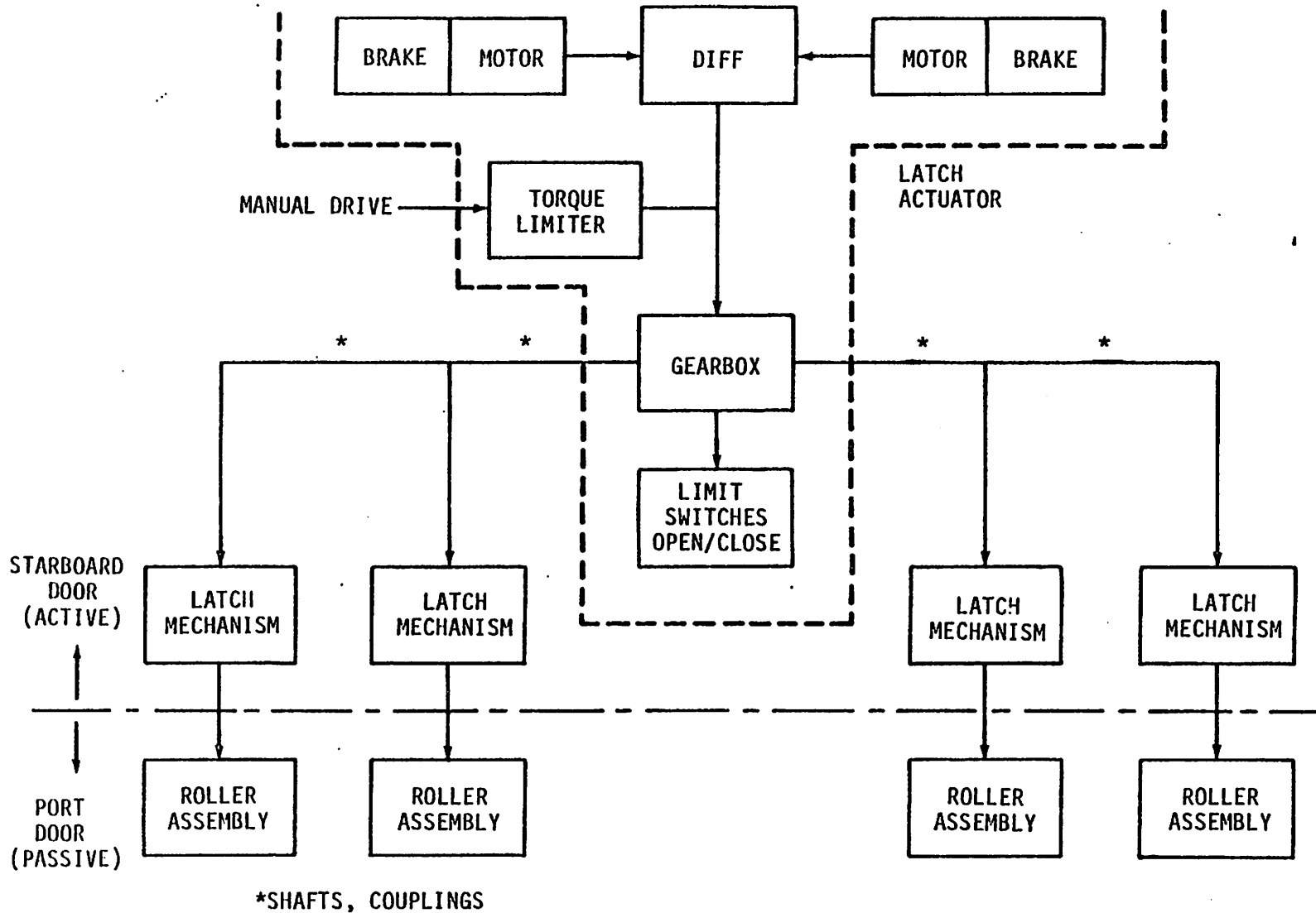


Figure 3-3.- Centerline latches mechanical block diagram (typical 1 of 4).

Figures 3-4 and 3-5 show Extravehicular Activity (EVA) disconnects within a centerline latch group which can be used to isolate a failed (jammed) latch from the group. Each of the four centerline latch groups contain these EVA disconnects.

The passive shear fittings (Fig. 3-4) within each centerline latch group are used for door alignment when closing as well as reacting fore and aft shear loads once the doors are closed.

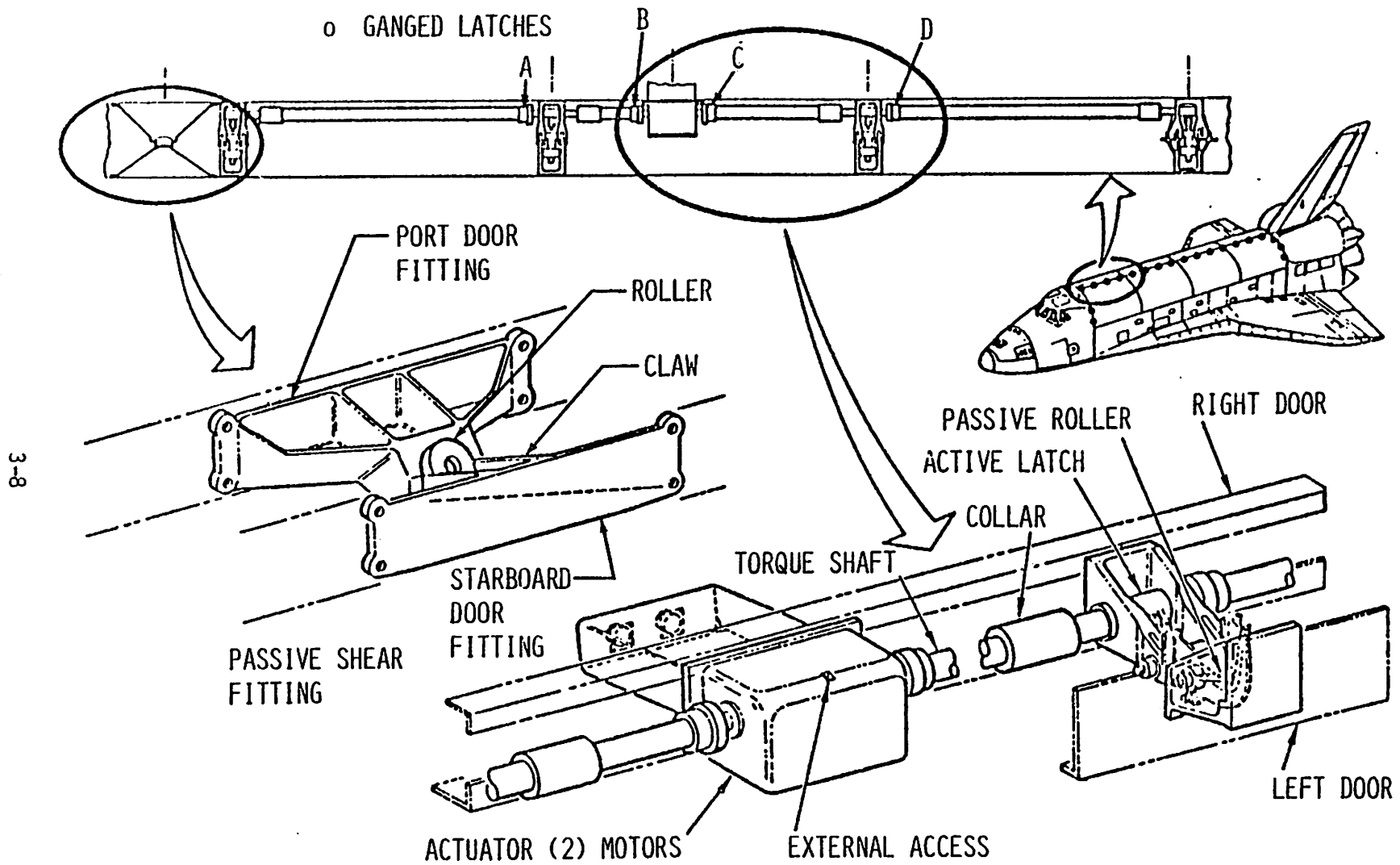


Figure 3-4.- Upper centerline latch system.

10C-PBD/R

3-9

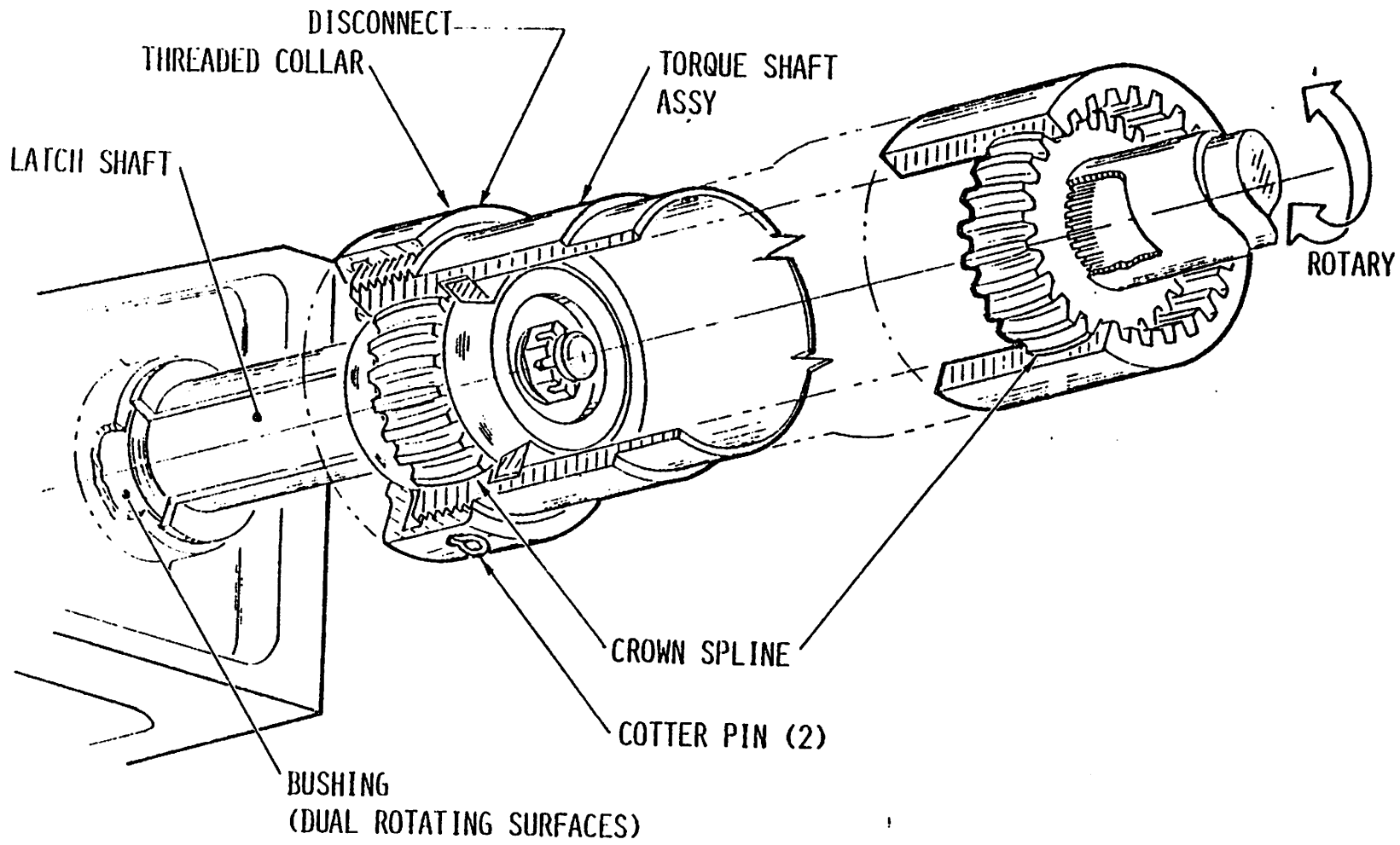


Figure 3-5.- EVA disconnect of torque shaft from actuator and latch assembly.

10C-PBD/R

Figures 3-6 and 3-7 show a typical centerline latch (hook) and roller interface (with deflection rollers removed for clarity).

Figures 3-8 and 3-9 show the deflection rollers and their interface with the hanger assembly on the port door (active hook not shown). The deflection rollers eliminate PBD overlap (due to thermal distortion) during door closing. All 16 centerline hook assemblies contain these deflection rollers. Twenty seconds are required to open or close a group of centerline latches (both motors operating). If one of the latch group motors fails, the operating time is 40 seconds. In Figure 3-6 it can be visualized that as the torque shaft rotates, the bellcrank and link cause the hook to rotate closed (or open), engaging the latch (hook) roller on the port door. In the auto mode of operation, the latch group motors will be automatically turned off if the operating time exceeds twice the normal time. If the Auto mode is terminated due to a failure, (operating time exceeded) a PLB DOORS CRT message and SM alert will occur.

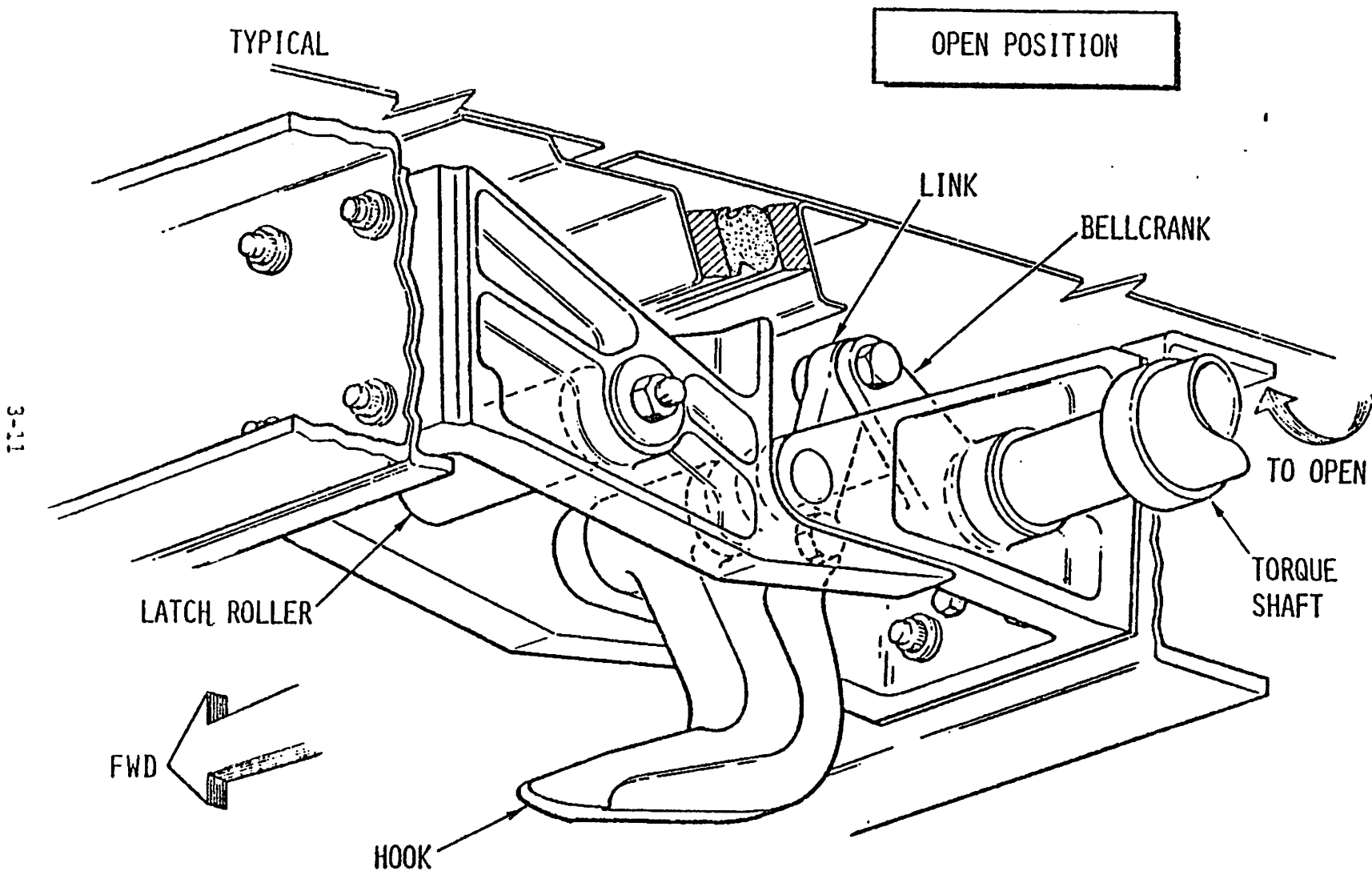


Figure 3-6.- Centerline latch hook (typical), open position.

10C-P8D/R

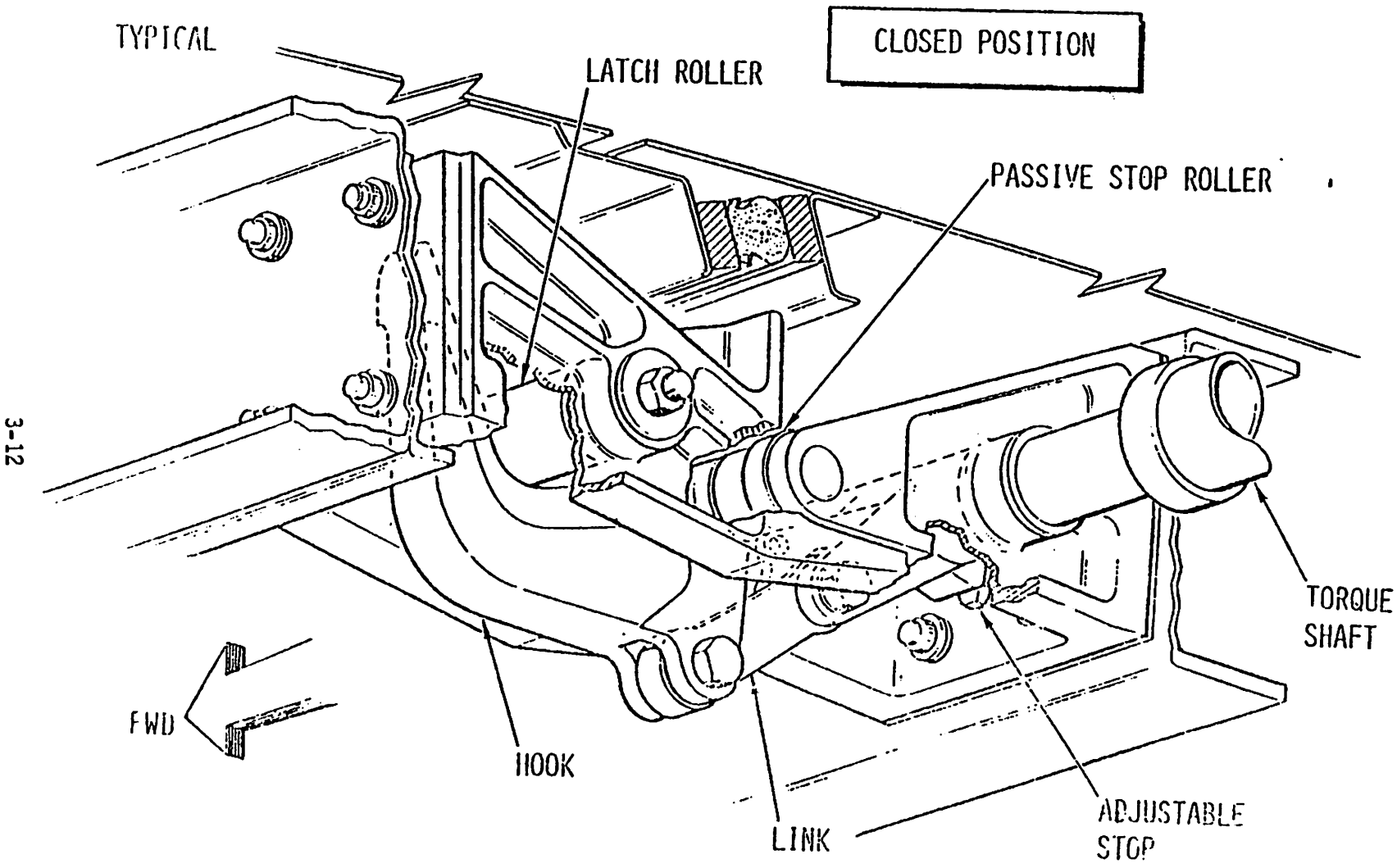


Figure 3-7.- Centerline latch hook (typical), closed position.

10C-PBD/R

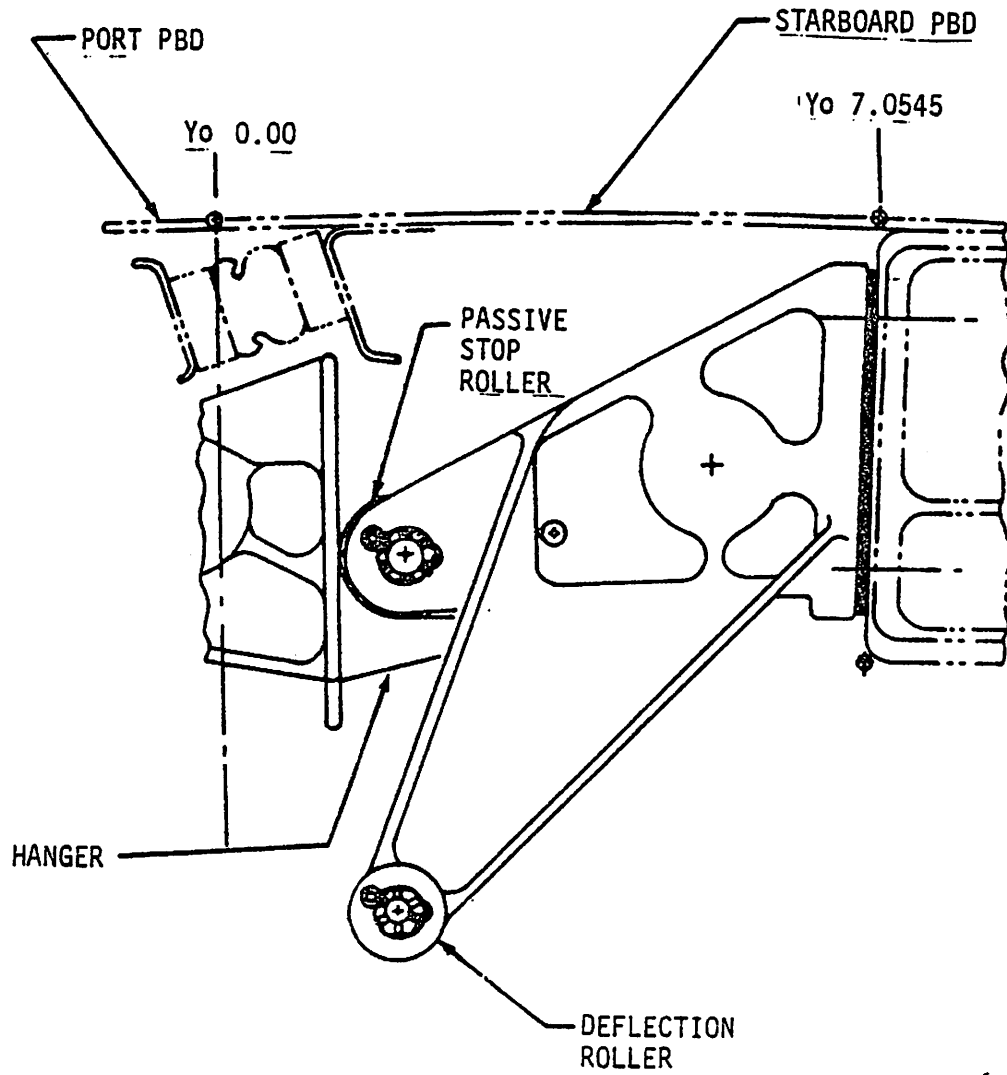


Figure 3-8.- Centerline latch hook.

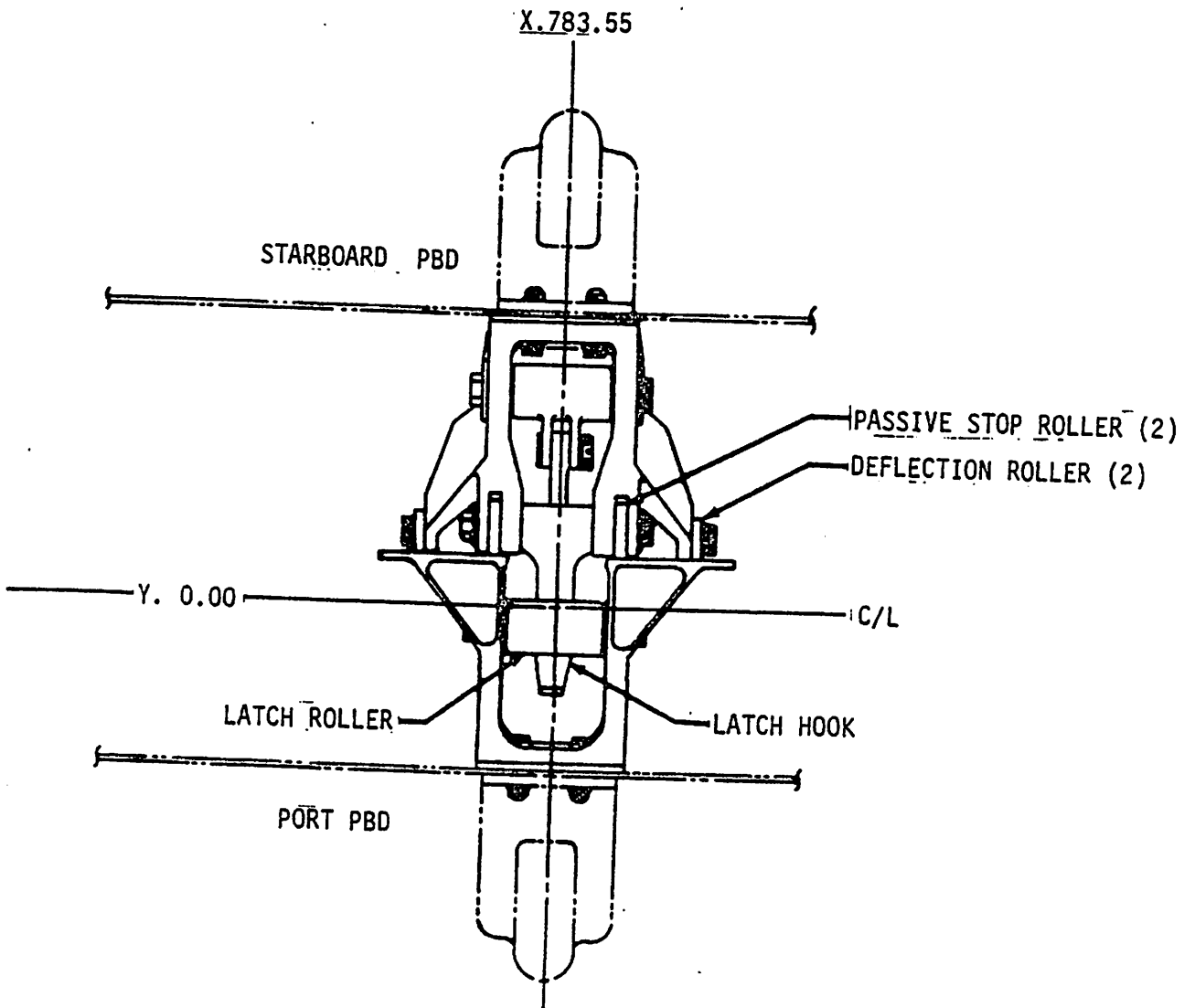


Figure 3-9.- Centerline latch hook, top view.

3.1.2 Bulkhead Latches

Figure 3-10 is a block diagram of one of the four bulkhead latch groups. Note the three "ready to latch" and one "door closed" switches in the lower right of the diagram. These four switches are enclosed in a switch module mounted on the bulkhead. Two switch modules per door are utilized (one on the forward bulkhead and one on the aft bulkhead.) When the door is nearly closed, it comes in contact with the striker arm on the switch modules and the "ready to latch" switch contacts are made, which activate the forward and aft bulkhead latch group motors. When the door is fully closed, the door closed switch turns off the door drive motors. The aft bulkhead switch module activates the aft bulkhead latch motors and turns off one door drive motor, and the forward bulkhead switch module activates the forward bulkhead latch motors and turns off the other motor in the door drive system. The latch motors are turned off by the limit switches shown at the lower left of the figure. Torque limiters are used to prevent damage (by slipping) in the event of mechanism jamming during latch operations.

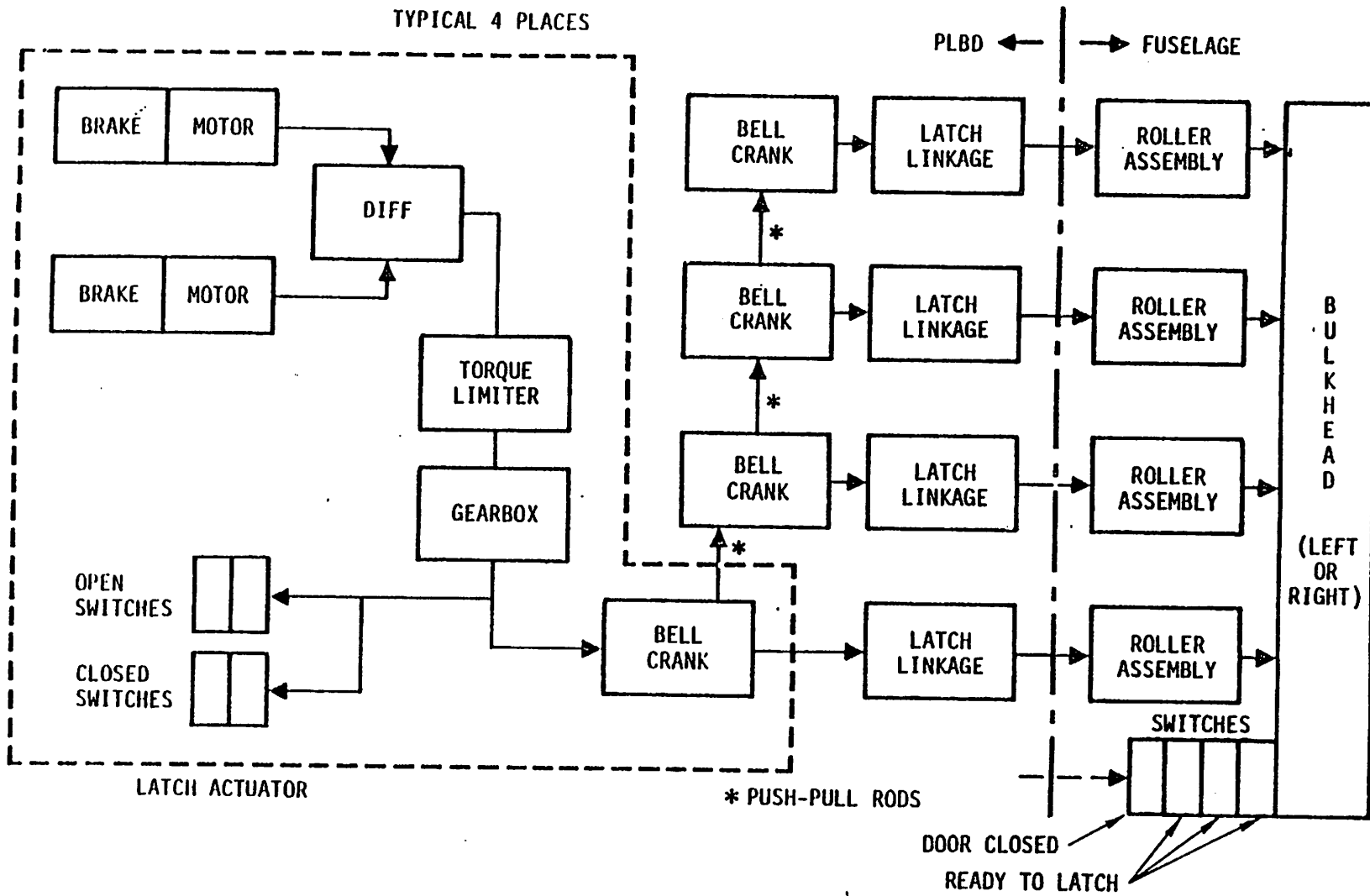


Figure 3-10.- Bulkhead latch systems mechanical block diagram.

Figure 3-11 shows the physical appearance of a typical bulkhead latch group. Note that all four latches are ganged together by linkage mechanisms. The bulkhead-mounted switch module is shown at the lower right. Typical EVA disconnect points in the linkage are shown. These disconnects can be disengaged (EVA) in the event of mechanism jamming during door closing. During latching operations, the actuator output arm rotates, which causes all four latches to rotate closed and engage the four rollers on the bulkhead. In the AUTO mode, the forward and aft bulkhead latches (per door) latch or unlatch simultaneously. The bulkhead latch motors will be turned off automatically (AUTO mode only) if operating time exceeds twice normal operating time of 30 seconds (PLB DOORS CRT message and SM alert occur).

3-18

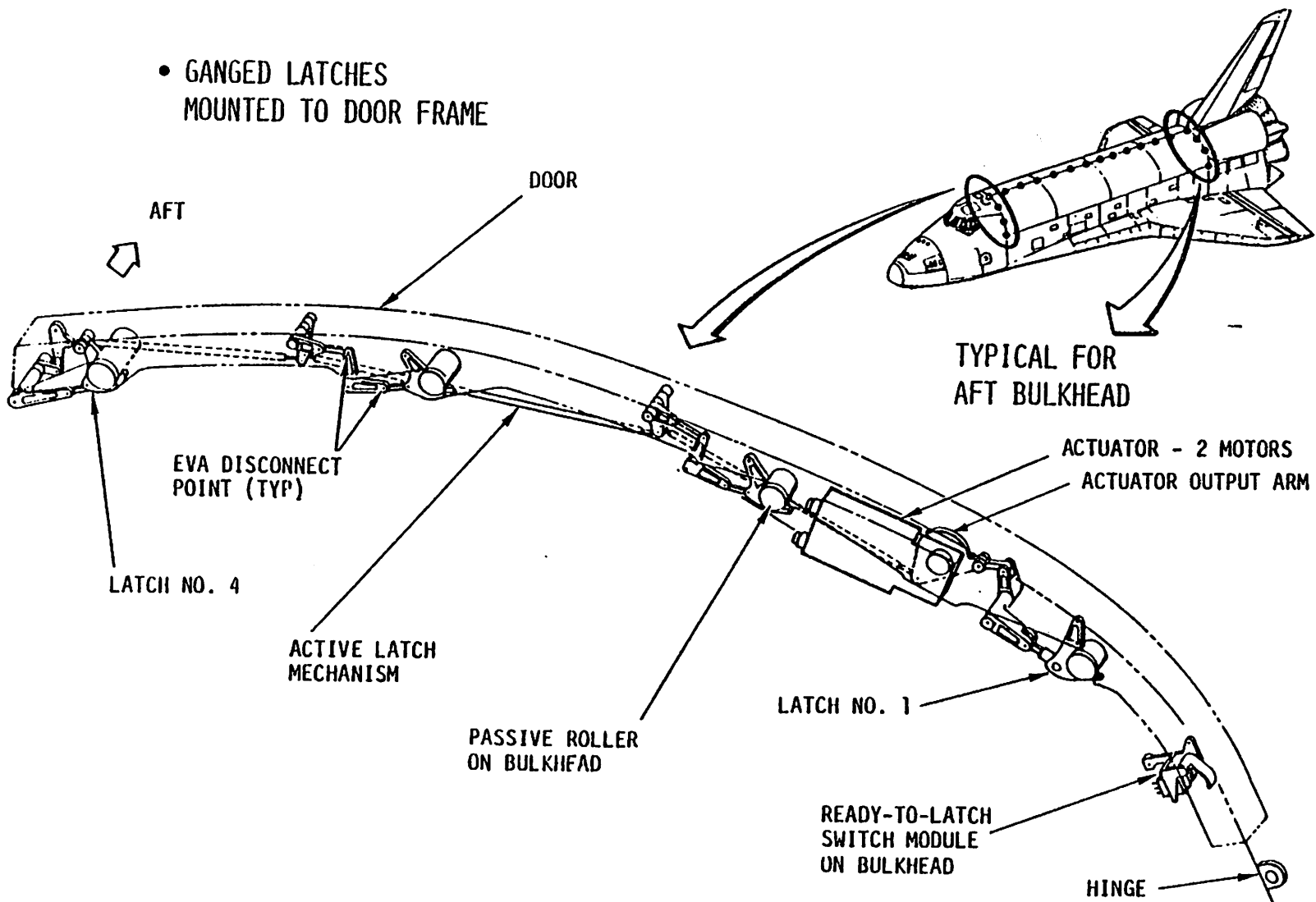


Figure 3-11.- Bulkhead circular latch system (typical).

10C-PBD/R

Figure 3-12 shows the reach capability of the forward and aft bulkhead latches during door closing operations.

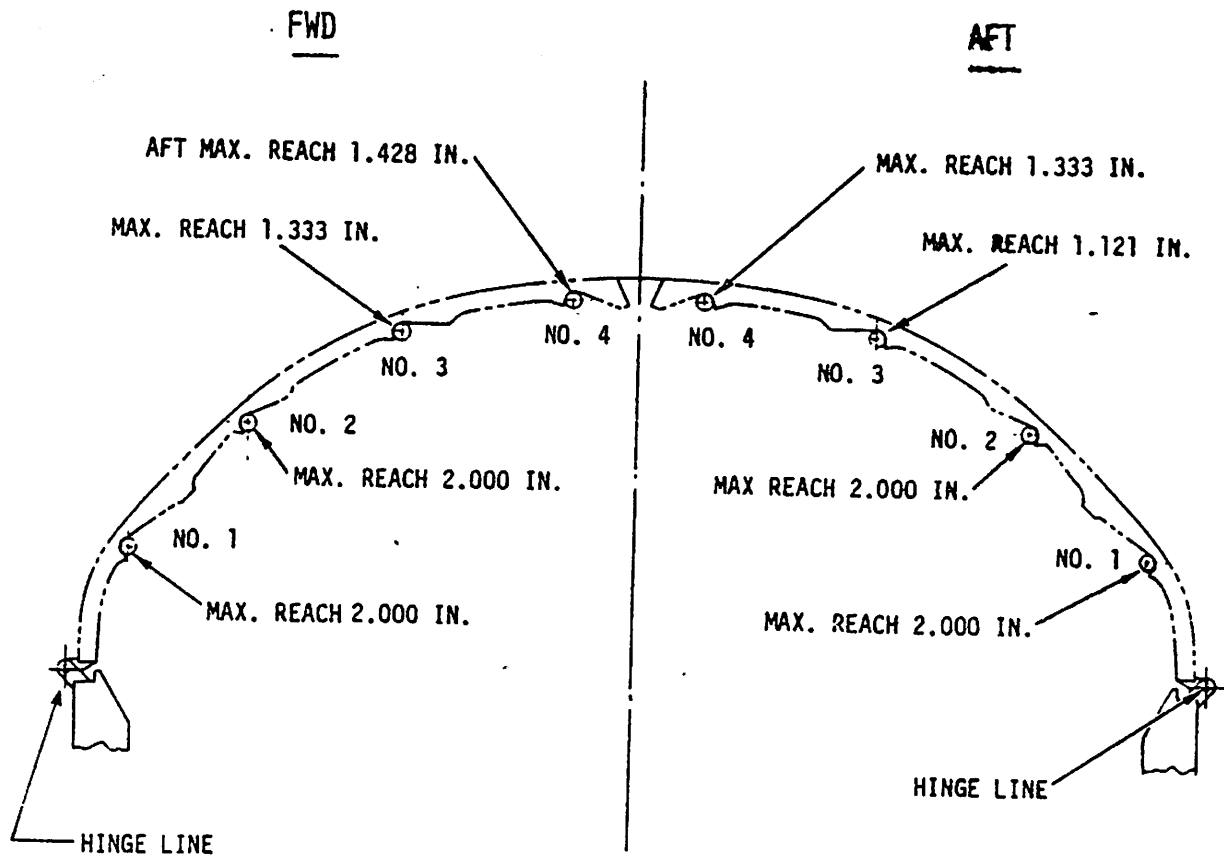
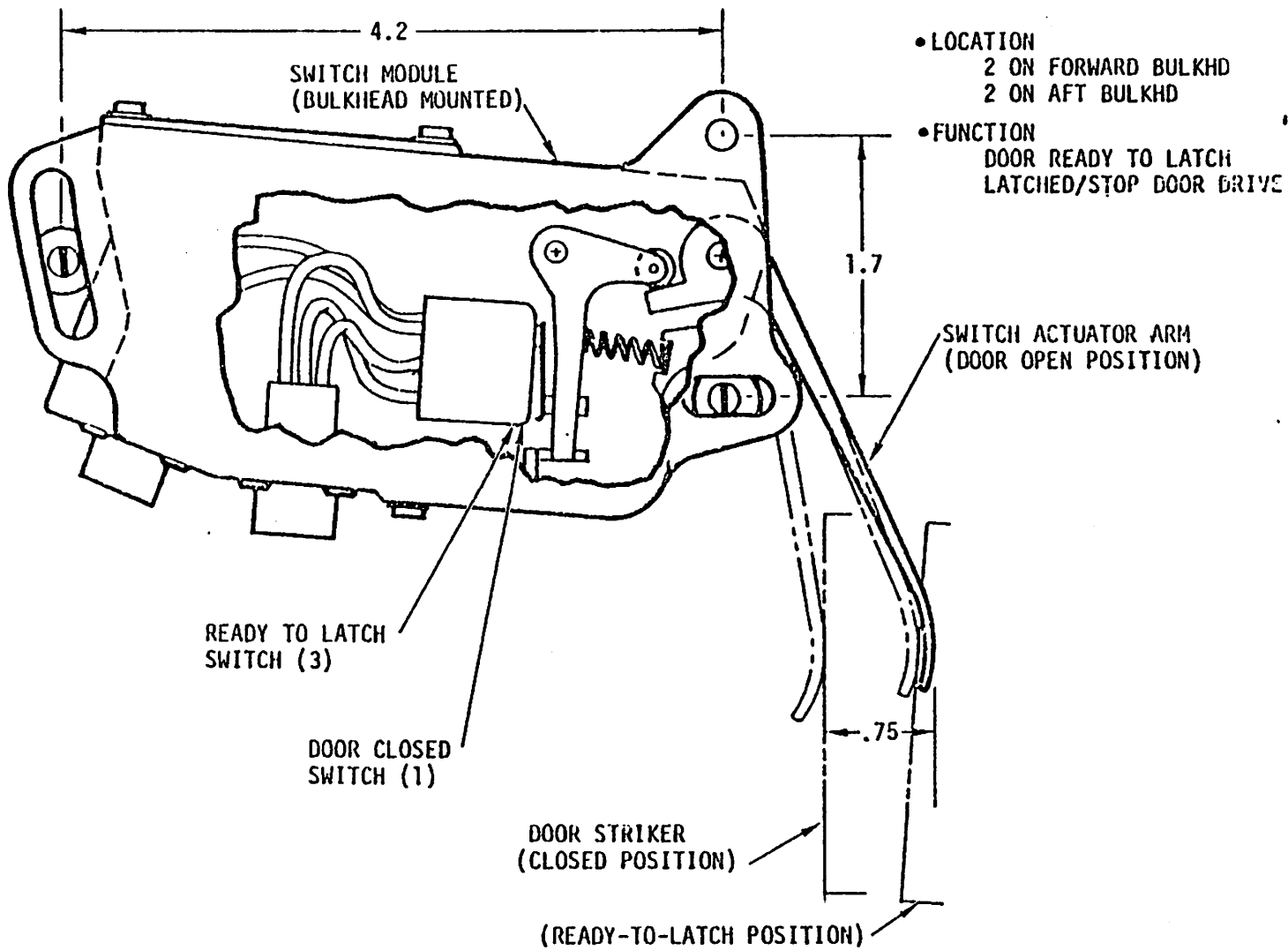


Figure 3-12.- Bulkhead latch reach capability.

Figure 3-13 shows a typical bulkhead switch module. The PBD closing sequence is timed in the AUTO mode of operation, which automatically turns off the PBD drive motors if door closing time exceeds twice normal operating time of 63 seconds. This will prevent damage to the system in the event of a "door close" switch turn-off function failure. A two out of three voting logic of the "ready to latch" switches precludes premature start signals to the bulkhead latch motors.

The bulkhead latch group opens or closes in 30 seconds (both motors operating). If one motor fails, it takes 60 seconds to open or close the latches.



3-21

Figure 3-13.- Payload bay door ready-to-latch switch module.

10C-P8D/R

3.1.3 Door Drive System

The doors are driven by two 3-phase AC motors per Power Drive Unit (PDU). The motors drive the PBD $\sim 174^\circ$ to the open position and are reversible to close the PBD. Together the motors open or close a PBD in 63 seconds. One motor alone requires 126 seconds to open or close a PBD.

Figure 3-14 is a block diagram of a typical door drive system. The door closed position switches shown are those discussed previously in the bulk-head switch module paragraph. The open position switches each turn off one door drive motor when the PBD is fully open. The manual disengage shown is for ground operations only.

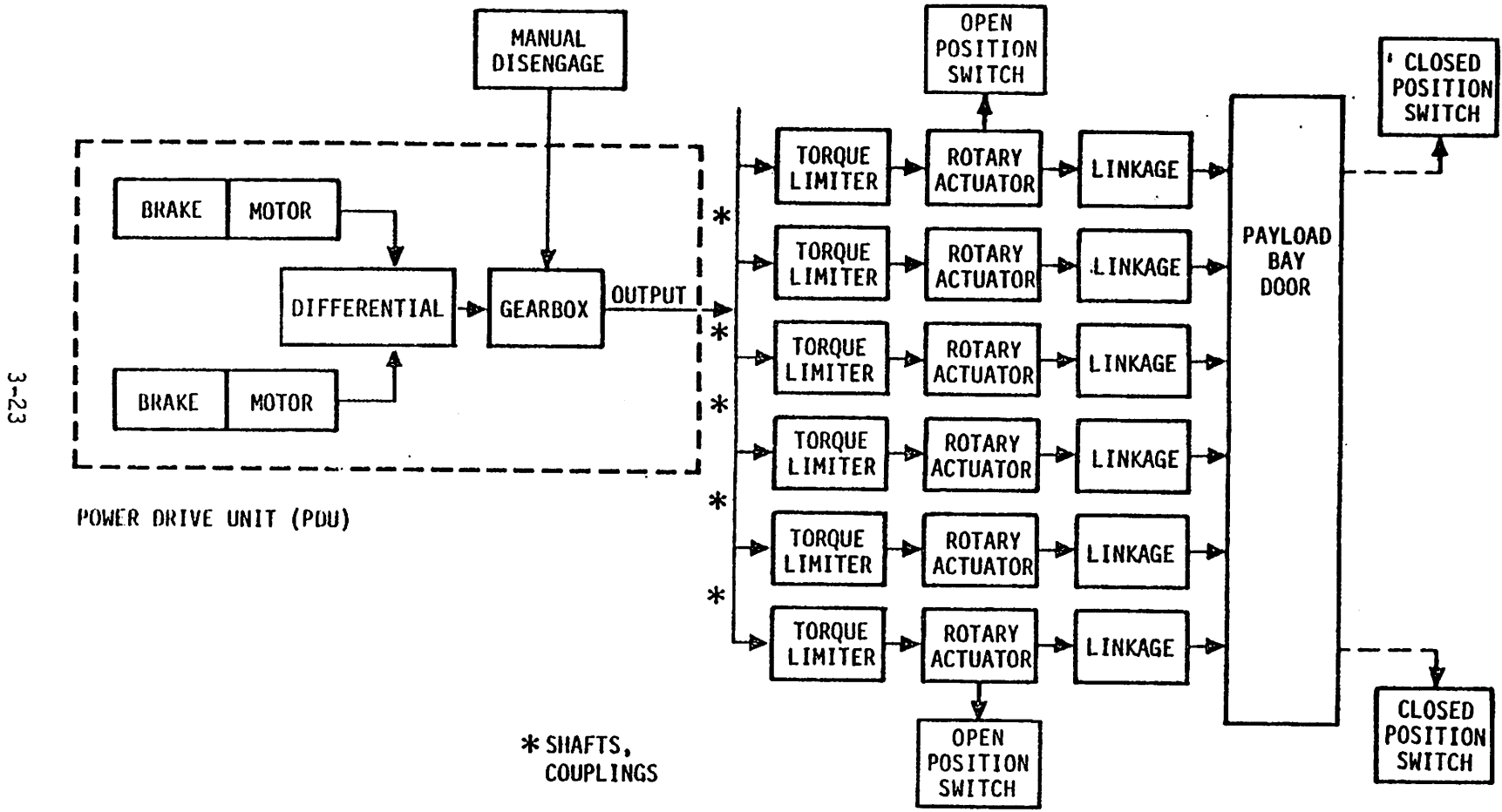


Figure 3-14.- PBD drive system mechanical block diagram.

10C-PBD/R

Figure 3-15 shows the physical appearance of a door drive system. Note the two bulkhead-mounted switch modules (discussed earlier). The three bolts on the bellcrank and the bolt connecting the link to the PBD (view A-A) are candidate disconnect points during contingency EVA in the event of linkage failure during door closing. It can be seen in view A-A, as the torque shaft rotates, the rotary actuator rotates with the shaft. The actuator rotation causes the push rod, bellcrank, and link to move, which pushes the door open. Torque limiters are also used in this system to prevent damage in the event of door or mechanism jamming. If the door operating time exceeds 126 seconds due to a failure, a PLB DOORS CRT message and SM alert will occur as well as the termination of the Auto sequence.

3-25

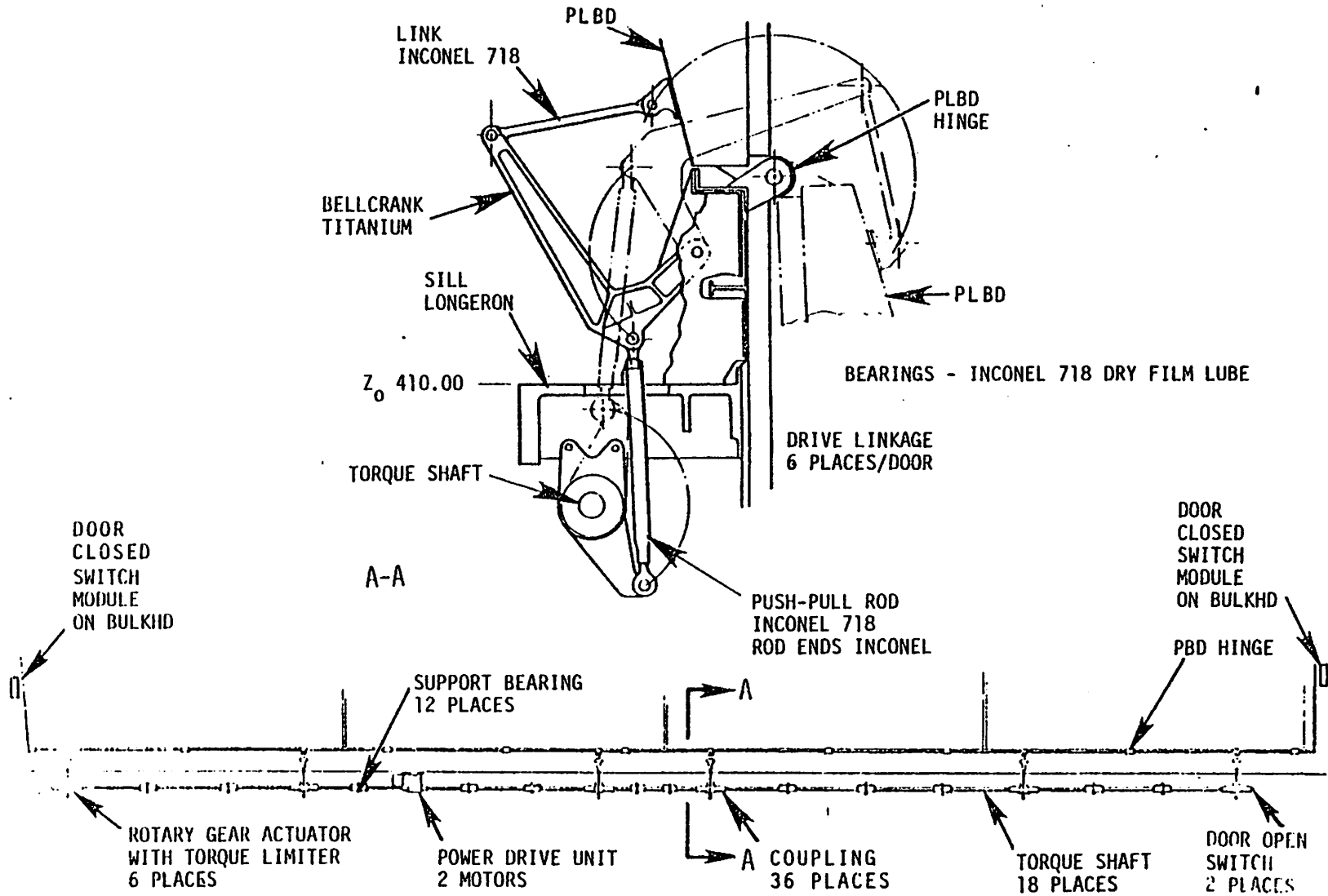


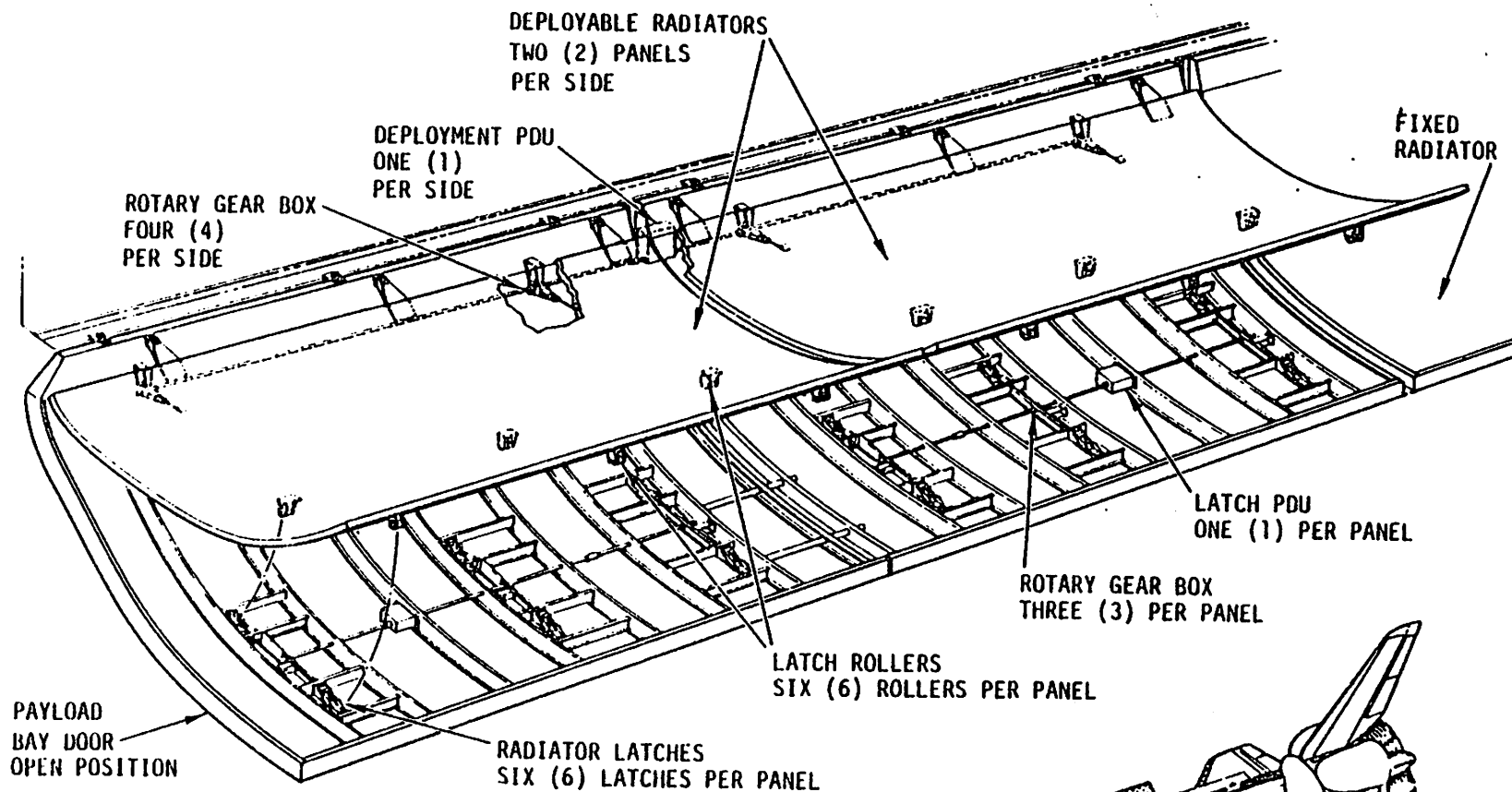
Figure 3-15.- PBD drive linkage.

10C-PBD/R

3.2 RADIATOR PANELS

There are eight radiator panels which are attached to the PBD's (Fig. 3-16). The two forward panels on each PBD are deployable when PBD's are open. This allows radiation of heat from both sides of these four radiator panels. The two aft panels on each PBD are fixed and radiate from one side only. The radiator panels reject the heat (by radiation) from the ECLSS freon loops which is collected from various heat exchangers and cold plate mounted equipment located throughout the vehicle. The PBD's will be opened and the four forward radiator panels deployed in orbit. The deployable radiator panels will be stowed and the PBD's closed prior to entry. ECLSS freon coolant loop 1 flows through the port radiator panels and freon coolant loop 2 flows through the starboard radiator panels (flow is from aft to forward).

3-27



VEHICLE TOTALS
TWO DEPLOYMENT PDUs (8 SWITCHES) (4 MOTORS)
FOUR LATCH PDUs (16 SWITCHES) (8 MOTORS)
EIGHT DEPLOYMENT GEAR BOXES
TWELVE LATCH GEAR BOXES
TWENTY FOUR LATCHES

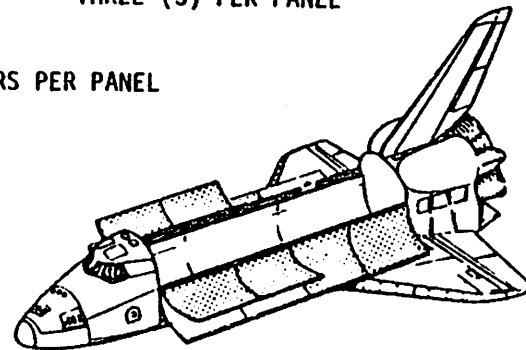


Figure 3-16.- Deployable radiator mechanism.

10C-PBD/R

Each deployable radiator panel is secured to the PBD in the stowed position by six ganged latches. Figure 3-17 is a block diagram of a radiator panel latch system. Two 3-phase AC motors in one PDU are used to latch or unlatch the six latches/panel simultaneously. The motor shaft rotation is reversible by reversing two of the three AC phases (by cockpit switch action, Panel R13) for latch and unlatch operation. Two open and two close limit switches are used to turn off the motors when the latches are unlatched and latched. One set of switches controls one motor, and the other set controls the other motor. The differential allows dual or single motor operation. Control switches on Panel R13 allow single or dual motor operation. When the radiators are deployed or stowed in orbit, all four panels are unlatched/latched and deployed/stowed simultaneously. Radiator status flags on Panel R13 receive signals from the limit switches to reflect radiator panel status. Torque limiters prevent damage to the system in the event of jamming in the linkages.

Latching or unlatching the radiators takes 26 seconds with both motors in a PDU operating. One motor alone takes 52 seconds to latch/unlatch the latch group.

3-29

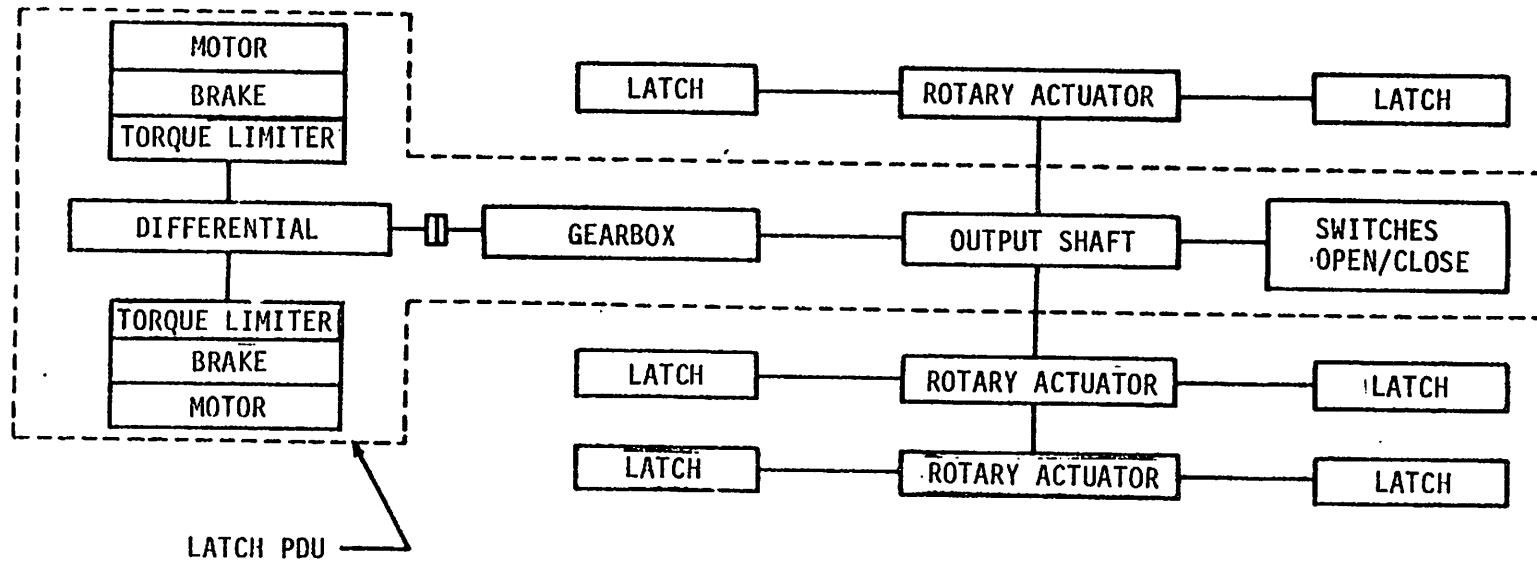


Figure 3-17.- Deployable radiator latch system block diagram.

10C-PBD/R

Figure 3-18 is a more detailed view of the radiator latch mechanism. In this figure it can be seen that as the PDU rotates the torque shaft, the rotary actuator will push or pull on the push rods to latch or unlatch the hooks.

Figure 3-19 shows a latch with its linkages and the latch/passive roller interface in the latched configuration. The passive rollers are attached to the radiator panels.

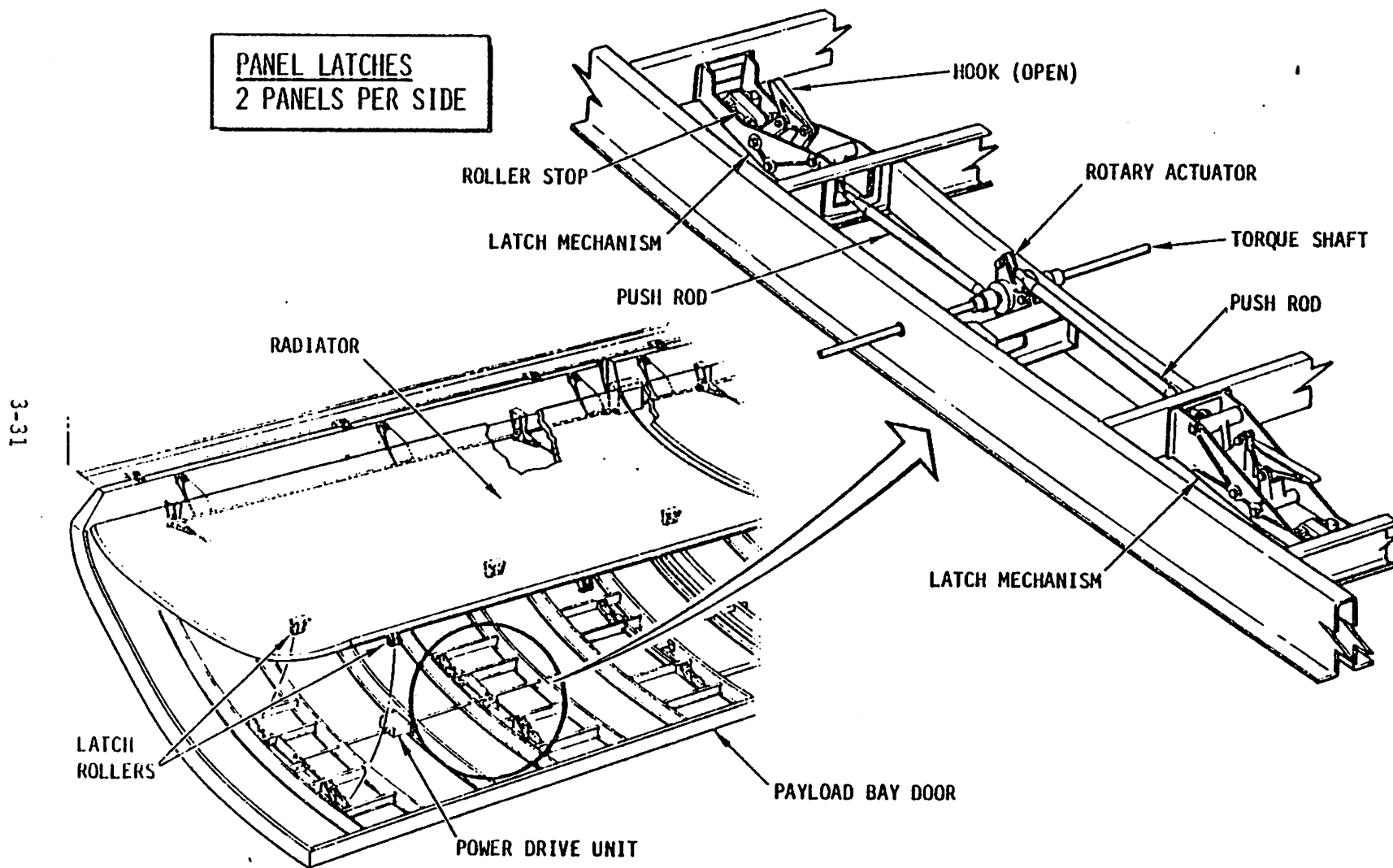
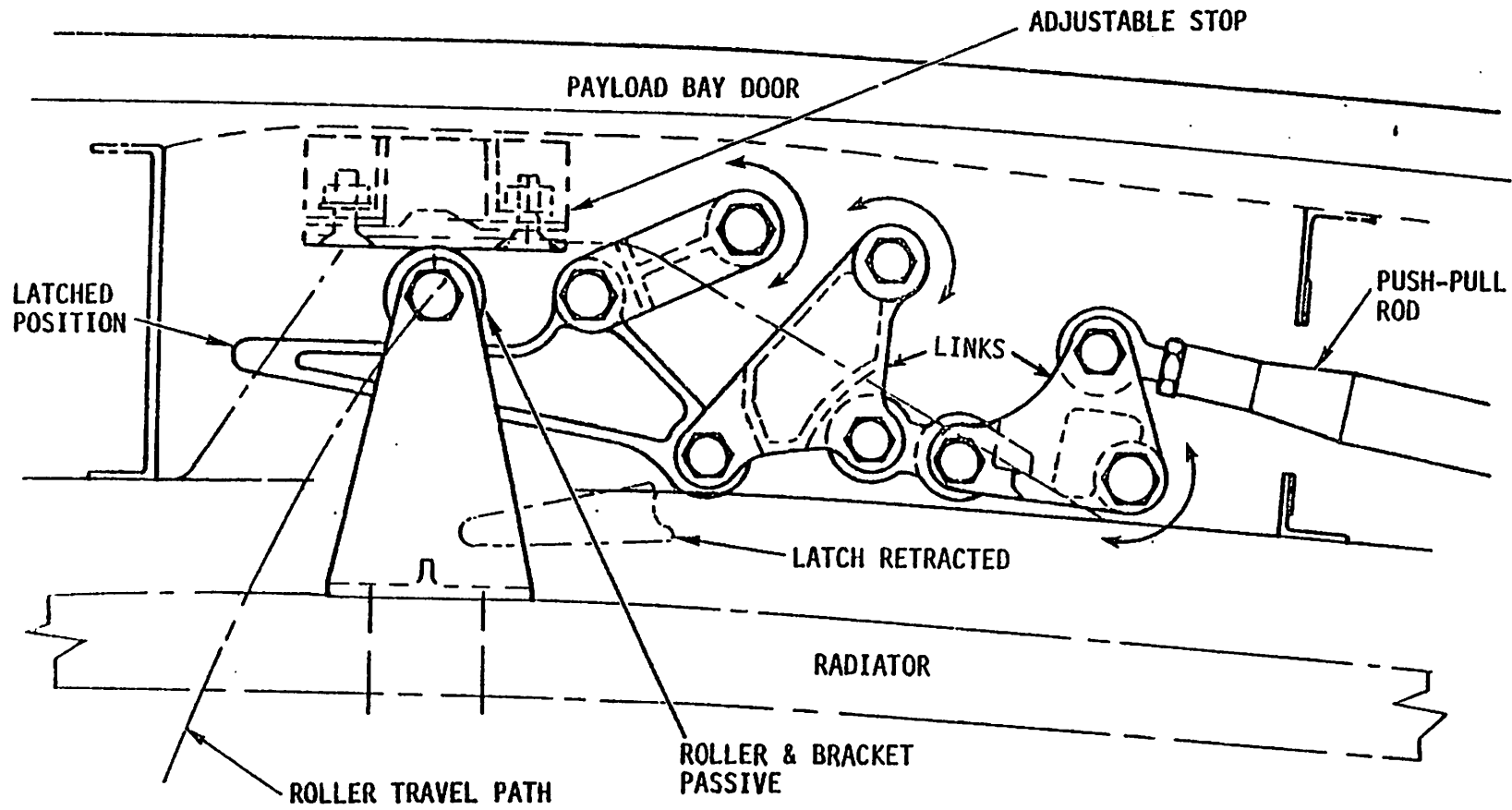


Figure 3-18.- Deployable radiator latch system.

10C-PBD/R

• TYPICAL LATCH & ROLLER



3-32

Figure 3-19.- Radiator latch system.

10C-P8D/R

There are two radiator deploy systems; one port and one starboard. The deploy systems drive the radiator panels away from the PBD (deployed) or to the stowed position.

Figure-3-20 is a block diagram of a radiator deploy system. Each deploy system PDU (actuator assembly) employs two 3-phase AC motors. These motors are reversible by reversing 2 of 3 phases (by switch action, Panel R13). Two deploy and two stow limit switches turn off the PDU motors when the radiators are deployed/stowed. Torque limiters prevent system damage in the event of jamming or binding during system operation.

Switch controls on Panel R13 allow single or dual motor operation to deploy or stow the radiators. Both port and starboard radiators are deployed or stowed simultaneously. The radiators deploy $\sim 35.5^\circ$ from the PBD's in 43 seconds.

3-34

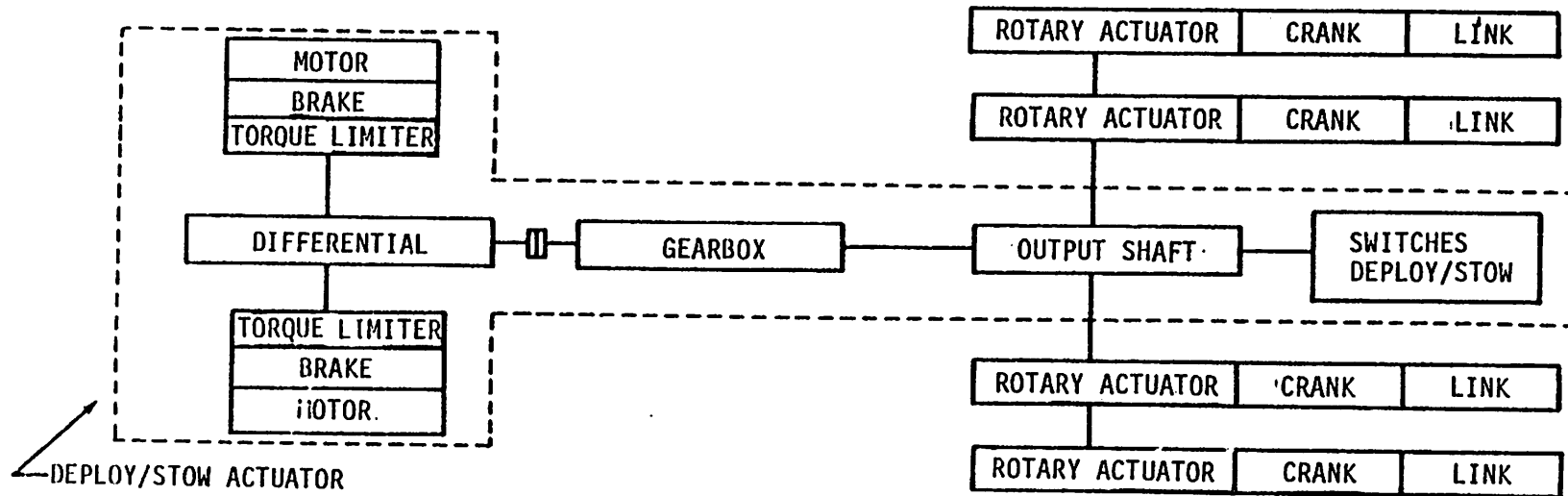


Figure 3-20.- Deployment system radiator.

10C-P8D/R

Figure 3-21 shows a closeup of one of the radiator deployment rotary actuators. As the rotatory actuator shaft rotates, the deployment crank and link straighten out and push the radiator panels away from the PBD to the deployed position. Each rotary actuator crank can be disengaged from the rotary actuator by removal (EVA) of a retractable shear pin (Fig. 3-22). Removal of this shear pin allows the crank to rotate freely from the rotary actuator. This allows (EVA) radiator panel stowing in event of a failed rotary actuator. If the PDU has failed, all four rotary actuator retractable shear pins must be removed to allow manual stowing of the radiators. No EVA is planned if a failure occurs during radiator deployment.

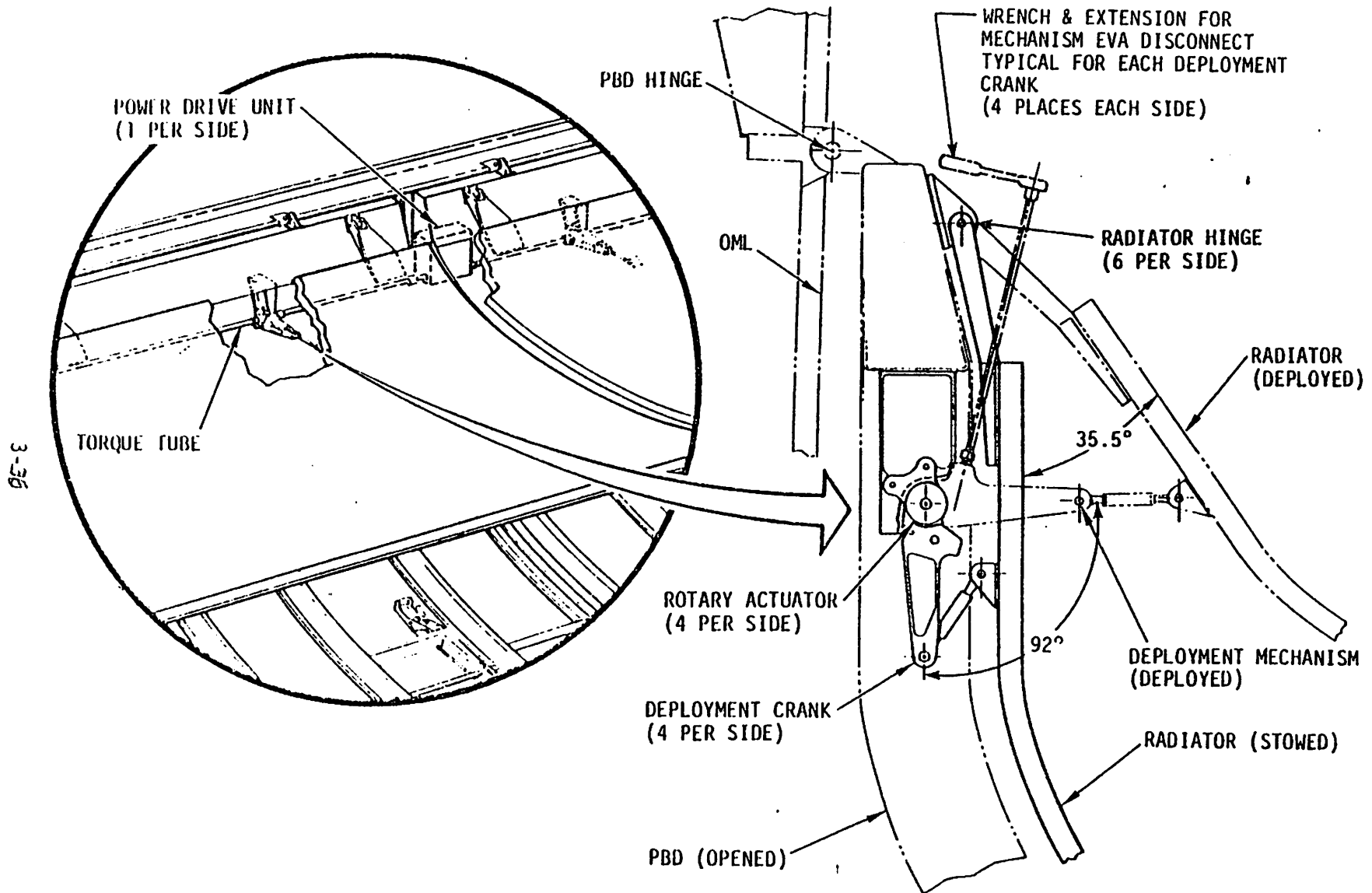


Figure 3-21.- Radiator deployment mechanism.

10C-PBD/R

3-37

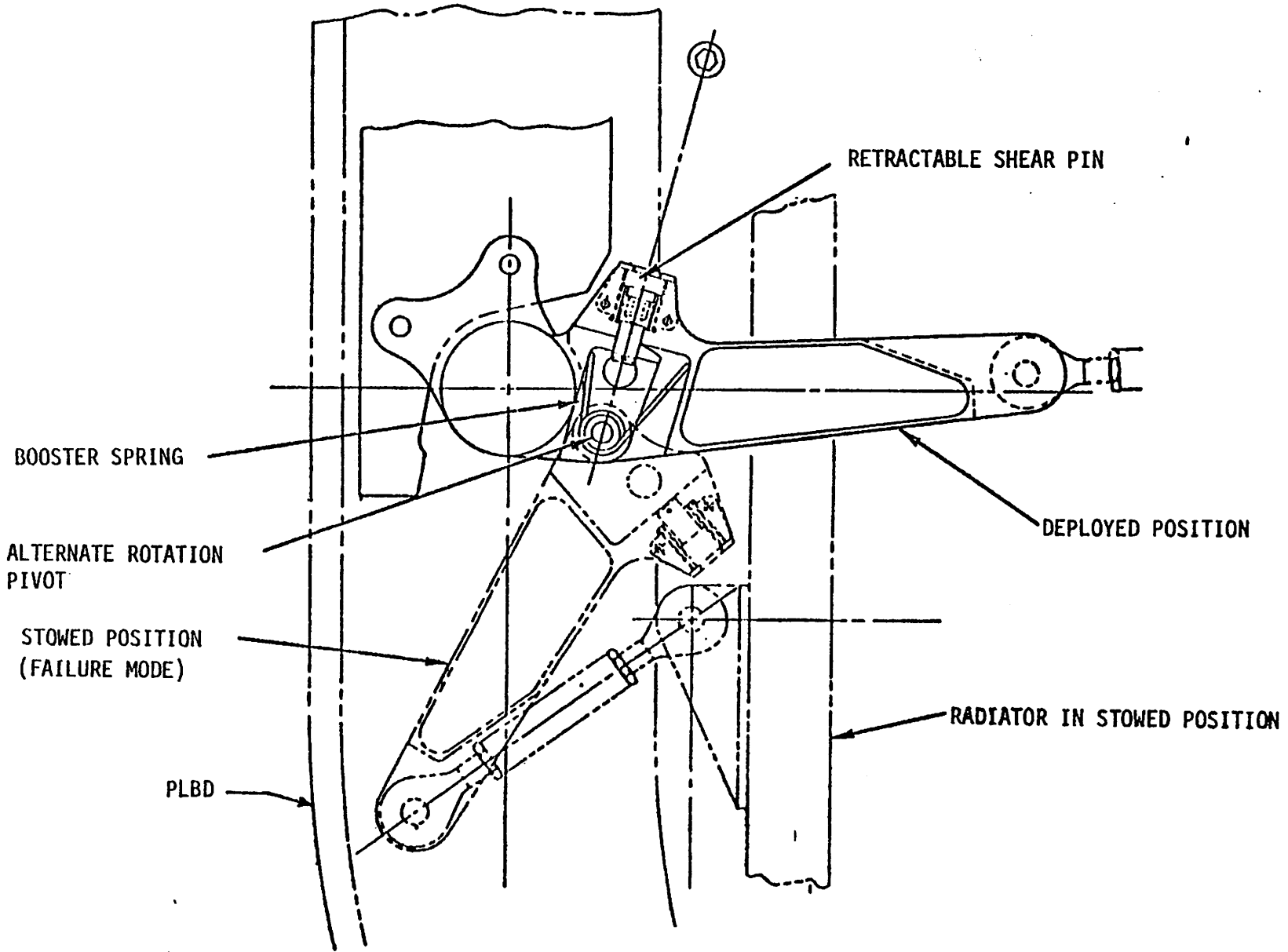


Figure 3-22.- Radiator deployment mechanism disconnect features.

100-P80/R

3.3 PAYLOAD BAY DOOR ELECTRICAL POWER AND CONTROL SYSTEMS

The PBD's operate in two basic modes, AUTO and MANUAL. The AUTO mode executes all the steps necessary to fully open or close the PBD's. In the MANUAL mode, desired latch group(s) or door(s) are specified individually (by computer keyboard operation) to be opened or closed.

The PBD power and control system consists of three basic areas. These are the Data Processing System (DPS), the Mid-Motor Control Assemblies (MMCA's), and the actuator assemblies (motors). Figure 3-23 shows the relationship of these three areas. AUTO or MANUAL commands from the DPS are sent to the MMCA's, which in turn activate the proper actuator assembly motors to open or close latches and/or doors. Microswitch feedback signals are sent to the DPS to produce PBD/latch status on the CRT display and to drive the PBD status flag on Panel R13. The status (OPEN/CLOSE) of the individual PBD limit switches is also displayed on the CRT.

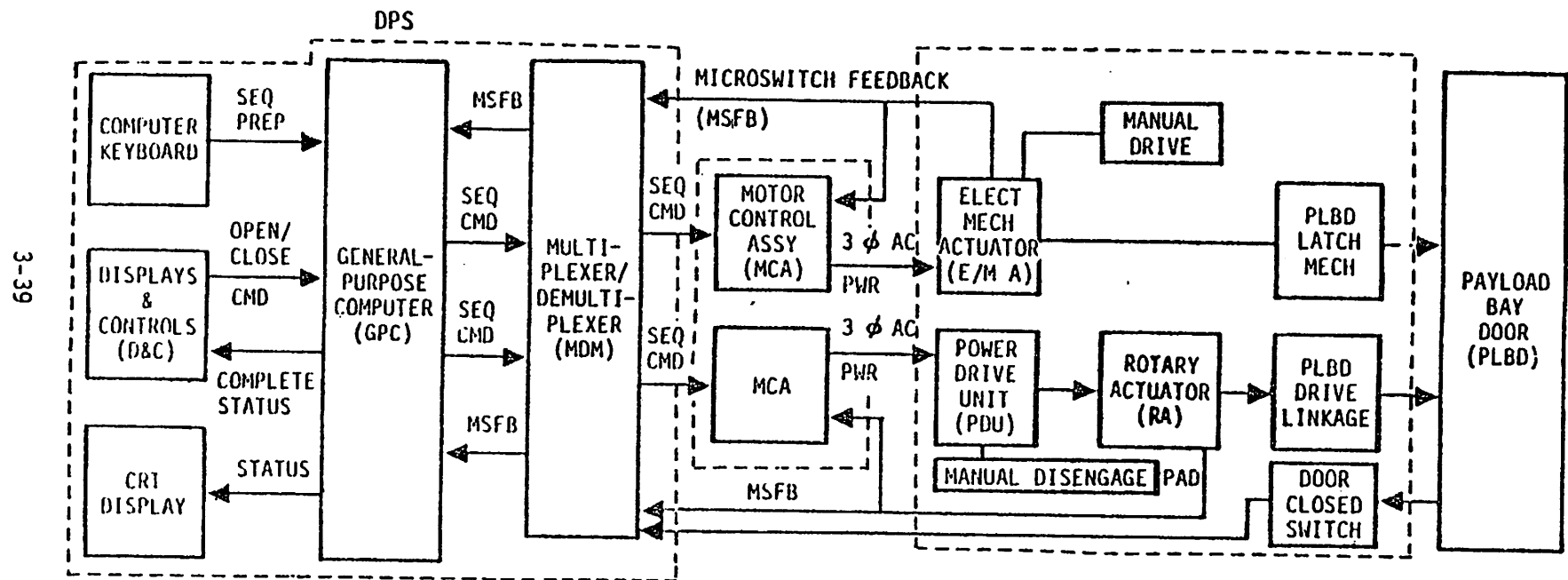
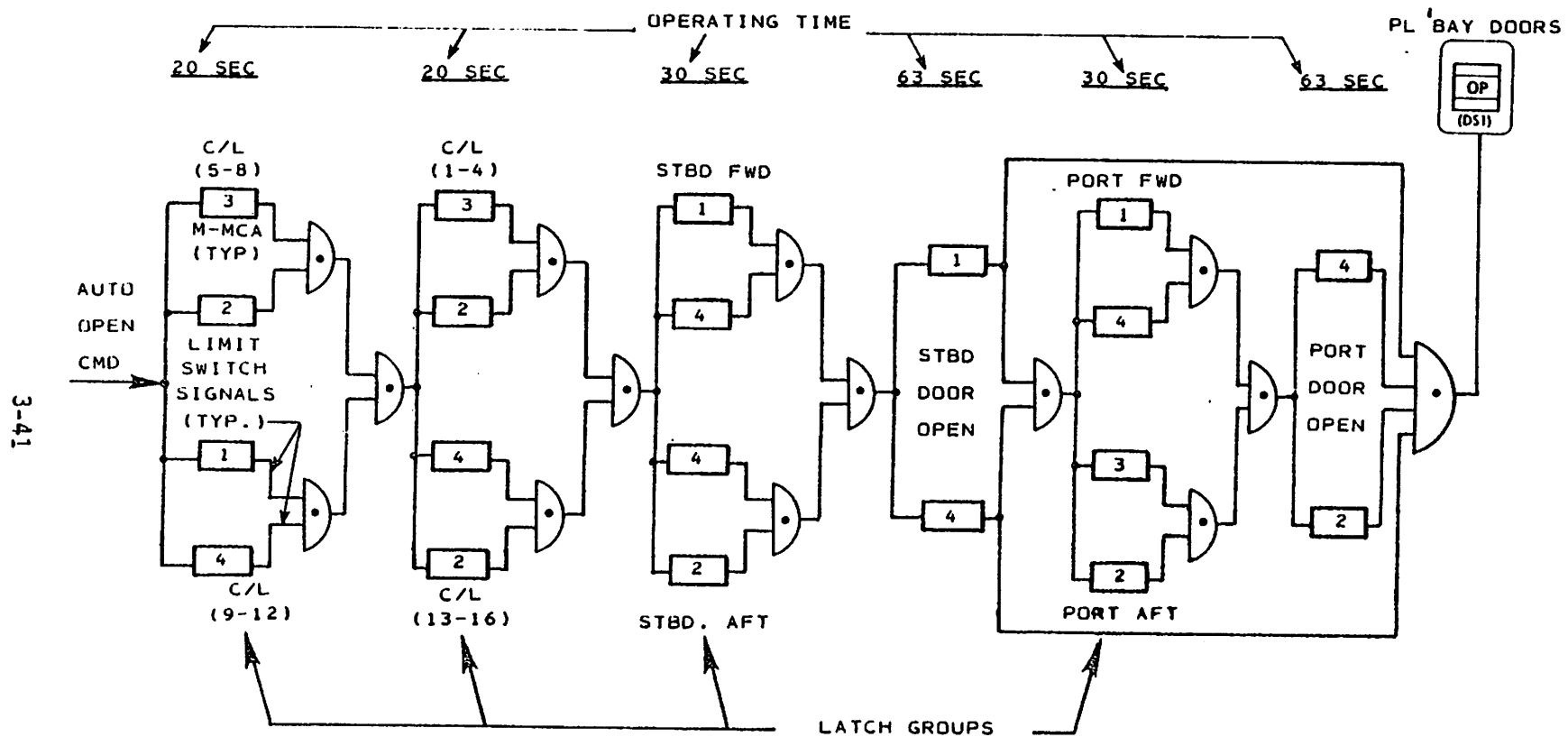


Figure 3-23.- PBD block diagram - power and control.

Figure 3-24 is a simplified diagram of the PBD AUTO OPEN sequence signal flow. Each PBD latch group and PBD drive motor MMCA is shown. The signal from each MMCA is enabled by a limit switch closure. The operating times shown at the top of the diagram reflect all motors operating nominally. Each MMCA has its own timer and each timer is set to twice the nominal operating times shown. This allows enough time for single motor operation of a latch group or door (both sets of limit switches will close) without getting a sequence fail signal (PLB DOORS CRT message and SM alert). All limit switch contact closures are displayed on the PBD CRT display under MICRO-SW STAT. During the AUTO (or MANUAL) sequence, the crew can observe the status of these switches' change state. Microswitch status is also sent to Mission Control Center (MCC) by telemetry. The PBD status flag (Panel R13) will go barberpole during door opening or closing, and will display OP or CL only when the selected position is attained by the auto mode. The PBD status flag will remain in its present state when the manual mode is used.



NOTE: NUMBERED BLOCKS REPRESENT M-MCA'S.
 EACH M-MCA RELEASE LIMIT SWITCH CONTACT,
 MUST BE CLOSED FOR AUTO-SEQUENCE TO
 CONTINUE.

Figure 3-24.- PBD auto-open signal flow (simplified).

3-41

10C-PBD/R

Figure 3-25 is a simplified diagram of the PBD ready to latch switch modules and associated circuitry. The diagram is typical for the port and starboard doors. It can be seen that AND gates prevent a single switch contact closure from enabling a command to the bulkhead latches. It is also evident that only two of three switch contacts per module need to close to enable the ready to latch signal.

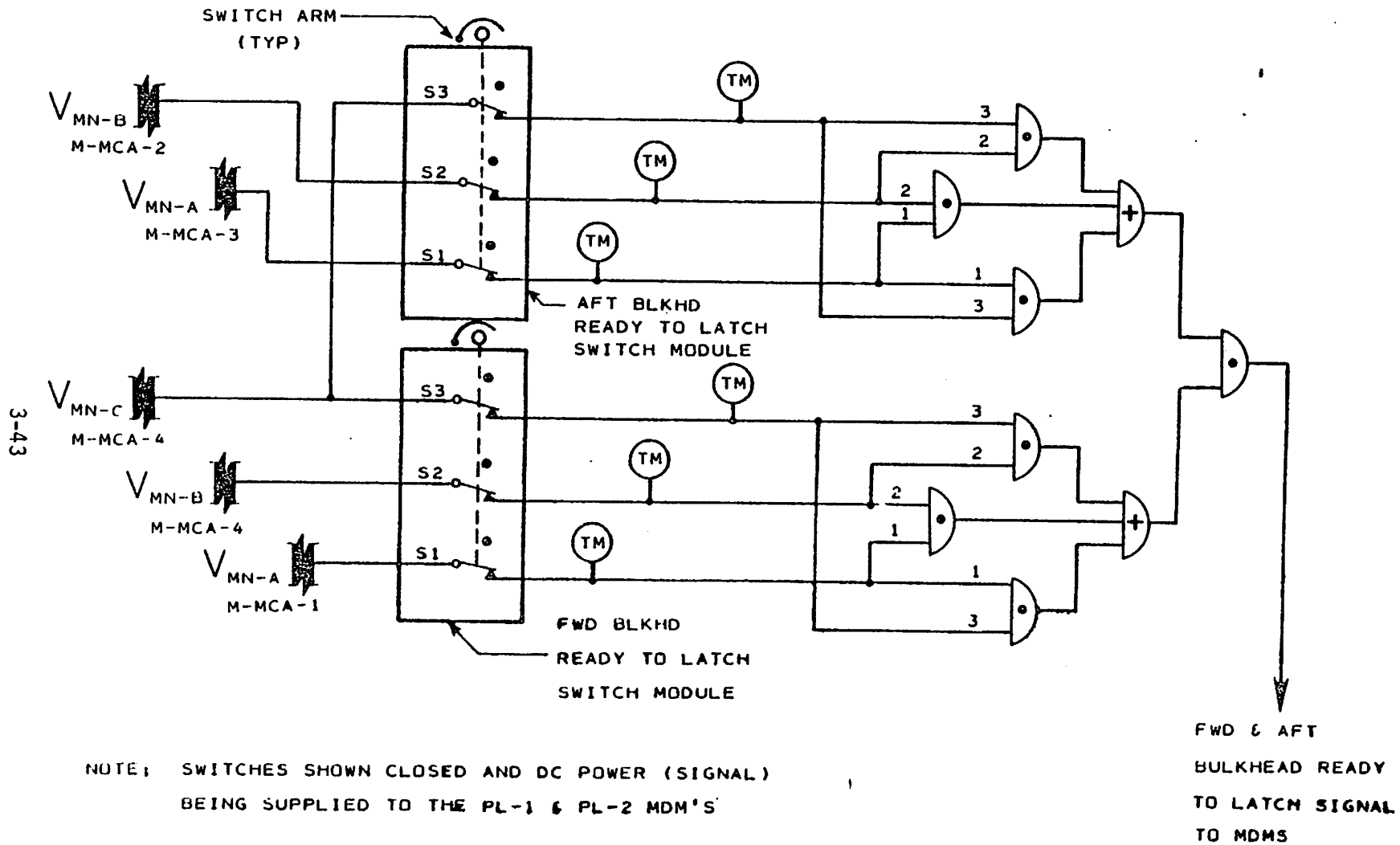


Figure 3-25.- PBD ready-to-latch switch modules electrical circuitry (simplified).

Figure 3-26 is a power configuration table for the PBD latch groups and doors. By using the table, you can relate the various buses to MMCA's and their respective actuator assemblies. You can also see which actuator assemblies are affected by loss of a DC bus, an AC bus, an MMCA, or an MDM. The loss of any one of these will cause an increase in operating time (single motor operation remaining) of the particular actuator assembly with which it is associated.

PLBD POWER CONFIGURATION

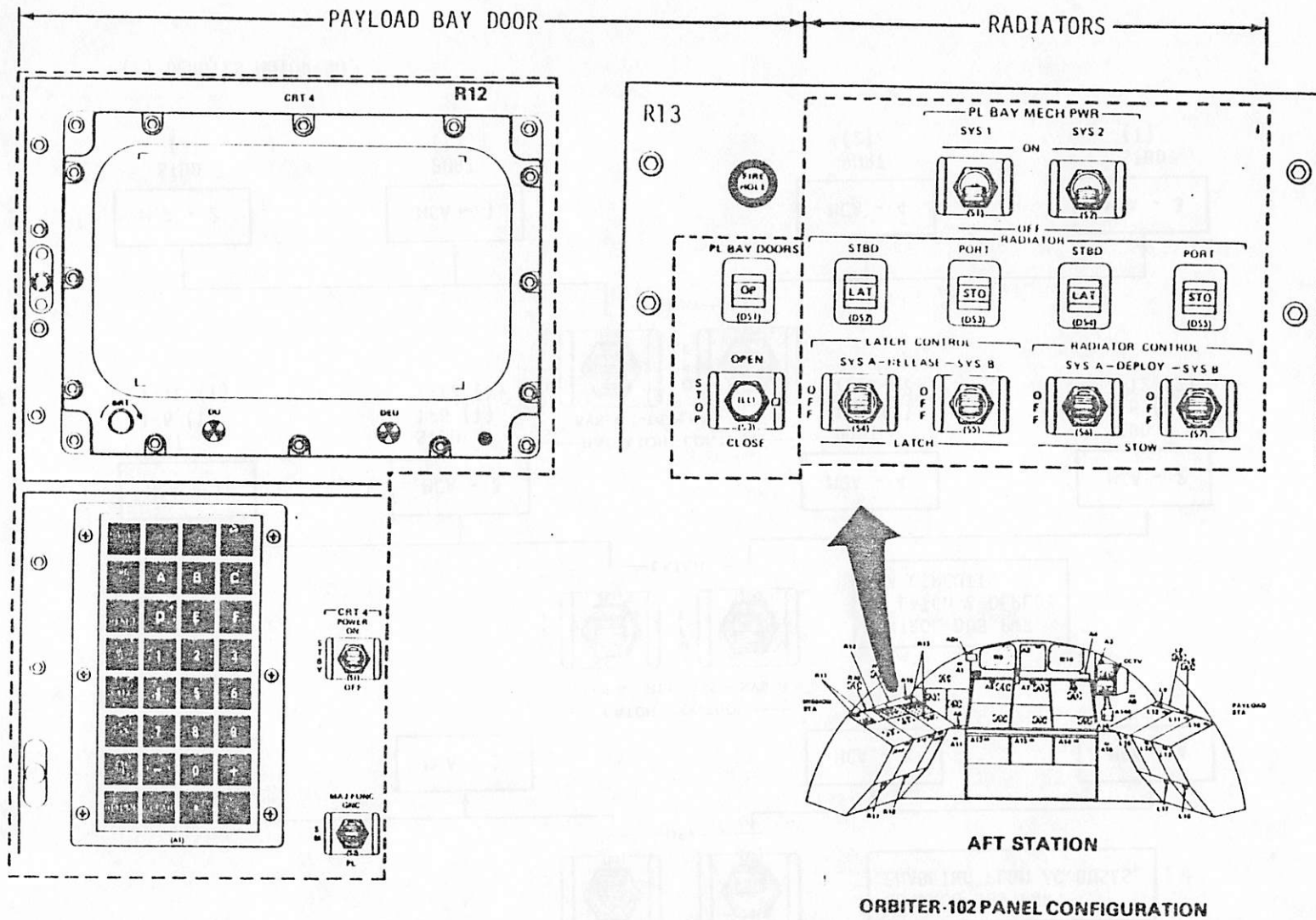
ACTUATOR ASSEMBLY	MMCA	LATCH GROUP	MDM	AC BUS	DC BUS
CENTRAL LATCH LINES	3 2	5-8	PL-1 PL-2	AC 1 AC 3	MN A MN C
	1 4	9-12	PL-1 PL-2	AC 1 AC 3	MN A MN C
	3 2	1-4	PL-1 PL-2	AC 1 AC 3	MN A MN C
	4 2	13-16	PL-2 PL-1	AC 3 AC 2	MN C MN B
STARBOARD BULKHEAD LATCHES	1 4	FWD BLKHD	PL-1 PL-2	AC 1 AC 2	MN A MN B
	4 2	AFT BLKHD	PL-2 PL-1	AC 3 AC 2	MN C MN B
PORT BULKHEAD LATCHES	1 4	FWD BLKHD	PL-1 PL-2	AC 1 AC 2	MN A MN B
	3 2	AFT BLKHD	PL-1 PL-2	AC 1 AC 3	MN A MN C
STARBOARD DOOR	1 4	STBD DOOR	PL-1. PL-2	AC 1 AC 2	MN A MN B
PORT DOOR	4 2	PORT DOOR	PL-2 PL-1	AC 3 AC 2	MN C MN B

Figure 3-26.- PBD power configuration.

3.4 RADIATOR PANEL ELECTRICAL POWER AND CONTROL SYSTEM

The radiator electrical power and control system consists of four basic areas. These are power sources (DC, AC, and control buses), crew-operated controls (PNL R13), MMCA's, and the actuator assemblies (motors). The radiator deploy and stow operation is by manual (crew) control only. This is accomplished by use of the PL BAY MECH PWR switches and the LATCH and RADIATOR CONTROL SYS A and SYS B switches on Panel R13. Associated with these switches are four status flags for latch and radiator status (Fig. 3-27).

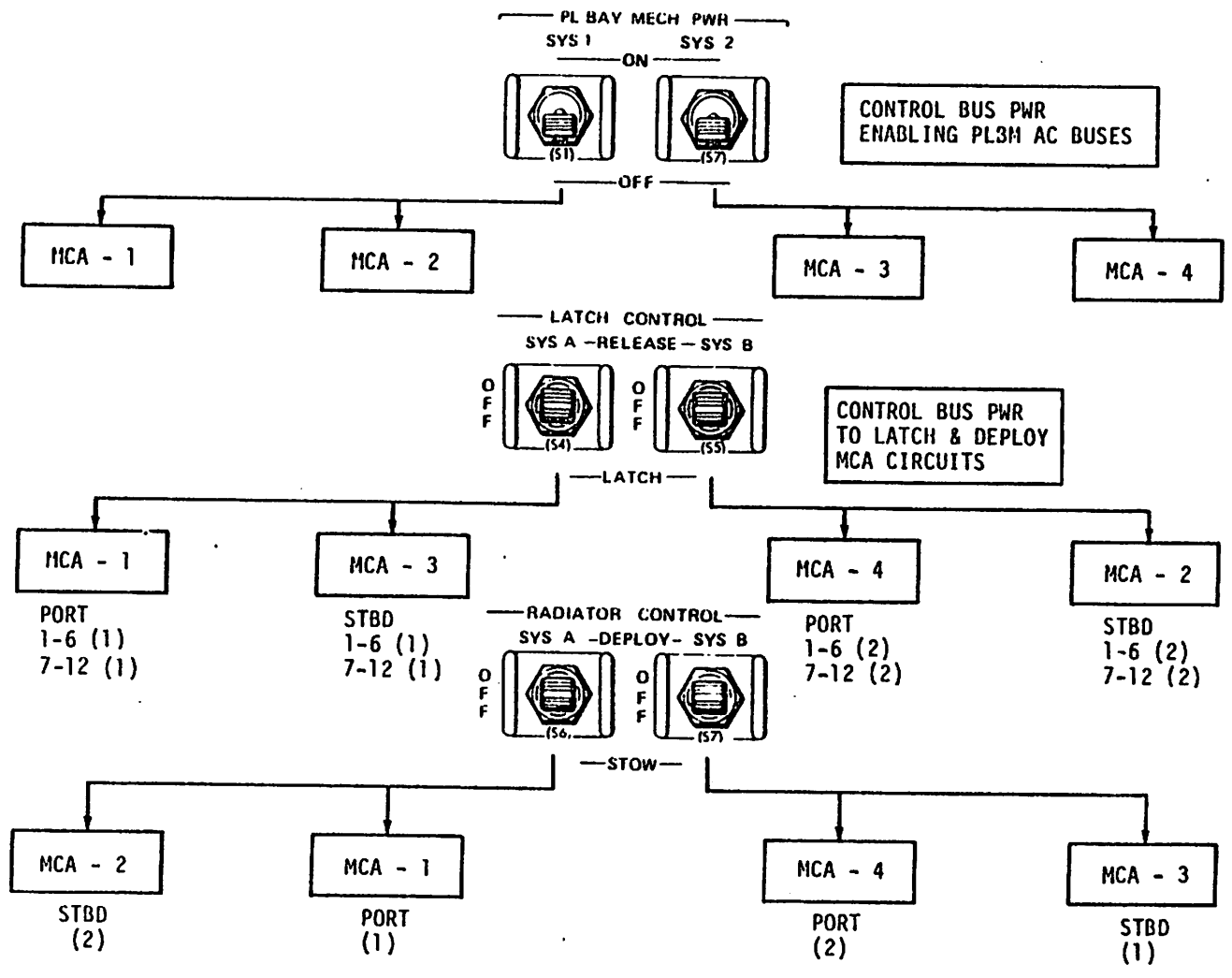
To deploy the radiators, Sys 1 and Sys 2 mech pwr switches are ON, the latch control switches (SYS A and B) are placed to RELEASE. In 26 seconds, the status flag will show REL. The radiator control switches (SYS A and B) are placed to DEPLOY, and in 43 seconds the status flags will show DEP. The stow sequence is just the reverse. The electrical power and control system for the radiators is designed to permit loss of one of two control switches (latch or radiator) or loss of one mechanical power source (sys 1 or sys 2) and still be able to latch/unlatch and deploy/stow the radiators. For example, in Figure 3-28 it can be seen that if PL BAY MECH PWR System 2 fails, MMCA-3 and -4 are lost. This failure still allows latch and radiator control by MMCA-1 and MMCA-2 (single motor operation). Likewise, if a latch or radiator control switch fails, the other system (MMCA's) can still perform the operation (single motor operation).



3-47

Figure 3-27.- PBD/radiator displays and controls.

10C-PBD/R



() DENOTES MOTOR NO.

Figure 3-28.- Radiator control.

3-48

10C-PBD/R

Figure 3-29 shows the latch status signal flow for the starboard radiator (port radiator is similar). In the figure you will note the two enable signals to the radiator deploy MMCA's. These signals and those from the port radiator must be present to enable the radiator deploy circuitry. The absence of these enabling signals prevents inadvertent deployment of the radiators while still latched.

In the figure it can be seen that one limit switch signal from each latch group (1-6 and 7-12) is required to provide a LAT or REL status on the flag.

3-50

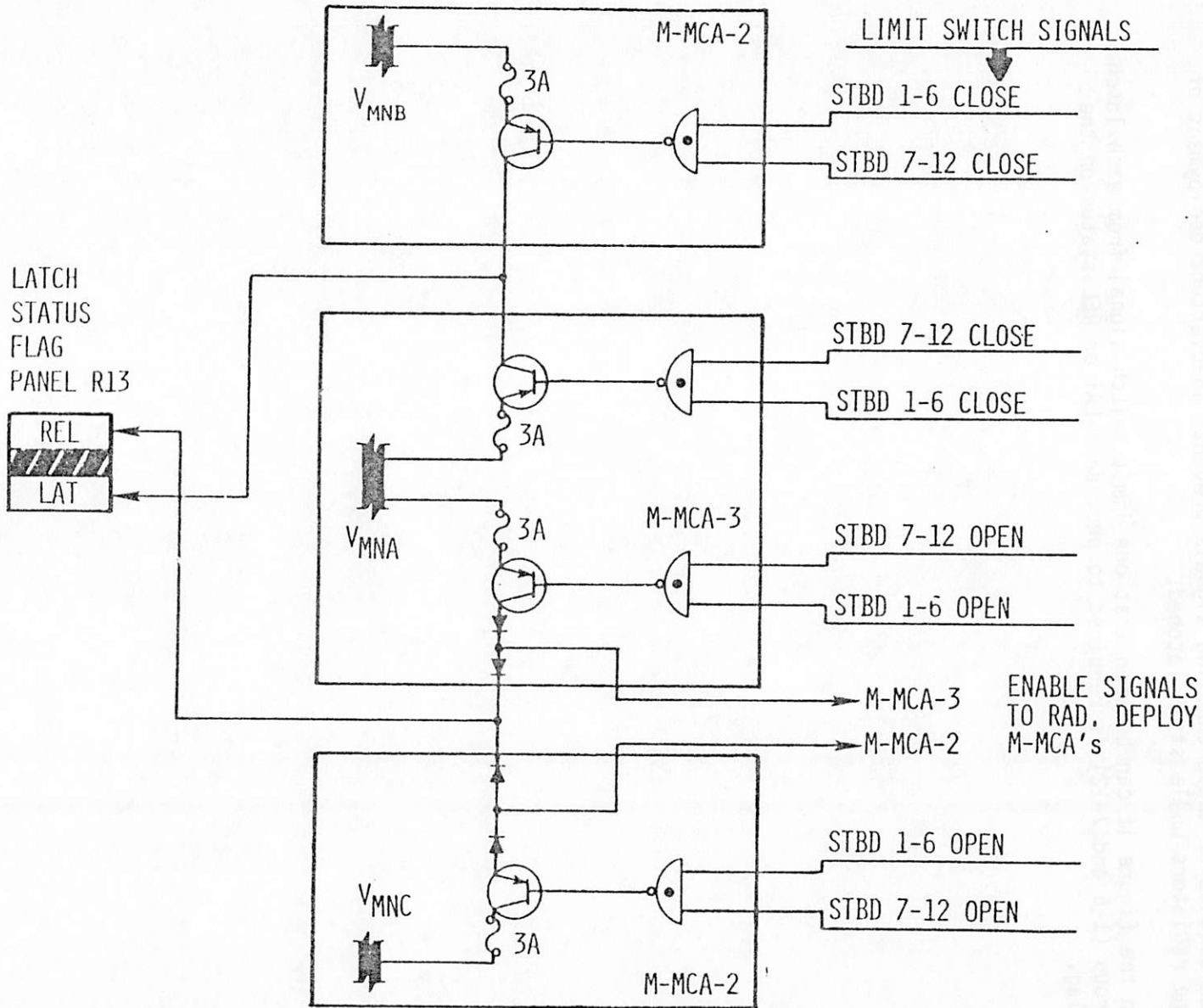


Figure 3-29.- Latch status signal flow, STBD radiator.

100-PBD/R

Figure 3-30 illustrates the radiator deploy/stow status signal flow (starboard radiator). It should be noted that both limit switch signals from an actuator assembly are required to provide the status signal to the flag.

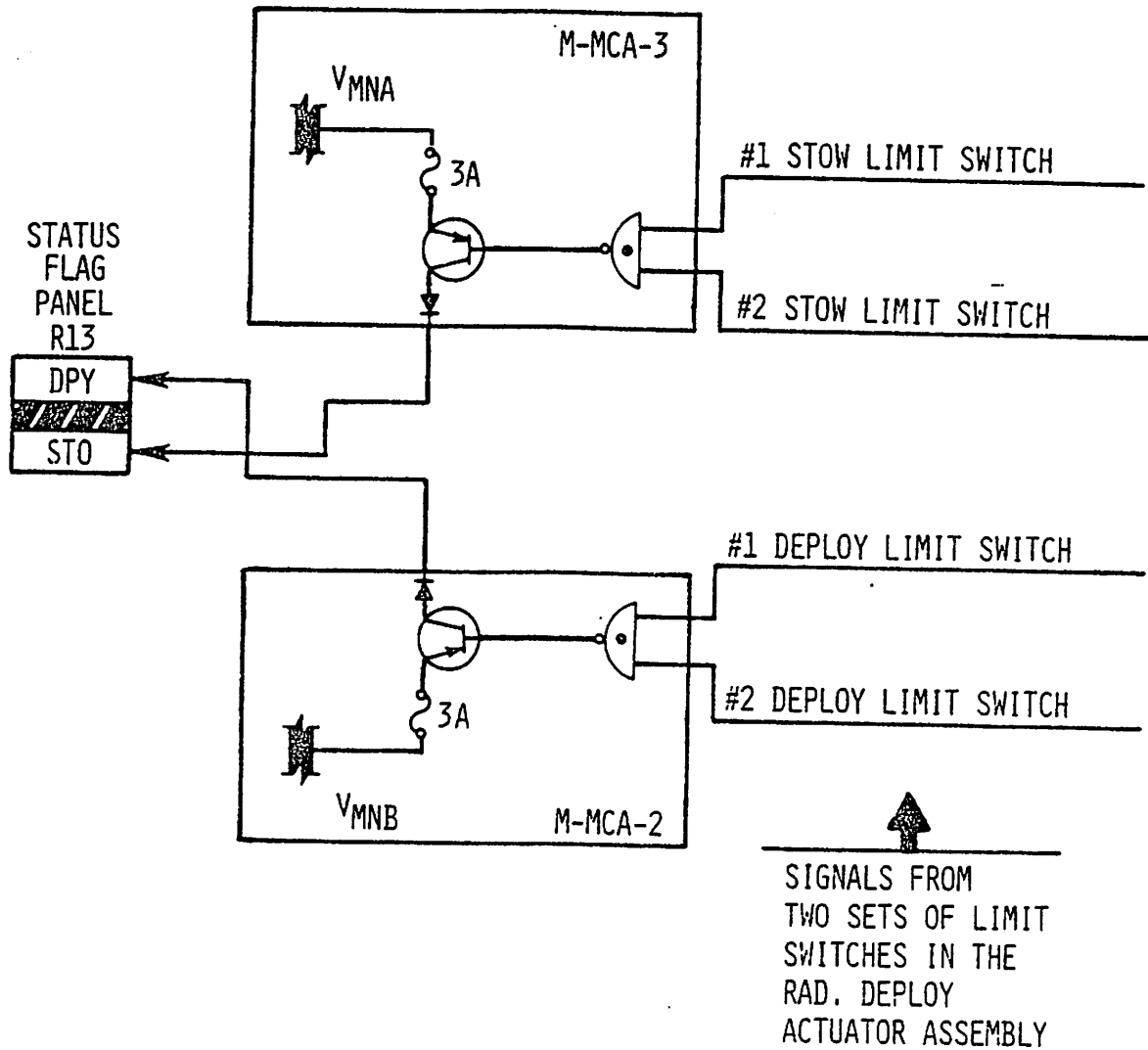


Figure 3-30.- Radiator deploy/stow status signal flow (STBD RAD).

Figure 3-31 shows power configuration tables for the port and starboard radiators. The various buses can be related to MMCA's and their respective actuator assemblies. By studying the tables, the redundancy provided in the radiator latch and deploy systems can be seen. Also, the latch groups or deploy actuator assemblies which are affected by loss of a DC bus, an AC bus, or a control bus can be identified. A loss of any one of these buses will cause an increase in operating time (single motor operation remaining) of the particular latch group or deploy actuator with which it is associated.

STARBOARD RADIATOR				
ACTUATOR ASSEMBLY	MMCA	DC BUS	AC BUS	*CONTROL SW CONTROL BUS
LATCH GROUP 1-6	2	MN B	AC 2	BC 1
LATCH GROUP 7-12	3	MN A	AC 1	AB 1
RADIATOR DPY/STO	3	MN A	AC 1	BC 1/BC 2
	2	MN C	AC 3	CA 1
	3	MN A	AC 1	AB 2

PORT RADIATOR				
ACTUATOR ASSEMBLY	MMCA	DC BUS	AC BUS	*CONTROL SW CONTROL BUS
LATCH GROUP 1-6	4	MN B	AC 2	BC 2
LATCH GROUP 7-12	1	MN A	AC 1	AB 2
RADIATOR DPY/STO	1	MN A	AC 1	AB 1
	4	MN C	AC 3	CA 2
	4	MN C	AC 3	CA 1/CA 2
	1	MN A	AC 1	AB 2/AB 1

*Control switches are the LATCH control and the radiator control switches on Panel R13.

Figure 3-31.- Radiator power configuration.

SECTION 4
DISPLAYS AND CONTROLS

Panel MA73C (Fig. 4-1) contains the MCA logic circuit breakers, and switches.

Panel R13 (Fig. 4-2) contains the PBD dedicated control switch, the radiator control switches, the PBD status flag, and radiator status flags. Panel R12 (Fig. 4-2) contains CRT 4 and the keyboard used for PBD operations in SM and Backup Flight System (BFS). Figure 4-3 illustrates the MCC CRT display of PBD/radiator parameters, and Figure 4-4 shows a typical PBD CRT display. An operational description of the CRT display follows the figure.

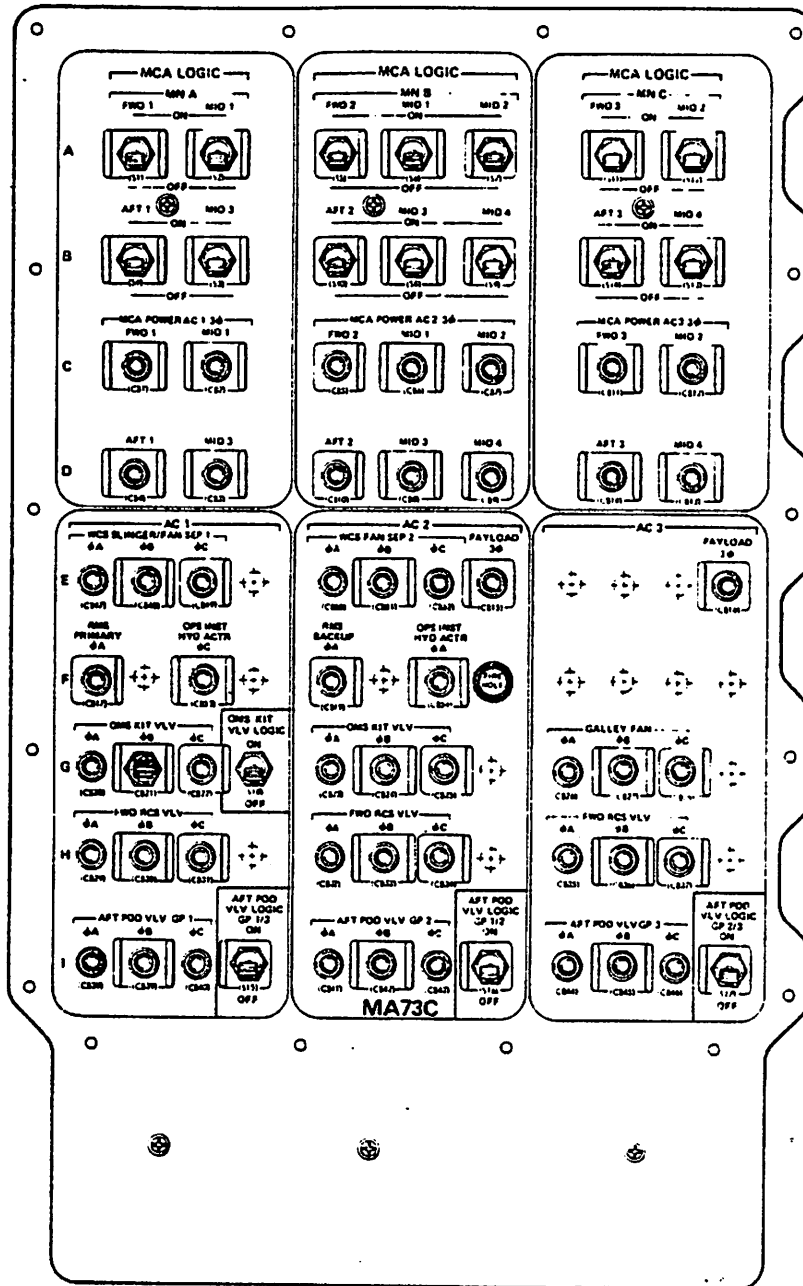


Figure 4-1.- Panel MA73C.

4-3

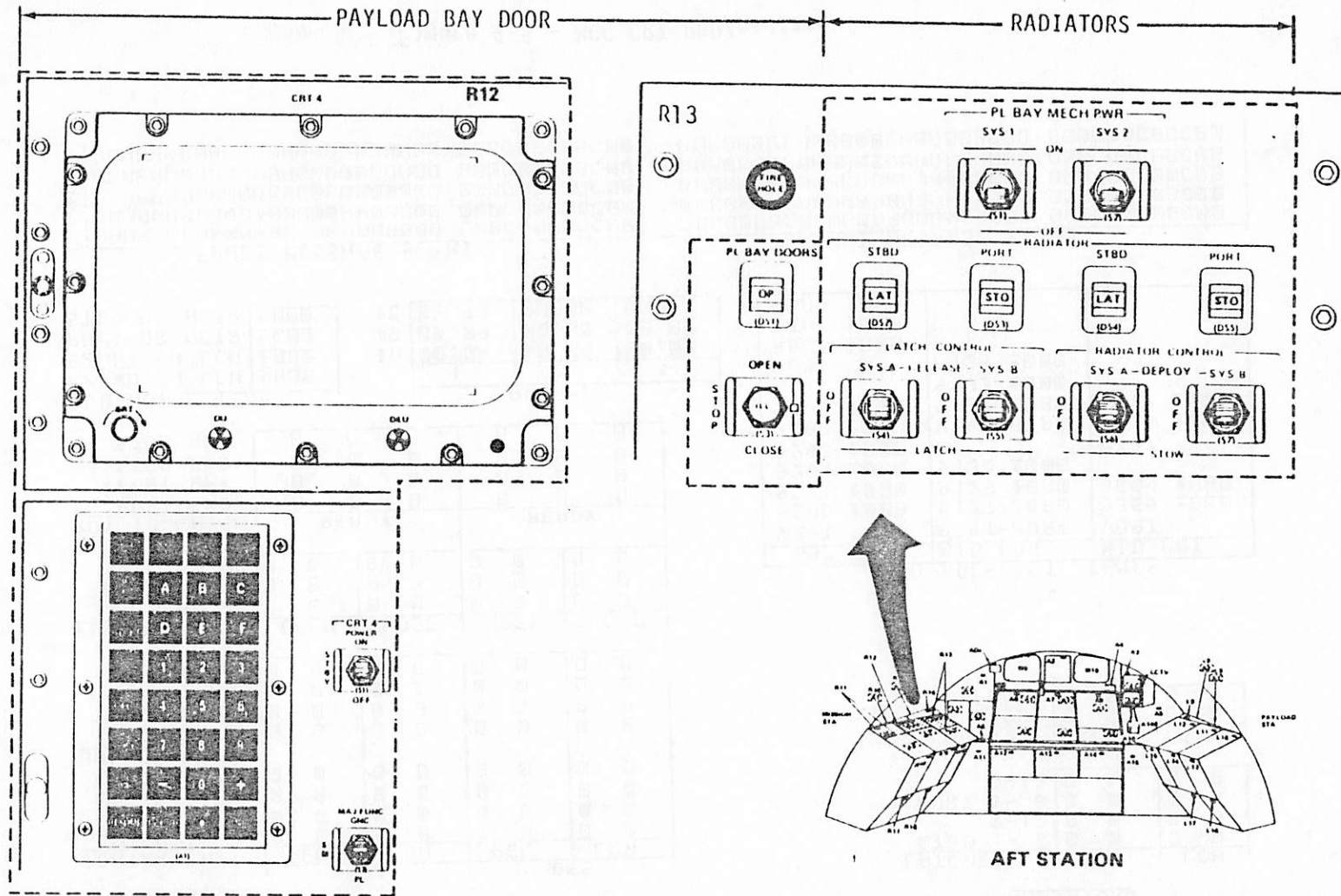


Figure 4-2.- PBD/radiator displays and controls.

ORBITER-102 PANEL CONFIGURATION

10C-PBD/R

PAYLOAD BAY DOORS
 SEQ 0000

CENTERLINE	PRI		BFS	
	REL	LCH	REL	LCH
LATCH 5-8	0 0	0 0	0 0	0 0
LATCH 9-12	0 0	0 0	0 0	0 0
LATCH 1-4	0 0	0 0	0 0	0 0
LATCH 13-16	0 0	0 0	0 0	0 0
BULKHEAD				
STBD FWD	0 0	0 0	0 0	0 0
STBD AFT	0 0	0 0	0 0	0 0
PORT FWD	0 0	0 0	0 0	0 0
PORT AFT	0 0	0 0	0 0	0 0

RADIATORS

LATCHES	REL	LCH
STBD 1-6	0 0	0 0
7-12	0 0	0 0
PORT 1-6	0 0	0 0
7-12	0 0	0 0

PANELS	DEPLOY	STOW
STED	0 0	0 0
PORT	0 0	0 0

PBD OP/CL	OPEN	CLOSE	OPEN	CLOSE
STBD DR	0 0	0 0	0 0	0 0
PORT DR	0 0	0 0	0 0	0 0
PBD/GPC	0 0	0 0	0 0	0 0

RDY TO LATCH	READY	READY
PORT FWD	0 0 0	0 0 0
PORT AFT	0 0 0	0 0 0
STBD FWD	0 0 0	0 0 0
STBD AFT	0 0 0	0 0 0

PBD MOTOR TEMPS

P/FWD BH LCH	±000
S/AFT BH LCH	±000
PORT DR ACTR	±000
STBD DR ACTR	±000

AC AMPS

	1	2	3
+A	00.00	00.00	00.00
+B	00.00	00.00	00.00
+C	00.00	00.00	00.00

PRD DEFLECT TEMPS

592 ER	MID LON	MID ROT
V34T	V34T-PORT	V09T
9200 ±000	9127 ±000	9359 ±000
9201 ±000	9129 ±000	9504 ±000
9204 ±000	9130 ±000	
9203 ±000		V34T
9202 ±000	V34T-STBD	9116 ±000
9100 ±000	9131 ±000	9117 ±000
	9133 ±000	
	9134 ±000	
V09T		
9458 ±000		
9207 ±000		
9309 ±000		

FAULT MESSAGE - PRI

1	AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA	000C00C00C00
2	BBBBBBBBBBBBBBBBBBBBBBBBBBBBBB	000C00C00C00
3	CCCCCCCCCCCCCCCCCCCCCCCCCCCC	000C00C00C00
4	DDDDDDDDDDDDDDDDDDDDDDDDDD	000C00C00C00
5	EEEEEEEEEEEEEEEEEEEEEEEEEEEE	000C00C00C00
6	FFFFFFFFFFFFFFFFFFFFFFFFFFFFFF	000C00C00C00

FAULT MESSAGE - BFS

1	AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA	000C00C00C00
2	BBBBBBBBBBBBBBBBBBBBBBBBBBBBBB	000C00C00C00
3	CCCCCCCCCCCCCCCCCCCCCCCCCCCC	000C00C00C00
4	DDDDDDDDDDDDDDDDDDDDDDDDDD	000C00C00C00
5	EEEEEEEEEEEEEEEEEEEEEEEEEEEE	000C00C00C00
6	FFFFFFFFFFFFFFFFFFFFFFFFFFFFFF	000C00C00C00

Figure 4-3.- MCC CRT PBD/radiator.

4-4

10C-PBD/R

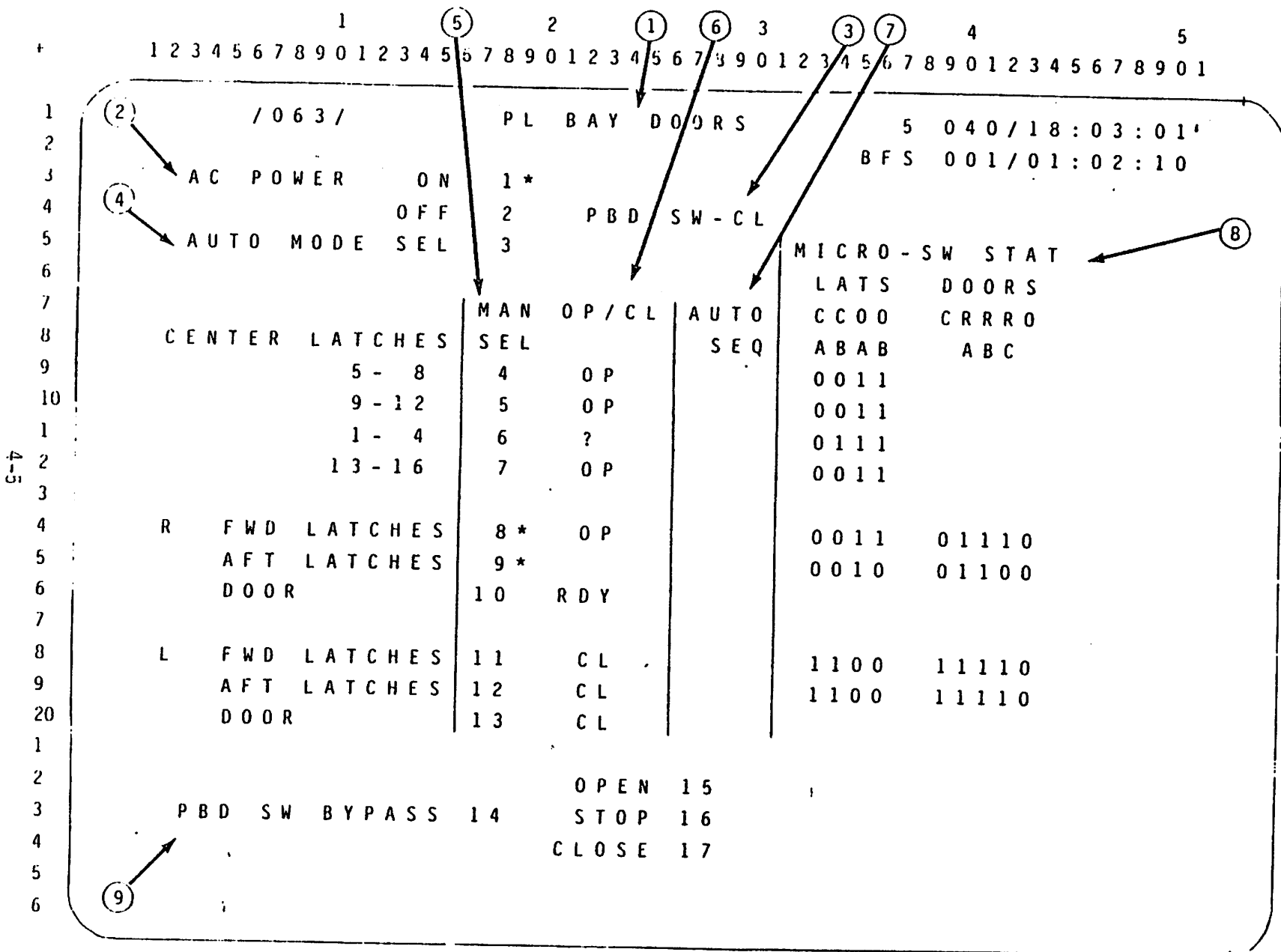


Figure 4-4.- PBD typical display.

① PL BAY DOORS

An SM Operational Sequence (OPS) available in OPS 2 provides capability to monitor and control the PBD OPEN/CLOSE operations.

② AC POWER

The capability to apply and remove AC power (AC POWER) to all PBD latch and door actuator motor control assemblies is provided by Items 1 (ON) and 2 (OFF) controls. An asterisk (*) will be driven after the item number of the option currently selected. These items are mutually exclusive, in that selection of either position causes the other to be deselected. The display is initialized with the OFF item selected. When operation of this OPS major mode is terminated, the AC power will be selected OFF.

③ PBD SW-

The status of the PBD dedicated control switch (PBD SW-) is provided for procedural assistance. The text output displayed for this parameter is open (OP), stop (STOP), close (CL), or fail (FAIL) to indicate the hardware switch contacts position or to indicate a switch failure. An "M" will be displayed in the parameter status field whenever the data is missing.

④ AUTO MODE SEL

Item 3 provides the crew with the control to select/deselect the AUTO mode (AUTO MODE SEL) of PBD operation. Selection of this mode will be illegal if the PBD dedicated control switch is in any position except STOP or PBD SW BYPASS STOP (Item 16) is not selected (when the PBD dedicated control switch has been bypassed by executing Item 14). After execution of Item 3, the PBD AUTO sequence is initiated when the PBD dedicated control switch is placed in OPEN/CLOSE position or the PBD SW BYPASS OPEN (Item 15) or CLOSE (Item 17) is selected (after the PBD dedicated control switch has been bypassed by executing Item 14); the latches and doors are then automatically cycled in a predefined sequential order. Each latch group and door in the OPEN/CLOSE sequence will be verified prior to initiating the next step in the sequence. The capability exists to stop the PBD AUTO OPEN/CLOSE sequence at any point by selecting the STOP position of the PBD dedicated control switch or the PBD SW BYPASS STOP (Item 16) as applicable. The sequence will commence from this point when the PBD dedicated control switch or PBD SW BYPASS is returned to either the OPEN or CLOSE position. An asterisk (*) will be driven after the item number to indicate the selection of the PBD AUTO mode. When the entire PBD OPEN/CLOSE sequence is completed, the AUTO mode will be automatically deselected and the asterisk blanked.

If the OPEN/CLOSE AUTO sequence fails prior to sequence completion and MANUAL mode of operation is to be attempted, the AUTO mode must be deselected (by ITEM 3 EXEC) prior to initiating the MANUAL operations.

⑤ MAN SEL

The crew has the option to select/deselect individual latch group or door sequences to be cycled. This MANUAL mode capability is provided under the manual select column (MAN SEL) by executing Items 4-13, as desired. The selected sequence is initiated when the PBD dedicated control switch is placed in the OPEN/CLOSE position or the PBD SW BYPASS OPEN (Item 15) or CLOSE (Item 17) is selected (after the PBD dedicated control switch has been bypassed by executing Item 14). In MANUAL mode, return of the PBD dedicated control switch to the STOP position or executing PBD SW BYPASS STOP (Item 16) halts the selected option. A return to the OPEN or CLOSE position or execution of Items 15 or 17 will reenable the option. An asterisk (*) will be driven after the item number of the sequence(s) selected for MANUAL mode operation.

In the MANUAL mode, the capability exists to select additional individual latch group or door items regardless of the position (OPEN/CLOSE) of the PBD dedicated control switch or PBD SW BYPASS OPEN/CLOSE item selection. The additional selected latch group or door OPEN/CLOSE sequence is begun immediately upon entering the additionally selected items. However, these items cannot be deselected unless the PBD dedicated control switch is returned to the STOP position or the PBD BYPASS SW "STOP" (Item 16) is selected.

The display is initialized with neither the AUTO or MANUAL mode selected. When operation of this OPS major mode is terminated, the currently active PBD mode (AUTO or MANUAL) will be deselected and the appropriate asterisk(s) blanked.

An "ILLEGAL ITEM ENTRY" CRT message will be output to the display of any of the following operator PBD setup errors:

- A. If one of the individual latch or door items (Items 4-13) is entered while the PBD dedicated control switch is in the OPEN or CLOSE position or PBD SW BYPASS OPEN or CLOSE item (Item 15 or 17) is selected and the AUTO mode select item (Item 3) is selected, the item entry will be rejected.
- B. If one of the individual latch or door items (Items 4-13) is entered while the PBD dedicated control switch is in the OPEN or CLOSE position or PBD SW BYPASS OPEN or CLOSE item (Item 15 or 17) is selected and none of the items were initially selected, the item entry will be rejected.
- C. If the PBD AUTO mode select item (Item 3) is entered while the PBD dedicated control switch is in the OPEN or CLOSE position or PBD SW BYPASS OPEN or CLOSE item (Item 15 or 17) is selected, the item entry will be rejected.
- D. If one of the PBD SW BYPASS control items, OPEN (Item 15), STOP (Item 16) or CLOSE (Item 17), is entered while the PBD SW BYPASS (Item 14) is deselected, the item entry will be rejected.

- e. If termination of this OPS mode is initiated and either the PBD dedicated control switch is not in the STOP position or the PBD SW BYPASS STOP item (Item 16) is deselected (as applicable), the entry will be rejected.

If the PBD dedicated control switch is in the STOP position or the PBD SW BYPASS STOP (Item 16) is selected, entry of the PBD AUTO mode select item (Item 3) will deselect all the individual latch and door items (Items 4-13) and select the AUTO mode item. If the PBD dedicated control switch is in the STOP position or the PBD SW BYPASS STOP (Item 16) is selected, entry of any of the individual latch or door items (Items 4-13) will select the desired item(s) and deselect the PBD AUTO mode select item (Item 3).

⑥ OP/CL

The status of the following PBD latch groups, doors, and associated microswitches are provided:

- A. Centerline latch groups 5-8, 9-12, 1-4, and 13-16.
- B. Port and starboard door forward/aft bulkhead latch groups.
- C. Port and starboard door open, bulkhead ready-to-latch, and close.

These parameters are ordered in the sequence of operation; the OPEN sequence reading from top to bottom and vice versa for the CLOSE sequence.

For each of the latch groups, a text output of open (OP), close (CL) or question mark (?) will be displayed in the OP/CL status column. For each door, a text output of open (OP), close (CL), bulkhead ready-to-latch (RDY), or question mark (?) will be displayed in the OP/CL status column. During the transient period of the latches or door travel between the two positions, the text field will be blank. This text output indicates the combinational logic status of the associated microswitches. The "?" status reflects an off-nominal microswitch configuration which may be indicative of a failure, but will not necessarily prevent completion of the sequence. An "M" will be displayed in the status field of the OP/CL column opposite any latch group or door for which any data required to perform combinational logic is missing. If a parameter value required to satisfy a specified criterion has a "M" parameter status indicator enabled, that parameter value will continue to be used.

⑦ AUTO SEQ

For each of the latch groups and doors, a down arrow (↓) will be displayed in the AUTO sequence (AUTO SEQ) column to indicate when a failure of the door drive or latch group to open or close within a specified time period has occurred during the AUTO mode only. Single motor operation per actuator assembly should open or close the door drive or latch group within these specified times. Any failure to open or close within the specified time will halt the AUTO sequence

and annunciate a Class 3 alarm and CRT message. The value of the fail parameter will be reset and the down arrows blanked when this OPS major mode is terminated or if the PBD AUTO mode is deselected (ITEM 3 EXEC) or if the manual mode is selected.

⑧ MICRO-SW STAT

The status of the individual microswitches (MICRO-SW STAT) associated with each latch group and door is output as a numeric value, "0" for open and "1" for closed switch contacts. For each latch group under the latches (LATS) column are the four microswitches indicative of the latch group operation; two close (CA, CB) and two open (OA, OB). For each door, right and left, under the doors (DOORS) column are the two groups, fwd and aft, of five each microswitches indicative of door operations; one close (C); three bulkhead ready-to-latch (RA, RB, RC), and one open (O) for each group. It is this combinational logic that is used to determine the text status to be output in the OP/CL column for the individual latch groups and doors.

The display will reflect the current status of the latch groups, doors, and associated microswitches any time this OPS major mode is called up.

⑨ PBD SW BYPASS

Capability is provided to use item entries to control the Payload Bay Doors sequence in place of the PBD dedicated control switch. The software PBD switch bypass (PBD SW BYPASS), with its three-position controls (OPEN, STOP, and CLOSE), functions with the same constraints as those defined for the hardware switch when used to operate the PBD modes.

The PBD switch bypass, Item 14, provides the crew with the control to select/deselect the software switch which bypasses the dedicated control switch. When the bypass item is initially selected, the STOP item (Item 16) will be selected automatically. The OPEN, STOP, and CLOSE items (Items 15, 16, and 17 respectively) are mutually exclusive and execution of any of these items without first selecting Item 14 will be illegal and rejected. A subsequent item entry of the bypass item will deselect all four items. An asterisk (*) will be driven after the item numbers of the options currently selected. When SM is initialized from mass memory, the PBD switch bypass items will be deselected and thereafter shall reflect crew inputs.

If termination of this OPS mode is initiated when either the PBD dedicated control switch is not in the STOP position or the PBD SW BYPASS STOP (Item 16) is deselected (as applicable), the entry shall be rejected and an "ILLEGAL ITEM ENTRY" CRT message displayed.

TABLE 4-I.- PBD/RAD CONTROLS

PANEL	TYPE	NOMENCLATURE/ POSITION	FUNCTION	REMARKS
MA73C	Circuit Breaker CB-2	MCA Power AC1-3 ϕ MID 1	3-Phase AC power to MMCA-1	
MA73C	Circuit Breaker CB-3	MCA Power AC1-3 ϕ MID 3	3-Phase AC power to MMCA-3	
MA73C	Circuit Breaker CB-6	MCA Power AC2-3 ϕ MID 1	3-Phase AC power to MMCA-1	
MA73C	Circuit Breaker CB-7	MCA Power AC2-3 ϕ MID 2	3-Phase AC power to MMCA-2	
MA73C	Circuit Breaker CB-8	MCA Power AC2-3 ϕ MID 3	3-Phase AC power to MMCA-3	
MA73C	Circuit Breaker CB-9	MCA Power AC2-3 ϕ MID 4	3-Phase AC power to MMCA-4	
MA73C	Circuit Breaker CB-12	MCA Power AC3-3 ϕ MID 2	3-Phase AC power to MMCA-2	
MA73C	Circuit Breaker CB-13	MCA Power AC3-3 ϕ MID 4	3-Phase AC power to MMCA-4	
MA73C	2-pos toggle	MCA Logic MNA MID 1/ON-OFF	Turns ON-OFF MNA power to MMCA-1	
MA73C	2-pos toggle	MCA Logic MNA MID 3/ON-OFF	Turns ON-OFF MNA power to MMCA-3	
MA73C	2-pos toggle	MCA Logic MNB MID 1/ON-OFF	Turns ON-OFF MB power to MMCA-1	
MA73C	2-pos toggle	MCA Logic MNB MID 2/ON-OFF	Turns ON-OFF MNB power to MMCA-2	
MA73C	2-pos toggle	MCA Logic MNB MID 3/ON-OFF	Turns ON-OFF MNB power to MMCA-3	
MA73C	2-pos toggle	MCA Logic MNB MID 4/ON-OFF	Turns ON-OFF MNB power to MMCA-4	
MA73C	2-pos toggle	MCA Logic MNC MID 2/ON-OFF	Turns ON-OFF MNC power to MMCA-2	
MA73C	2-pos toggle	MCA Logic MNC MID 4/ON-OFF	Turns ON-OFF MNC power to MMCA-4	

TABLE 4-I.- PBD/RAD CONTROLS - Concluded

PANEL	TYPE	NOMENCLATURE/ POSITION	FUNCTION	REMARKS
R13	3-pos toggle	PL Bay Doors OPEN-STOP-CLOSE	Initiates PL Bay Door OPS	
R13	Talkback	PL Bay Doors OP-BP-CL	Indicates PL Bay Door status	Auto Mode only
R13	2-pos toggle	PL Bay Mech Pwr SYS-1 ON-OFF	Provides cont Bus Pwr to MMCA-1,-2; enabling AC Buses	
R13	2-pos toggle	PL Bay Mech Pwr SYS-2 ON-OFF	Provides cont Bus Pwr to MMCA-3,-4; enabling AC Buses	
R13	Talkback	Radiator STBD LAT-BP-REL	Indicates STBD RAD Latch status	
R13	Talkback	Radiator Port LAT-BP-REL	Indicates Port RAD Latch status	
R13	Talkback	Radiator STBD STO-BP-DEP	Indicates STBD RAD position	
R13	Talkback	Radiator Port STO-BP-DEP	Indicates Port RAD position	
R13	3-pos toggle	Latch control Sys-A LATCH-OFF-RELEASE	Initiates RAD Latch OPS, 1/2 the motors	By MMCA 1 & 3
R13	3-pos toggle	Latch Control Sys-B LATCH-OFF-RELEASE	Initiates Latch OPS, 1/2 the motors	By MMCA 2 & 4
R13	3-pos toggle	Radiator Control SYS-A DEPLOY-OFF-STOW	Initiates RAD DEP/STO OPS, 1/2 the motors	By MMCA 1 & 2
R13	3-pos toggle	Radiator control SYS-B DEPLOY-OFF-STOW	Initiates RAD DEP/STO OPS, 1/2 the motors	By MMCA 3 & 4

SECTION 5
SYSTEMS PERFORMANCE, LIMITATIONS, AND CAPABILITIES

5.1 PBD CENTERLINE LATCH SYSTEM

- Latch group open/close operating time: 20 seconds (2 motors)
: 40 seconds (1 motor)
- Temperature limitations - operating: +250° F to -100° F
non-operating: +330° F to -167° F
- Manual disconnects provided for contingency EVA latch operations.
- Actuator torque limiter setting: 3500 in-lb.
- Manual or Auto mode of operation.
- Latches open prior to bulkhead latch opening.
- Motors will run on two phases, but will not start on two.

5.2 BULKHEAD LATCH SYSTEM

- Latch group open/close operating time: 30 seconds (2 motors)
: 60 seconds (1 motor)
- Temperature limitations - operating: +250° F to -100° F
non-operating: +330° F to -167° F
- Manual disconnects provided for contingency EVA latch operation.
- Manual or Auto mode of operation.
- Closed prior to C/L latches closing.
- Actuator torque limiter setting: 14,200 in-lb.
- Motors will run on two phases, but will not start on two.

5.3 PAYLOAD BAY DRIVE SYSTEM

- Special Ground Support Equipment (GSE) required for one g operation.
- Max opening in one g is 88° due to white room size at KSC.
- PBD open/close time: 63 seconds (2 motors)
: 126 seconds (1 motor)
- Temperature Limitations - operating: +157° F to -100° F
non-operating: +340° F to -100° F

- Starboard door must open first, close last.
- Disconnects provided for contingency EVA operation during door closing.
- Manual or Auto operations.
- PBD rotates $\sim 174^\circ$ from close to open.
- COAS alignment accuracy = 0.1 in. at 40 ft, during PBD alignment check prior to C/L latch closure.
- PBD's cannot be closed with both radiators deployed, but can be closed with one radiator stowed (one deployed) if payload does not interfere with radiators.
- PBD drive system power drive unit output load capacity: 1070 in-lb; required: 648 in-lb.
- Motors will run on two phases, but will not start on two.

5.4 RADIATOR SYSTEM

- Designed for zero g operation (deploy/stow).
- Counterbalance (GSE) required for one g operation.
- Latches designed to engage rollers under maximum expected radiator panel warpage.
- Radiator panels deploy 35.5° .
- Latch/unlatch operating time: 26 seconds (2 motors)
: 52 seconds (1 motor)
- Radiator deploy/stow operating time: 43 seconds (2 motors)
: 86 seconds (1 motor)
- Deploy mechanism contains disconnects for contingency EVA stow operation.
- Both port and starboard radiators latch/unlatch and deploy/stow simultaneously.
- Single or dual motor operation is possible by switch controls (Panel R13).
- Radiators cannot be deployed unless unlatched.
- Freon loop 1 flows through the port radiator panels.
- Freon loop 2 flows through the starboard radiator panels.
- Total freon in all eight radiator panels is ~ 143 lb.
- Radiator weight (dry) (all eight panels) ~ 1553 lb.

- Radiator capacity \sim 61,000 Btu/hr; 30 percent effectiveness is lost if radiators cannot be deployed.
- Radiator mechanism temperature limits - operating: +250° F to -100° F
non-operating: +350° F to -167° F
- Radiator latch mechanisms torque limiter set point: 4400 in-lb.
- Radiator deploy mechanisms torque limiter set point: 4400 in-lb.
- Latch and deploy motors will run on two phases, but will not start on two.

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PRELIMINARY

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Payload Bay Doors/
Radiators

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